RTT TECHNOLOGY TOPIC
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GNSS2, GPS3, LTE

In a little over six weeks' time, two Galileo satellites will join two satellites already in orbit, part of a $20 billion European project to build a 30 satellite Medium Earth Orbit **G**lobal **N**avigation **S**atellite **S**ystem (GNSS) constellation.

This follows the launch of two satellites in April with three more planned later this year for the Chinese Compass system, part of a network of thirty five satellites, five in geostationary orbit, three in inclined geostationary orbit and twenty seven in **M**edium **E**arth **O**rbit scheduled to be fully operational by 2020.

This means that there will be four global satellite navigation systems, European Galileo, US GPS, the Russian Glonass system and China's Compass, also known as Beidou (named after the Big Bear constellation). India plans to implement its own regional system.

To date the combination of military requirements and a perceived need to maintain investment in projects that might help economic recovery have helped to ring fence GNSS funding so it is reasonable to expect that deployment and upgrade plans will continue to progress. Given that many smart phone applications realize value from GPS and or Glonass based location capabilities it seems sensible to review the potential impact that these new and or evolved systems might have on LTE handset and network value.

Table 1 summarizes the four options.

Table 1 Global navigation satellite systems

System	GPS	Glonass	Compass	Galileo
Country of origin	US	Russia	China	Europe
Orbital height	20,180 km(12540 miles)	19130 km (11890 miles)	21,150 km (13130 miles)	23,220 km (14,430 miles)
Number of satellites	24 now extended to 27	24	5 geostationary 30 MEO	30 in three orbital planes

These systems are generically described as GNSS2 or in the case of GPS, GPS 3.

GNSS2 and GPS3 systems provide optional civilian access to additional frequencies to improve location accuracy. The newer generation satellites, including GPS orbit replacements are also higher power. While this will improve the link budget, it will still be challenging to produce RF front ends in user devices. If the additional location capabilities are supported it will also be necessary to implement dual receiver or multi band GNSS receiver front ends.

The additional frequency bands and wider application base implied in second generation GNSS system specifications also means that interference from terrestrial networks including LTE networks and LTE user devices will become more complex to manage.

This is therefore a good time to review the potential benefits of supporting GNSS2 dual band or multi band receivers in LTE smart phones and the related technical challenges both in terms of user device design and network implementation.

Table 2 GNSS Frequency Bands

GPS					
	L1	L2C	L3	L4	L5
Application	Coarse acquisition	Ionospheric error correction	Nuclear detonation detection	Not used	Safety of Life
Channel bandwidth MHz	20	20			24
Centre Frequency MHz	1575.42	1227.6	1381.05	1379.913	1176.45
Glonass	Satellites transmit on individual channels between 1598.06 MHz to 1605.38 MHz and 1615.5 MHz	Satellites transmit on individual channels between 1240 MHz and 1260 MHz,			
Compass	1561.10 1589.74	1207.14 1268.52			
Galileo	1559- 1592 MHz	1176.45 1207.40 1227 1278.75			

Why bother with dual band?

A new signal L1C will be transmitted on the L1 channel from GPS 3 satellites from 2014 to provide inter-operability between GPS and other GNSS systems.

The decision as to whether to support the additional L2C ionospheric error correction channel depends on taking a view on the potential LTE applications. These dual band networks allow user devices to resolve a position anywhere in the world within 45 cm. Agricultural machine to machine applications and automotive LTE might be vertical markets that could be enabled by sub 50 cm positioning capabilities together with other related and unrelated market opportunities.

Why bother with multi band?

Adding in the ‘safety of life’ L5 channel provides access to a signal with additional processing gain (across 24 rather than 20 MHz of channel bandwidth). This translates into a 3 dB link budget improvement. A combination of rubidium and caesium atomic clocks on present and future satellites provides additional positioning accuracy. Safety-of-Life Service is intended for transport applications, particularly aviation where lives could be endangered if the performance of the navigation system is deliberately or accidentally degraded. As with ionospheric error calculation, a decision to support multiband including the L5 channel depends on taking a view of the potential size and value of markets that might benefit from this capability. Automotive LTE is the most likely candidate but other transport systems (trains and boats and planes) designated as safety critical could be target markets.

