esa

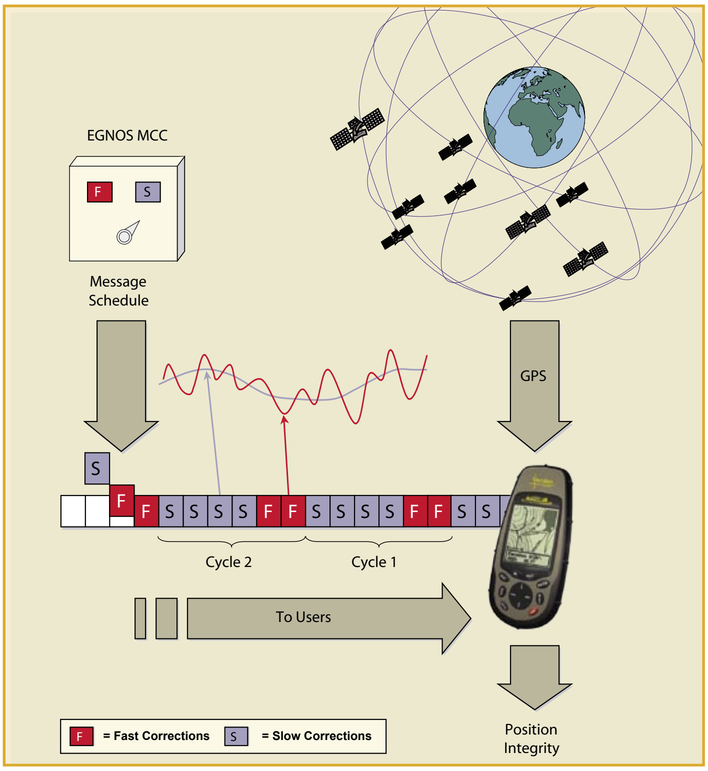
EGNOS FACT SHEET

12: THE EGNOS SIGNAL EXPLAINED

The ESTB has been broadcasting a pre-operational EGNOS signal since February 2000. When operational in 2004, EGNOS will deliver improved levels of accuracy, integrity and availability to European aviation, maritime and land users. This article outlines the differences between Differential GPS (DGPS) and EGNOS, describes the EGNOS signal structure, discusses how an EGNOS/GPS receiver processes the signal, and concludes by looking at the benefits of the EGNOS signal.

Why is the EGNOS signal different from DGPS?

DGPS was developed to enhance GPS accuracy. Conceptually, range errors estimated by a static reference station are broadcast to users where they are applied as corrections. The accuracy may be as good as 1m, but it is limited by the user/reference station distance, the need for common-view satellites, and receiver algorithms. Multi-reference station solutions can overcome some of these problems. Users also have to purchase an additional receiver to use the corrections.



EGNOS Data Processing

EGNOS is being been developed to enhance GPS accuracy, availability and integrity (quality of service) over and beyond the European region. 34 Reference and Integrity Monitoring Stations (RIMS) around Europe monitor GPS and relay their data to four Master Control Centres (MCCs). These generate a single set of integrity data and Wide Area Differential (WAD) GPS corrections for Europe. The latter comprise terms to correct for each satellite's clock and ephemeris errors as well as errors due to the ionosphere. The integrity data and WAD corrections are modulated on a GPS look-alike signal and broadcast to users from three geostationary satellites. The resulting performance (close to 1m across Europe) is independent of user/reference station distance. Users will benefit from enhanced availability due to the three additional ranges, as well as not needing to purchase a separate receiver to use the corrections. The EGNOS message structure is different to DGPS because it needs to accommodate both the WAD corrections and integrity information that provides a 6-second time-to-alarm.

What information does EGNOS broadcast?

