

Galileo – Potential in Indian Market

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ABSTRACT: Galileo is increasingly becoming important even before it is functionally operational due to the multitude of advantages for which it is being designed. Some of its intended commercial applications are: Location Based Services (LBS), personal navigation devices, intelligent transportation systems (ITS) etc. The reliability, robustness and the satellites visibility are expected to improve the receiver performance significantly, due to a relatively larger constellation and a robust signal structure. Although GPS based navigation systems have performed remarkably well in benign environments where there is less of interference and under good signal strength conditions, nevertheless, a stand-alone GPS receiver cannot meet the positioning requirements as mandated by the proliferating applications.

The recent phenomenal growth in IT Services in India has triggered technological advancements in many commercial applications such as Mobile phone services, cable networks which also integrate Internet services, digital audio/video applications etc. As India is a hotbed for commercial businesses, several international organizations are investing in various technological areas. With India intending to participate in Galileo and Glonass systems, there is a significant thrust in the navigation applications. The flexibility, robustness and integrity features of the Galileo signals are the driving forces in the expected growth of the Galileo receivers. In addition, the FCC E-911 mandate has propelled the growth of positioning capability in mobile phones. Furthermore, reduction in the cost of Mobile phones has significantly increased its market potential with number of users approximately doubling every year.

This paper will address how Galileo Navigation System will influence the Indian market, especially the location based services which is expected to have an enormous growth in the very near future. It also dwells on the possible applications that might arise with combined GPS/Galileo Systems, and quantitative improvements in interference environments. An overview on the Galileo signal structure, the constellation structure and the market potential are also provided.

INTRODUCTION:

The need to determine the 'location' of the user in most of the upcoming applications has triggered the growth of Satellite Navigation market. In fact, location has become the buzzword mainly due to the proliferating applications such as LBS and Telematics. Owing to their small sizes, low costs, better accuracies, global coverage, Satellite based navigation receivers are poised to replace the once dominant terrestrial networks. Moreover, the evolving market is witnessing an increased awareness in the user's utilization of the location based services, and this trend is forcing the system designers to provide 'quality' signals with robust performances. LBS and Telematics which are widely considered as the attractive markets are the main driving factors for future global navigation satellite systems (GNSS) development (Styles, 2003; Swann, 2003). Several market studies have been conducted to determine the satellite navigation market in the next decade, and the forecast shows a good growth in both revenues and the number of users.

Global Navigation Satellite Systems popularly called as GNSS facilitates the users to compute their position by transmitting ranging signals. By measuring the distance to a minimum of 4 satellites, the receiver solves a set of non-linear equations to optimally estimate its position. The principle advantage of the GNSS receiver is its bounded accuracy anywhere across the globe. Differential corrections can also be applied to enhance this accuracy. These 'merit-factors' have resulted in further deployment of new constellations with additional services to cater to customer needs. Some currently operating GNSS systems are: GPS with a constellation of 24 satellites, and GLONASS with about 8 satellites. To address the growing market needs and to show the sovereignty of Europe, the EC and ESA have joined hands to develop the Galileo Navigation system. Unlike GPS and GLONASS which are controlled by military and primarily targeted for military applications, Galileo is civilian controlled with a major focus on civilian applications. The constellation is expected to have 30 satellites with improved signal structures to address variety of market scenarios. Four different services are provided, with an 'open service' providing the free but limited accuracy signal that can be

accessed by everyone. The other services are accessible only by the 'privileged' users. Furthermore, Japan's Quasi-Zenith Satellite System (QZSS) also transmits 'GPS-like' ranging signals though it is primarily a Communication Satellite System. India's IRNSS and China's Twinstar are some other proposed initiatives in these areas. To further improve the stand-alone GNSS receiver capability in terms of accuracy and integrity, satellite based Augmentation Systems such as WAAS, EGNOS, MSAS and the upcoming GAGAN constellations are deployed.

