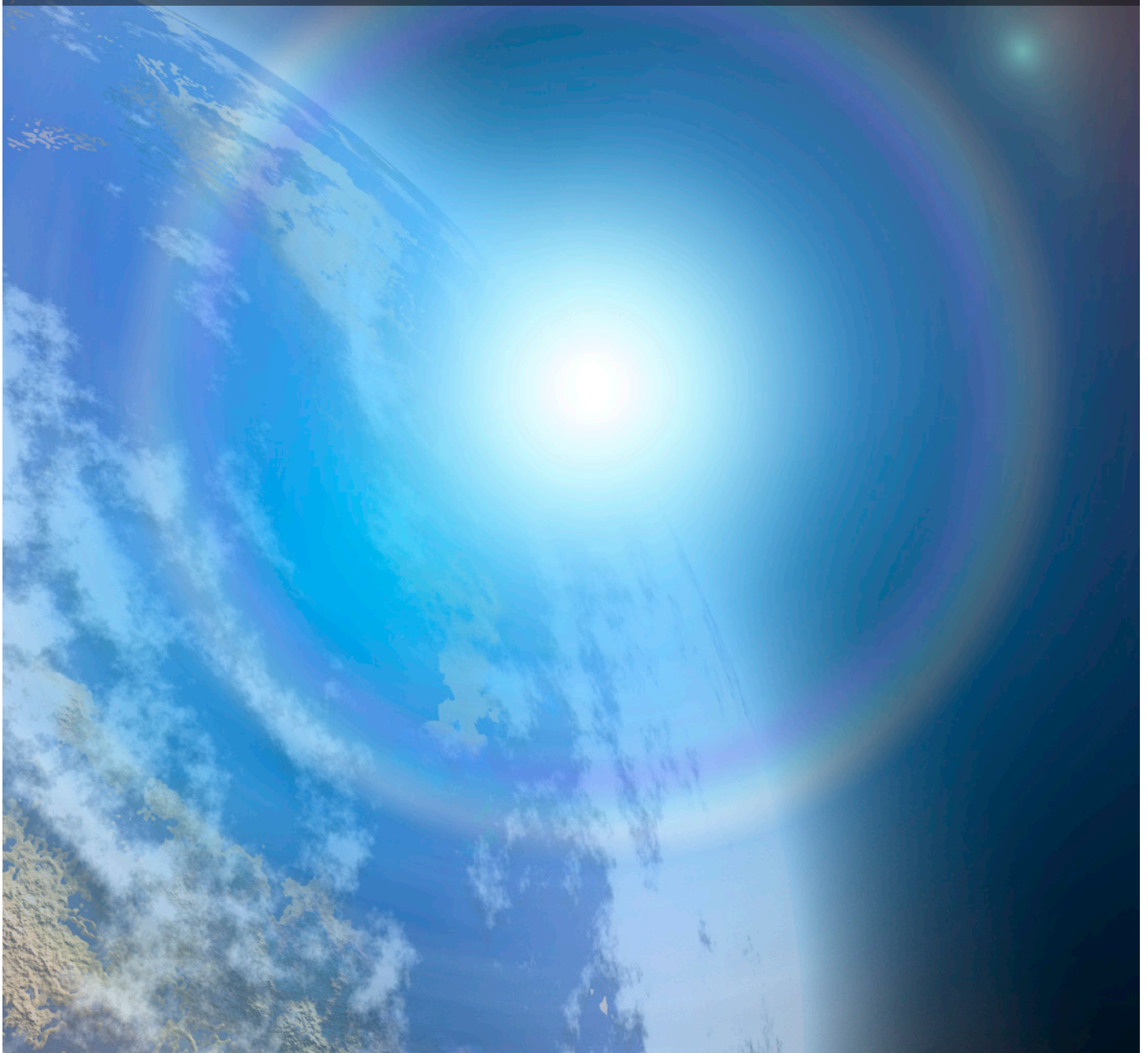


SATELLITE NAVIGATION TECHNOLOGY TRENDS



Satellite navigation technology & trends

1. Existing satellite navigation systems

1.1. GPS

GPS, officially named NAVSTAR by the US Department of Defense, is a satellite based navigation system with more than 24 satellites. The satellites circle the Earth at a height of 12,000 miles twice a day. Global Positioning System provides the exact location at any time irrespective of weather. Satellites are monitored continuously through ground stations at numerous locations worldwide.

GPS III is the upgraded version of the US Department of Defense's GPS constellation of satellites. It is the next generation GPS navigation satellite system to be equipped with most sophisticated technology specifically designed for offering a high level of positioning accuracy to the nearest possible range. While current GPS offers positioning and navigation capabilities to both military and civilian applications, the new system is expected to offer much more in terms of signal quality, security and availability. The system is designed to further augment GPS capabilities as a world-class navigation system and offer high quality and equally reliable navigation services to military and civilian users, especially the aviation industry. GPS III would also provide state-of-the-art anti-jam functionalities, in addition to enhanced system reliability, accuracy, and security, and assure constant availability of signals for safety-critical applications.

1.2. Galileo

GALILEO is the European satellite radio navigation system initiated by the European Space Agency. When implemented, the system would provide exact and accurate location in both space and time. Consisting of a constellation of 30 precisely aligned satellites and a number of ground stations, the system provides several value added services. The 30 satellites of Galileo would revolve around the globe in three orbits at an altitude of over 23,000 km and is designed to convey real-time, accurate positioning of objects down to within meters. Galileo is the third such system in the world, the first two being the American GPS and Russian GLONASS. Satellite radio navigation these days provide an astounding accuracy of up to one meter. An advanced system, Galileo is to work in conjunction with the American GPS to provide better and more services than GPS. Using Galileo, one can determine the position or location of any moving/stationary object such as a vehicle, container, etc. to within a meter using an individual receiver.