EGNOS uses the same frequency (L1 1575.42 MHz)) and ranging codes as GPS, but has a different data message format. Sixteen different message types have so far been defined to broadcast integrity data and WAD corrections. The message schedule follows a 6-second duty cycle. This is structured both to prioritise the 6-second integrity time-to-alarm and to minimise the time for EGNOS initialisation.

Integrity is provided at two levels: coarse *use/don't use* for all satellites in view of the service volume (including the GEOs); and two parameters – σ^2_{UDRE} and σ^2_{UIVE} – that are statistical estimates of the satellite and atmospheric errors remaining after applying the WAD corrections. These are used to compute a certified error bound for the position solution in an integrity assessment.

Fast and slow WAD corrections model the temporal decorrelation of the different error sources. The fast corrections model rapidly changing error sources include satellite clock errors. The slow corrections model more slowly changing error sources including long-term satellite clock drift and ephemeris errors. Ionospheric delays are provided at pre-defined grid points.

ESA Navigation Web Page:
www.esa.int/navigation

ESA EGNOS Web Page:
www.esa.int/EGNOS/

ESA EGNOS for Professionals Web Page:
www.esa.int/navigation/egnos-pro

ESA ESTB Web Page:
www.esa.int/ESTB

ESA EGNOS Help Desk:
EGNOS@esa.int

ESA Galileo Web Page:
www.esa.int/Galileo

EC Galileo Web Page:
http://europa.eu.int/comm/dgs/energy_transport/galileo/

FAA GPS Product Team:
http://gps.faa.gov/

Galileo Joint Undertaking:
www.galileoju.com

Type	Comment	Type	Comment
0	Don't use this SBAS signal for safety applications	17	GEO satellite almanacs
1	PRN Mask assignments	18	Ionospheric grid point masks
2 - 5	Fast corrections	24	Mixed fast/slow error corrections
6	Integrity information	25	Slow satellite error correcions
7	Fast correction degradation factor	26	Ionospheric delay corrections
9	GEO navigation message	27	SBAS service message
10	Degradation parameters	63	Null message
12	SBAS Network Time/UTC offsets		

EGNOS Data Processing

How does a user receiver process these data messages?

Processing the corrections is quite complex both because the messages have been designed to minimise the bandwidth requirements and because they need to account for updated GPS navigation information.
The receiver estimates corrections for satellite clock and ephemeris errors using the fast and slow satellite data messages. It has to account for both range-rate effects between successive fast corrections and performance degradation if a message is missed. The σ^2_{UDRE} term characterises statistically the residual range errors after having applied the fast and slow clock and ephemeris corrections.
The receiver predicts ionospheric delays for each range in three steps: it estimates where the satellite – receiver range pierces the ionospheric grid; the vertical delay at the pierce point is then interpolated from the surrounding grid points; and finally this is applied to the range measurement. The σ^2_{UDRE} term is applied to the range vector where it characterises statistically the residual ionospheric errors. Tropospheric errors may be mitigated using a simple model related to the receiver's position and the day number in the year.

EGNOS receivers compute a certified error bound for the position solution based on data broadcast by the GEO satellites, the user/satellite geometry, and the probability of integrity non-detection. This was described in the September 2001 issue of ESTB News.

So what are the benefits of the EGNOS signal?

The EGNOS signal is compliant with international standards for satellite based augmentation systems. As such, EGNOS will be interoperable with similar systems in the US (WAAS), Japan (MSAS), Canada (CWAS), and India, contributing to a true worldwide seamless navigation service.

The EGNOS signal design is based on GPS. Consequently, a GPS receiver with minimal hardware modifications can track the EGNOS signal. This has two benefits: EGNOS provides additional range measurements that enhance availability; and EGNOS corrections can be used without purchasing a separate receiver.

Finally, EGNOS provides both enhanced accuracy and integrity (quality of service). The pre-operational EGNOS test bed is already delivering one-metre accuracy (similar to DGPS) that is independent of user/reference station distance. The integrity will give users additional confidence in the total system, alerting them within six seconds when something goes wrong.