The major market for the GNSS is expected to be LBS which use mobile phone as one of its key component. To avail location based services, the mobile phones either use 'handset-based' or 'network-based' techniques to compute its position. Handset-based techniques use GNSS signals to compute its position, whereas terrestrial network is used for position computation in Network-based. Therefore, the market is presently split; but, with the growing satellite market and also the availability of chipsets which can be integrated into the phones, handset market is expected to grow much faster. Also, the FCC E-911 compliance can be met with lesser investment using handset-based technique, and therefore the GNSS market is expected to dominate in the near future. With Galileo system providing more services, the market is rapidly tilting towards handset-based technology.

India is one of the fastest growing mobile communications market in the world. With decreasing tariffs and increasing value-added services the Service Providers provide, a complete mobile revolution is taking place in India. With its cost effective solutions and technology expertise, India is becoming a hot-bed for investment and collaboration especially for location based services. Moreover, India's participation in Galileo program heralds a new beginning in the Indian navigation market. To capture the market, more and more service providers are looking into integrating the positioning technologies into their products to provide location based services such as fleet management, mobile tourist, emergency services, people finding, asset tracking, games etc. Have a late start in the mobile market, India has certainly an edge over the other already established markets such as Europe and North America, in that, the new handsets with position capability can easily be sold. With number of handsets increasing exponentially every year, India is poised to become one of the leading markets in the telecommunication industry.

The end market is the important driver for the generation of new systems, and Satellite based navigation is not an exception to this. A rigorous market analysis was done before the inception of Galileo system to ensure that it will not be another catastrophe like some of its predecessors. The market forecast reveals good returns on the investments. With India signing the agreement, Galileo market or combined GPS/Galileo market will certainly

influence India's economy. An explosive growth in several technological areas such as telecommunications, internet, wireless, broadband coupled with Satellite based positioning technology will herald a new era in the growth of Indian market. This paper explores the various benefits that Indian market can have by having access to Galileo signals.

GALILEO CONSTELLATION

A 30 satellite constellation with 3 as active spares is defined for the Galileo Space Segment to provide adequate coverage to the world-wide users. The satellites are positioned in MEO orbit at approximately 23,000 kms and an inclination of 56 deg. The distribution of satellites provides a better geometry, as defined by DOP parameters, in addition to providing increased visibility of satellites to enhance the overall performance of the receiver. Each satellite in the constellation is also equipped with a Search and Rescue transponder to help users in distress – an exclusive frequency is allocated for this purpose.

The Galileo Signal Task Force has planned the frequency spectrum in such a way that some of them (E5a and L1) are inter-operable with the GPS signal structure. This provides overall benefit to the receiver design in terms of reduction in the complexity of RF front-end design. Moreover, the combined GPS and Galileo satellites not only increase the visibility at higher mask angles leading to improved performance in urban areas, but also increase the number of measurements in the position calculation. It is envisaged that most of the future commercial receivers will not be stand-alone which can receive only Galileo or GPS signals, but will have the capability to receive signals from both the systems. Especially, with the proliferating LBS and telematics applications, the combined GPS / Galileo systems will provide an overall advantage to the end-user in terms of accuracy and availability.

GALILEO SIGNAL STRUCTURE

Any new GNSS services should be backward compatible with the already existing systems such as GPS to have influence on the market, as GPS market is well established and widespread. Any non-compatibility with its predecessors will only act as a deterrent to the new system's growth. One of the promising features of Galileo is its partial compatibility with GPS which benefits the end-user. Galileo uses CDMA technology similar to GPS with overlapping frequencies on E5a and L1 bands (as shown in Figure 1).

Galileo primarily offers four different services: OS (Open Services), CS (Commercial Services), PRS (Public Regulated Service) and SOL (Safety of Life Service) on ten different navigation signals in the frequency ranges 1164 to 1215 MHz (E5a and E5b), 1260 to 1300 MHz (E6) and 1559 to 1592 MHz (E2-L1-E1) which are part of the Radio Navigation Satellite Service (RNSS) spectrum.