The system also provides services across various sectors such as road, maritime and rail transportation, public works, social services, rescue and search activities, judicial system and custom services and recreation. The system is expected to be functional by 2010. Over the years, several countries have become part of the project, including China, India, Israel, Morocco, Ukraine, South Korea, and Saudi Arabia. China has proposed to make an investment of around US\$295 million in the project.

1.3. GLONASS

GLONASS satellites were first launched successfully in 1982. The system, officially declared operational in September 1993, had its last satellites put in orbit in late 1996. With this, the long pending need of the Russian military for a Satellite Radio Navigation System was answered. With satellites that now make up the system being technologically obsolete, the system currently functions in a degraded mode. Starting in 2001, a replacement program was initiated to enhance the satellite constellation by launching 12 additional satellites. Subsequently, Russia has developed and launched an improved version of GLONASS satellite on December 26, 2004

comprising of a three-satellite block. The new GLONASS satellite has a seven-year operational lifespan and is relatively more sophisticated than the previous version. In 2005, Russia also entered into a joint venture with Indian government whereby India consented to share the cost of developing upgraded GLONASS satellites, in addition to launching two of these satellites. The new generation satellite would enhance navigational and commercial applications and offer commercial services to airlines, shipping, and surface transport. The joint venture allows Russia to expand GLONASS operational satellites to 24 by the end of 2010.

2. GPS versus A-GPS review

Handset-Based Technologies GPS handset devices are based on embedded GPS engines/antennas that allow them to determine a user's location. The satellite-based systems provide an accuracy of less than 20 meters, compared to other network-based solutions. Since the receiver can track signals only in the line-of-sight, they are not useful in areas where the signal cannot be accessible such as in apartments, offices, etc. GPS chips in handset-based receivers are powered by the same source (batteries) that powers the handset. And with the receiver taking time to get a fix on the location, consumption of power increases proportionally. Overall, a handset with GPS chipset provides at least 5%-10% less battery power for talking.

In a bid to avoid such a power drain, A-GPS was developed. There are two flavors of A-GPS developed, network-based that use SUPL or similar protocols, and network independent that use pre-calculated orbital data based on mathematical formula and downloaded seeds.

Other advantages of A-GPS technology are related to shorter wait time and greater sensitivity. TTFF is reduced because the receiver no longer has the task of decoding the navigation data bits, a task that takes tens of seconds. Instead, the assistance server provides the satellite orbit and clock parameter values to the receiver.

Increased receiver sensitivity is directly related to the TTFF and the number of frequency bins which must be searched to find a satellite signal. Because the receiver has fewer frequency bins to search in an AGPS architecture, it can dwell in each bin for longer periods of time. This additional dwell time increases the sensitivity of the receiver, so that it can use signal strengths below the conventional thresholds to make range measurements.

Additionally A-GPS is mandated by US and European authorities as a way to implement E911 and E112 emergency services.

The A-GPS system used for E911/E112 implementation utilizes the mobile phone network to assist the GPS receiver in the mobile phone to overcome the problems associated with TTFF and the low signal levels that are encountered under some situations.

For A-GPS, the network provides the Ephemeris data to the cell phone GPS receiver and this improves the TTFF. This can be achieved by incorporating a GPS receiver into the base station itself, and as this is sufficiently close in position to the mobile the data received by the base station is sufficiently accurate to be transmitted on to the mobiles. The base station receiver is obviously on all the time, and will be located in a position where it can "see" the satellites.

The information provided can be either the Ephemeris data for visible satellites or, more helpfully the code phase and Doppler ranges over which the mobile has to search, i.e. 'acquisition data'. These ranges can be estimated as the position of the mobile is bounded because it must be within the cell served by the particular base station. This technique is able to improve the TTFF by many orders of magnitude.

Assisted GPS or A-GPS is also used to improve the performance within buildings where the GPS signals are by 20 dB or possibly more. Again by providing information to the GPS receiver in the mobile it is able to better correlate the signal being received from the satellite when the signal is low in strength. Using this technique it is possible to gain considerable increases in sensitivity and

some manufacturers have claimed it is possible to receive signals down to power levels of around -159dBm. The base station supplies the receiver with navigation message bits - 'sensitivity data'.

3. A-GPS based emergency services

3.1. State of E911 emergency service implementations by major NA wireless carriers

A second phase of E 911 service implementation is to allow a wireless or mobile telephone to be located geographically using some form of radiolocation from the cellular network, or by using a Global Positioning System built into the phone itself.

In North America TDMA and GSM networks such as AT&T Wireless Services and T-Mobile use network radiolocation based method, TDOA (Time difference of arrival). CDMA networks use handset-based radiolocation technologies with two major North American carriers, Verizon Wireless and Sprint PCS using A-GPS.

AT&T recently submitted a study with analysis of the existing challenges related to meeting location accuracy requirements in a network based technology solution. AT&T concluded that those challenges can be met through the deployment of A-GPS devices. In its proposal to FCC AT&T outlined a plan to improve E911 accuracy via introduction of A-GPS enabled phones and running an upgrade of the mobile network to support A-GPS.

3.2. Evolution of E112 emergency service in Europe & Japan

E112 emergency service in Europe is similar in functionality with NA E911 service. It was adopted in Europe since July 2003. The service implementation has not progressed as expected though with some EU countries still not fully implementing this service from mobile phones. In April of 2008 EU Telecom Commission update the Commission indicated that Caller location information for 112 calls from mobile phones is still not available in four EU countries: Italy, Lithuania, the Netherlands and Slovakia.

E112 in Japan is more advanced than in Europe with all three large wireless operators (DoCoMo, KDDI and Softbank) currently supplying A-GPS enabled handsets.