The future commercial positioning of the Compass system is still uncertain but it would be reasonable to assume that China LTE operators might want to add Compass positioning capability into future LTE handsets. Recent **press coverage of fishermen** provided with subsidised Compass receivers configured to receive SMS suggests that a broad range of potential market applications could be developed. Vendors selling into the China market would then need to support the Compass band plan.

Conversely China based vendors servicing the global market might be expected to include Compass functionality as a competitive differentiator.

Implications for LTE handset front end design

Baseband receiver modules are already available supporting GPS and Glonass and offer future Galileo signal compatibility as a firmware upgrade**.** This **U-blox device** is one example.

All of the GNSS systems use code correlation, similar to the 3G physical layer. This eases multi system baseband integration. The difficult bit is getting the RF front end to work and deciding which bands to support.

Most design teams know now how to manage the more obviously embarrassing intermodulation products including the susceptibility of L1 receive at 1575.42 MHz to GSM and LTE 1800 MHZ third order products and (in the US) the second harmonic of LTE Band 13 at 787.76 MHz. Given that 1575.42 MHz is the frequency that will be common to multiple GNSS systems this remains a major design and implementation consideration. This **Infineon data sheet** highlights the third order intercept, 1 dB compression point, LNA noise figure and gain budget and typical filter implementation both for existing GPS and future GNSS systems and the generic challenge of recovering signals at around -130 dBM in the presence of locally generated transmit power at 23 or 24 dBm.

The addition of other receive frequencies complicates this design process and requires additional front end real estate including antennas and filters within an already crowded space.

This would similarly imply that care will need to be taken that LTE transceivers do not desensitize GNSS stand-alone devices using these bands. The assumption could be that anything around 1.2 GHZ is sufficiently distant from existing GSM/HSPA and LTE bands to be unproblematic but every additional band increases the chance of unwanted intermodulation and front end compression. GNSS receivers capable of handling all four GNSS standards are more likely to be susceptible to interference. The recent experience with Light Squared highlights some of the risks of either LTE handset or base station TX paths compromising physically proximate GNSS receivers.

On the plus side, GNSS systems both old and new provide a wide choice of synchronization signals. The satellites being launched today have highly accurate rubidium and hydrogen maser frequency standards. This might at least ease some of the clocking problems that are likely to arise in wide area TDD LTE systems.

Summary

Hundreds of billions of dollars have been invested and are being invested in Global Navigation Satellite Systems.

GNSS systems are integral to almost every modern warfare and weapons system but the evolution of GPS receivers initially as a stand-alone consumer device and more recently as a smart phone application enabler shows that an acceptable and hopefully sustainable balance can be achieved between military interest and consumer benefit.

GPS 3 satellites and other GNSS satellites presently being launched offer higher power (an improved link budget) and access to additional frequency bands that enable new applications and markets to be developed. Each constellation provides optimum coverage over the land mass of regional economic interest. For example Galileo provides enhanced coverage over northern latitudes.

Integrating enhanced multi system GNSS functionality into future LTE smart phone platform and LTE networks would allow present location and positioning based applications to be developed in a number of new ways almost all of which could potentially realize additional subscriber value.

Network co-existence issues need to be rigorously qualified but it is the noise and isolation budgets within LTE user devices that will need to be particularly carefully considered. Adding additional highly sensitive receive paths to an LTE handset already supporting multiple TX and RX bands some of which will have similar channel bandwidths to GNSS will be a non-trivial design task and implies a need to reexamine how noise and interference is characterized and managed in future LTE handset design - a subject to which we will return in future technology topics.

Satellite systems are one of many topics addressed in RTT's latest book '**Making Telecoms Work- from technical innovation to commercial success'** published In January 2012 and available from the **RTT book shop.**

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