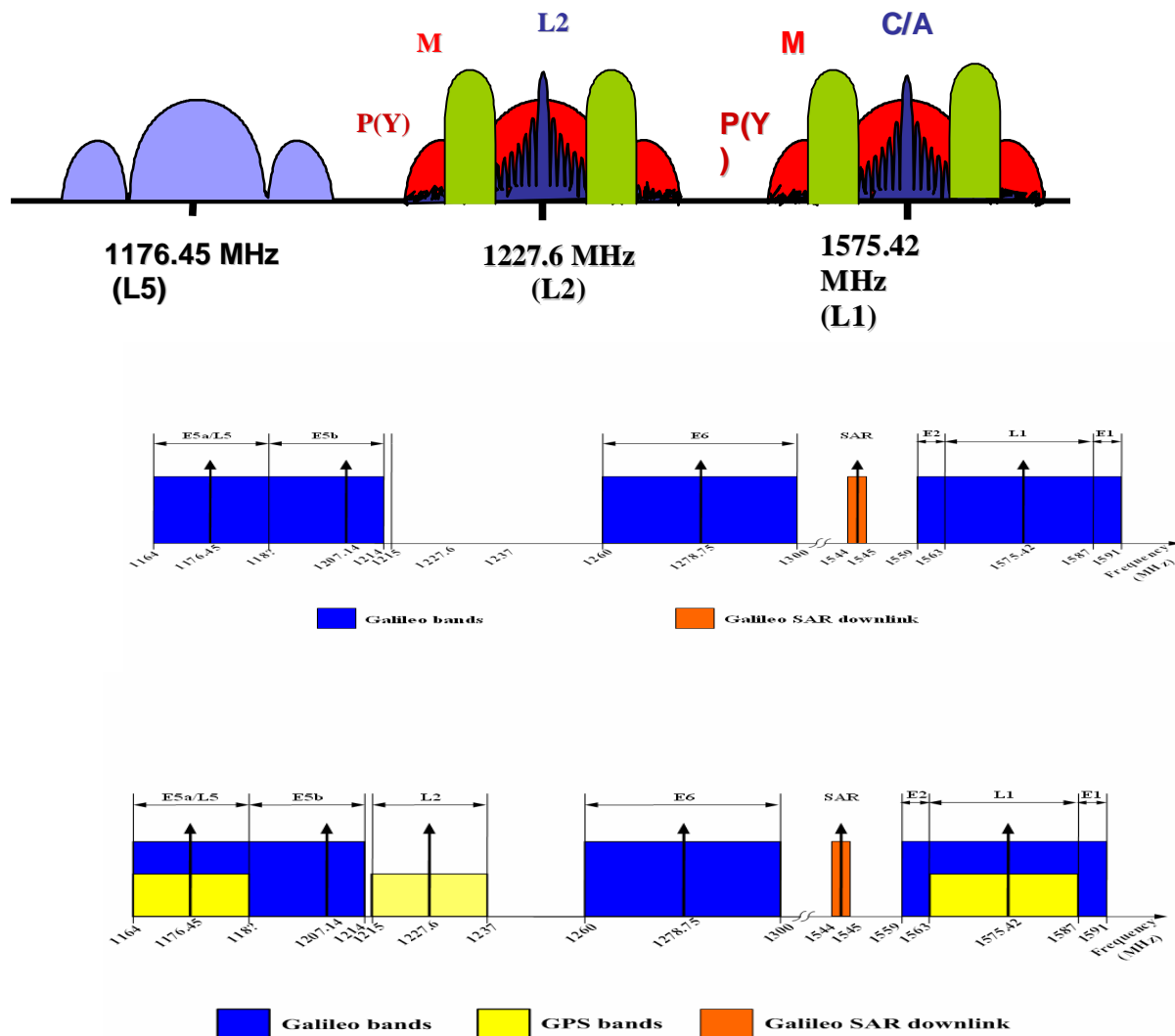


Figure 1. GPS, Galileo and GPS/Galileo Interoperable Frequency Spectrums

The chip rates for these signals ranges from 2–4 Mcps for the E1 and E2 carriers, 5–10 Mcps for the E6 carrier, and 10-20Mcps for the E5 carrier (Hein, et al., 2001). The principle advantage of Galileo system to civilian users is the availability of six ‘Open’ signals, of which three are data-less (ranging codes not modulated by data), which facilitates longer integration periods and improved post-correlated signal to noise ratio. These six signals termed as ‘Open Services and Safety of Life Services’ are available on E5a, E5b and L1 carrier frequencies. Furthermore, encrypted signals on E6 and E2-L1-E1 termed as ‘Commercial Services and Public Regulated Services’ are accessible only by authorized users. These signals provide better accuracies and features when compared to Open and Safety of Life Services.

