EGNOS FACT SHEET

3: INTEGRITY EXPLAINED

EGNOS will provide a European-wide, standardised and quality-assured augmentation service suitable for a diverse range of applications. Integrity is a key quality and safety parameter, alerting users when the system exceeds tolerance limits.

EGNOS will broadcast wide-area differential corrections to improve accuracy, and alert users within six seconds if something goes wrong (integrity).

Integrity can be considered both in terms of confidence and risk - if one is 99% confident that the system is performing correctly, there is also a 1% risk that it is performing incorrectly. A confidence-based definition of integrity is given in the International Civil Aviation Organisation's GNSS Standards And Recommended Practices (SARPS):

> *Integrity is a measure of the trust which can be placed in the correctness of the information supplied by the total system. Integrity includes the ability of a system to provide timely and valid warnings to users.*

An alternative risk-based definition is:

> *Integrity risk is the probability of providing a signal that is out of tolerance without warning the user in a given period of time.*

Integrity requirements are application-specific and generally specified in terms of three parameters with values specified by governing institutions.

Integrity is generally specified in terms of an alert limit, a time-to-alarm and a probability of non-integrity detection. These are all present, explicitly or implicitly, in the previous integrity definitions.

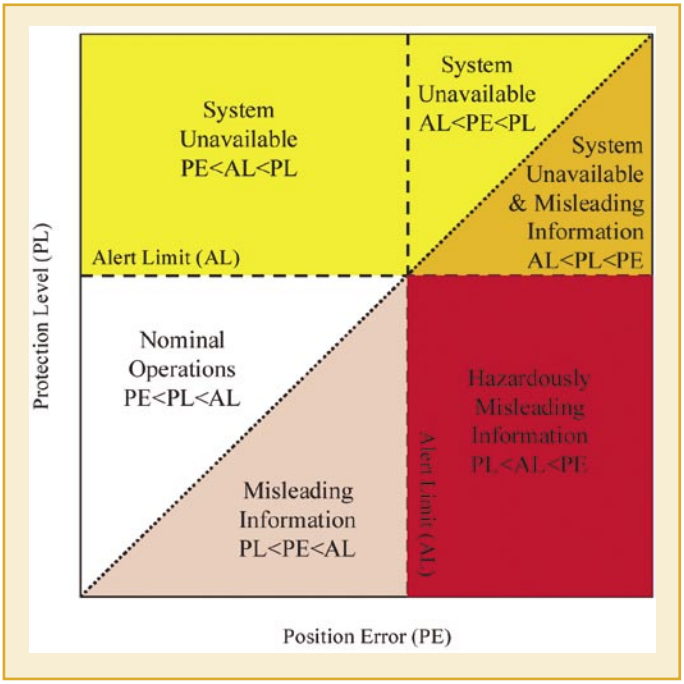
The alarm limit or alert limit (AL) for a measured parameter is the error tolerance not to be exceeded without issuing an alert to the user. It represents the largest error that results in a safe operation.

The time-to-alarm or time-to-alert is the maximum permitted duration between the onset of a failure and an alert being issued by the user's receiver.

The probability of non-integrity detection quantifies risk. It represents the probability that an error exceeds the AL without the user being informed within the time to alert.

The values assigned to these three parameters depend on the specific application and intended operation, and are generally determined by institutions (e.g. the International Civil Aviation Organisation or the International Maritime Organisation).

EGNOS receivers estimate protection levels based on data broadcast by the GEO satellites, the user/satellite geometry, and the probability of integrity non-detection.



The Solar-Terrestial Environment

EGNOS broadcasts corrections for errors in the GPS satellite clock and ephemeris data, as well as corrections for the ionospheric delay experienced by a single frequency user. It also broadcasts parameters that describe the residual range errors after application of both the clock and ephemeris corrections (the User Differential Range Error - UDRE) and the ionospheric corrections (Grid Ionospheric Vertical Error - GIVE).

The receiver combines satellite/user geometry information with EGNOS-corrected pseudo-ranges and internal estimates of the tropospheric delay to compute the user position. Ideally, the user wants the difference between the computed position and the true position, the true position error (PE), to be less than the AL. However, the true position is not known, and so the PE cannot be determined and an alternative approach is required.

In fact, the receiver continuously estimates a predicted position error, known as the protection level (PL), for each position solution. The PL is estimated based on the UDRE and GIVE parameters and other local error-bound estimates. It is scaled for compatibility with the probability of non-integrity detection so that the PL should always be larger than PE.

Integrity assessments are based on PL and AL. Users will

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

benefit from enhanced quality provided by the EGNOS integrity signal.

A new PL is estimated for each computed position solution. It is compared with the required AL, and an integrity alert triggered if PL>AL.

The relationship between PL, PE, AL and integrity is shown on the opposite page. There is an underlying assumption when assessing integrity that PL>PE, and this is the “safe” zone to the left of the leading diagonal. In the nominal operation case, PL<AL and the system is available. If the PL>AL for a particular operation, then the EGNOS integrity cannot support the operation, and the system is unavailable.

There is also an “unsafe” zone to the right of the leading diagonal where PL<PE and the integrity assessment provides misleading information. In theory, the case at the bottom left corner of the diagram (PL<PE<AL) is also “safe” because the AL has not been exceeded, but it should be noted that EGNOS also protects against these out of tolerance situations.

EGNOS has been designed to meet aviation’s demanding performance requirements including a 6 second time to alert. Consequently, all EGNOS users will benefit from the enhanced quality and safety provided by the EGNOS integrity signal.