The strength of the Galileo signals partly depends on the spreading pseudo-random codes. They are generated using a ‘tiered’ structure – short duration primary code modulated by a long duration secondary code. While the longer primary codes use shift registers of length up to 25, shorter secondary codes use pre-defined sequences of lengths up to 100. The distinguishing features of Galileo signals are the BOC modulation and the wide bandwidths. BOC modulations exhibit low pseudo range code measurement errors as the power spectral density is located at the lower and upper boundary of the frequency spectrum. Large bandwidth improves the accuracy and reduces the multipath error due to narrow correlator spacing.

Interoperability is the ability for the combined use of both GPS and Galileo systems to improve upon accuracy, integrity, availability and reliability by using single RF front end. The Galileo signal structure is designed in such a way that there is a partial frequency overlap which enables users to minimize the design complexity (Godet, 2002).

MARKET POTENTIAL

Galileo services have been predicted to cater to a wide range of applications, in particular LBS, and tremendously improve the market potential for service providers. The integration of positioning technology with mobile phones has in fact increased the scope for GNSS development. As location of the user becomes paramount in modern-day applications, reliable determination of position becomes critical, and this places an impetus on the technology developers to provide better services. Due to infrastructure and accuracy limitations, network based positioning technology will have limited influence on the growing market except at places where they already exist. Considering the improved services the upcoming GNSS systems such as Galileo provide, it is envisaged that handset based positioning is poised to capture the global market. Furthermore, a spurt in the growth in mobile phones with positioning capability is further fuelling the

growth rate of GNSS receivers, thanks also to the US Government mandate that every new mobile phone should have positioning capability. Therefore, to meet the user demands, the Galileo system designers are providing paid 'Commercial Services' through Service Providers for higher quality signals in addition to freely accessible 'Open Services' which has a limited accuracy of about 20 to 30m. Some potential applications for Galileo are: LBS, maritime, aviation, fleet management, telematics etc. Due to its higher power, Galileo also provides seamless navigation between indoors and outdoors.

According to the market survey, mobile phone users are expected to cross more than a billion within the next 5 years, and 30 to 50% users will be switching to new phones every year with better features. This will facilitate a significant market potential for Galileo as mobile phones manufactured from 2008 onwards can be integrated with Galileo or combined GPS/Galileo receivers. The prime market predicted for Galileo is Services industry with more than 90% revenues coming from LBS market. According to recent market survey, the overall GNSS market is expected to grow to about 200 billion euros in 2020. From the GNSS enabled mobile phone market shown in Figure 2, it can be seen that the number of users grow rapidly as the applications proliferate.

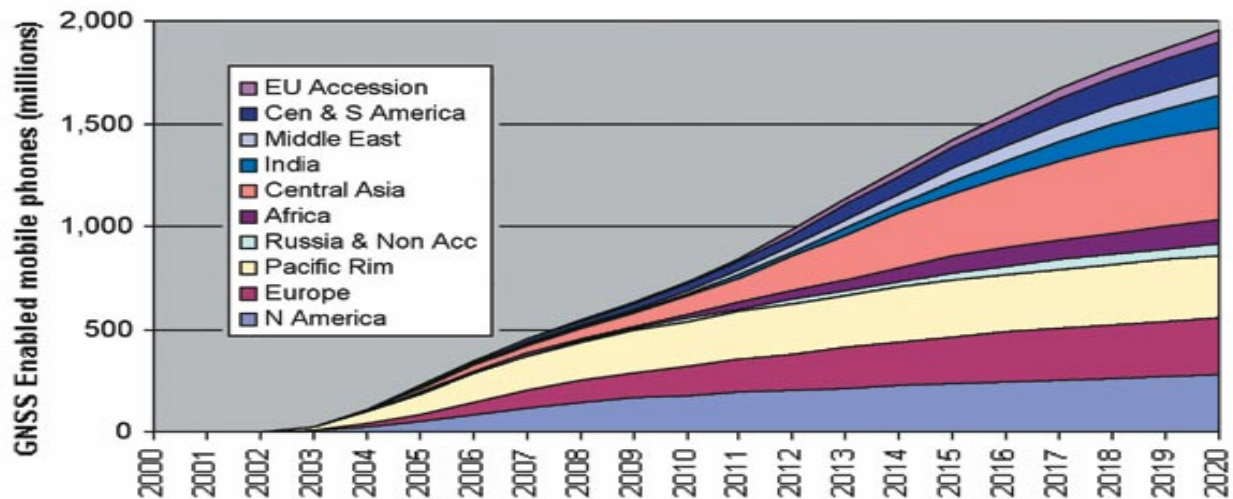


Figure 2. Handset Based Mobile Phone Market

INDIAN MARKET

The mobile market is one of the fastest growing markets in the world with an estimated population of about 2 billion in 2005. The device which was considered to be a luxury

at one time has become a necessity. With its huge population base and emerging customer centric policies, India is poised to become one of the biggest markets in the world. According to a study conducted by Telecom Regulatory Authority of India (TRAI), the usage of mobile

phones is higher in India due to lower tariffs with revenues amounting to about US \$12 billion in 2004-2005.

From just about 5 million users in 2000, the no. of users has increased to about 50 million in 2005, and it is forecasted to about 250 million in 2007. The rapid growth, in part, is due to an increase in the utilities provided by the Service Providers, and a stiff competition amongst them resulting in reduced tariffs. Though the present market is only 50 to 100 million US\$, it is expected to grow at a compound growth of 65% to about 500 to 1000 million US\$ in the year 2008. Wireless operators, music and film companies, cartoon artists, game-makers and musicians are all aggressively entering the mobile market for ring tones, gaming, mobile imagery and streaming audio and video. Mobile operators are constantly scouting for new services and applications to satisfy the growing needs of subscribers for information and entertainment. According to TRAI, in October 2004 mobile phone users grew more than the landline users, which is mainly due to the value added services that mobile operators provide.

With the increasing count in vehicle population every month, GNSS services would definitely be a multi-million dollar spinner for solution providers providing effective fleet management and route management services. One of the prominent telecom service providers has already launched GSM-GPS based fleet tracking solution. The GPS technology is rapidly changing how people find their way around. The GPS navigation will enhance the quality of life in cities and improve intra-city and inter-city transit, apart from opening up huge possibilities in logistics, security and adventure sports. Tourists to India stand to gain hugely if vehicles are fitted with GPS receiver, since they can be auto-directed to destinations of interest, restaurants, hotels or even emergency services without harassment or delay.

India plans to build its own regional GPS Augmentation System (GAGAN), consisting of a cluster of satellites, to emerge as a major hub in air navigation and other services. This project will help build a global positioning system that will be used to aid navigation systems for the management of air traffic, railways and ships. The indigenous system, known as Satellite based navigation system (SBAS), would be part of the Satellite based communications, navigation and surveillances/Air Traffic Management for civil aviation. A major plan for Satellite Navigation, including the implementation of Technology Demonstration System (TDS), over the Indian airspace as a proof of concept, has been jointly prepared by the Airports Authority of India (AAI) and Indian Space Research Organization (ISRO). The major objective is to bridge the gap between European Geo-stationary Navigation Overlay System (EGNOS) and the Japanese

MTSAT Space Augmentation System (MSAS) to provide a seamless navigation of aircraft from West to East and vice-versa.

Civil Aviation:

- Air transport is one of the crucial part in the economic development of Indian sub-continent. Air traffic to and from India is growing at a rate of about 20% per annum. According to analyst's forecast, India can spend \$35 bn in the next 20 years.
- The domestic passenger traffic in India is projected to grow annually at 12.5%. Over the next 5 years, Indian airports are likely to handle about 100 million international passengers annually. Indian Space Research Organization (ISRO) and Airport Authority of India (AAI) has spearheaded Indian efforts towards satellite-based navigation by initiating installation of a WAAS-like overlay system for the Indian aerospace called GPS And Geostationary Augmentation Navigation System (GAGAN).
- Based on TIFAC (Technology Information Forecasting Assessment Council) market research, India will require over \$2.8 billion by 2020 for aircraft infrastructure. The airport market estimate GPS based equipment will increase about 30% of the total aircraft infrastructure market.

Agriculture:

Over the years, India has developed one of the largest agricultural research systems in the world (Evenson, et al). Investments in agricultural research and extension accounted for nearly three-fourths of this growth in productivity. Much of this growth was the result of the new technology that was disseminated throughout India.

- The use of GIS in agriculture has increased because of misuse of resources like land, water, etc. GIS is the principal technology used to integrate spatial data coming from various sources in a computer. GIS coupled with GPS, microcomputers and RS is used for soil mapping, yield mapping.
- Precision farming is the spatial analysis capabilities of GIS that enable precision agriculture. GPS has greatly enabled precision farming and of great importance to precision farming, particularly for guidance and digital

evaluation modeling position accuracies at the centimeter level are possible in GPS receivers.

- The government claims that India has emerged as the seventh largest exporter of food grains in the world. For agriculture application GPS equipment manufactures are now quoting repeatable result of +/- 1 to 5 centimeter at 95% confidence level. In the next 5 years Indian Government estimated about 30- 40% increased use of GPS based precision farming in total agriculture industry.
- To increase productivity on a global scale, precision farming is a must for India. Precision farming features as one of the main research agenda in almost every five year plan, which involves utilizing state-of-art GNSS services with GIS. Galileo's improved signal quality with GAGAN's augmentation combined together will effectively improve the efficiency of seed spacing, tillage etc.

Mobile Tourist:

- A report from Confederation of Indian industry states that the number of tourist visiting India by 2010 will exceed 5 million which is substantial when compared to today's status. The travel industry is on a long-term upward trend indicating an opportunity for automating travel process using GNSS based LBS services.
- Mobile GIS solutions and location-based services will play a major role in Mobile tourists; they can able to get localized information on mobile devices anywhere anytime. One of the most obvious technologies behind LBS is positioning, with the most widely recognized system being the Global Positioning System (GPS).
- Market research shows that location-enabled services are believed to have the potential to drive revenue of more than \$13 billion by 2005. GIS can help the government in checking deforestation, town planners and can provide immediate answers on the type of location.
- Industrial GIS services are expanding at 10-15% per annum in India. GIS market in the "design software market" is expanded to increase moderately from 35 to 40% in next few years. Indian market sources estimate the entire GIS based industry spends Rs. 80 Crore annually on GIS product.

Government's initiative

Mobile services in India continue to grow as GSM and CDMA service providers aggressively attract and market to new subscribers. In India, mobile operators are looking for new services and contents to increase their market share. India's most prized resource in today's economy is its readily available technical workforce. The Government of India is stepping up the number and quality of training facilities in the country to capitalize on this extraordinary human resource. It is the growing industry that will help take the Indian economy to a sustained higher rate of growth and the policy makers are fully aware of this.

Technology can propel India to leadership in a networked world. As technology moves ahead, it will redefine how government interacts with citizens and transform the lives of people in remote areas. The technology revolution that is currently sweeping the globe offers India an exciting opportunity to bring about a quantum leap in its developmental journey. Technological breakthroughs now make it possible to banish poverty illiteracy and malnutrition from the lives of people.

Conclusion

Looking at the current market trend, it can be asserted that Galileo signals will certainly influence future commercial applications such as LBS and Telematics market. This can also be evidenced by the proliferation in these markets even before the launch of Galileo Satellites. The huge population combined with the explosive growth in the Communication market, India is poised to become one of the major markets for Galileo. Of several possible applications, this paper focused on few areas where Galileo system will influence Indian market. This is only a preliminary investigation, and much work needs to be done in terms of new applications and market revenues that Galileo will bring.

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