EGNOS Open Service Guidelines for receiver manufacturers

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BIOGRAPHIES

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Matthew Powe received his MEng in Engineering Science from Oxford University in 1994. He has worked as a navigation systems scientist at DERA and DSTL (part of the UK Ministry Of Defence) researching GNSS integrity, interference and signal design. As a Systems Engineer at Rockwell Collins (UK and France) he worked on the development of geolocation and radar systems. He is currently a Radionavigation Systems and Signals Engineer at the European Space Agency and is involved in Galileo system verification..

Ankit Raj Mathur obtained his MSc in Aerospace Communication Systems from ENST Telecom Paris / ISAE Supaero (France). Since 2004, he is working as a System Engineer in the ESA EGNOS Project Office in Toulouse, France. He has been involved in many projects related to EGNOS including system engineering, user performance, SISNeT and EMS.

Felix Toran biography holds a Ph.D. in Electrical Engineering by the University of Valencia (Spain), with “Doctor Europeus” mention. Since 2000, he works at the European Space Agency (ESA) as System Engineer. He is currently in charge of EGNOS Mission and Performance aspects at the EGNOS Project Office in Toulouse (France). He has been the recipient of several international awards, has co-authored over 110 technical publications and holds one patent..

Didier Flament is graduated from Ecole Centrale de Lille in Electrical Engineering. He received his PhD in Automatics in 1986. From 1987 to 1995, he has been System Engineer in charge of GNSS design and performance studies at ONERA (French Aerospace laboratory). From 1995 to 2007, he has been leading the System Engineering department and associated activities within EGNOS Prime Industry (THALES Alenia Space). He was also involved in Galileo design activities. Between 2008 to date, he is in charge of all system engineering activities at ESA EGNOS Project Office to develop and qualify new EGNOS system releases in the frame of the EC Delegation Agreement. He is also in charge of managing industrial contracts related to SBAS next generation definition which are implemented in the frame of ESA GNSS Evolution Program. He has 20 years of experience in GNSS System Design and Development, mainly for Aviation applications.

Eric Chatre graduated as an electronics engineer in 1992 from the ENAC (Ecole Nationale de l'Aviation Civile), Toulouse, France. From 1994 to 2001, he worked with the French Air Navigation Service Provider in Toulouse on implementation of satellite navigation in civil aviation. He then successively worked for the Galileo Joint Undertaking (GJU) and the GNSS Supervisory Authority (GSA) in charge of standardisation and certification matters for the European GNSS systems EGNOS and Galileo. He is now part of the European GNSS Programme Management Team of the European Commission, responsible for the European GNSS mission definition and implementation, system performance, user equipment, standardisation and safety certification. Eric Chatre is the European co-chair of the bilateral EU-US working group dealing with evolutions of GNSS systems.

ABSTRACT

Satellite Based Augmentation Systems (SBAS) consist of a network of reference stations distributed over a wide area that monitor the status of GPS and other Global Navigation Satellite Systems (GNSS). These reference stations send the data collected on the status of GPS to a master station where differential corrections and integrity are computed for every monitored satellite. Once these are computed a ground Earth station uplinks them to geostationary satellites that broadcast this information to the end user. Examples of SBAS systems are the European Geostationary Navigation Overlay Service (EGNOS), the U.S. Wide Area Augmentation System (WAAS), the Japanese Multifunctional Transport Satellite Augmentation System (MSAS), and the Indian GPS and GEO Augmented Navigation (GAGAN).

In the recent years SBAS systems have been topic of much study for Safety of Life (SoL) applications. User communities such as civil aviation have extensively used these kinds of systems relying on the accuracy benefits they provide but above all on the use of integrity. SBAS-enabled GNSS receivers for these applications have been designed and manufactured according to the recognized standards [1]. The standards have been developed by the civil aviation community and therefore solely address the use of SBAS for this type of safety-critical operations. This has provided receiver manufacturers with a clear view on how to design their products for SBAS SoL service. However, no similar guideline exist for less stringent applications that could strongly benefit from SBAS but do not require implementation of the very conservative algorithms elaborated for aviation.

Focusing on the particular case of EGNOS, besides the SoL service (declared operational on March 2011), the Open Service (OS) has been readily available and free to the public since October 2009. Since then most manufacturers have partially followed [1] for the design of their products. This has lead to several different implementations that in some cases may not be optimal. The objective of this paper is to present a work plan to produce set of clear guidelines for GNSS receiver manufacturers on how to properly make use of the EGNOS broadcast messages to improve their positioning accuracy measurements for Open Service. This topic was discussed in the context of the SBAS Interoperability Working Group (IWG) and the interest for such guidelines was confirmed by other SBAS providers.

INTRODUCTION

As previously said the objective of this work is to produce a set of guidelines for GNSS receiver manufacturers on how to best use SBAS broadcasted parameters for applications not requiring stringent safety levels. A first application for such guidelines is to make recommendations for the implementation of receiver algorithms for the EGNOS Open Service users. These tasks have been performed by the ESA European Navigation Laboratory (ENL) in coordination with the European Commission. The steps followed to produce these guidelines have been:

- Study of the SoL standards, previous literature and current implementations on EGNOS OS enabled receivers available on the market. This study provides a set of candidate implementations and algorithms for the EGNOS OS receiver guidelines.

- Development and testing of a laboratory prototype of an EGNOS Open Service receiver. The laboratory prototype is a flexible tool that contains the candidate implementations and algorithms previously identified. The prototype receiver post-processes observations from Receiver Independent Exchange Format (RINEX) files and EGNOS message files from the EGNOS Message Server (EMS) format [2]. This architecture allows testing the EGNOS OS algorithms to be receiver independent.

- Perform a test campaign using the prototype receiver, benchmarking the candidate implementations and algorithms in terms of accuracy, availability, algorithmic complexity, and other indicators. This test campaign has been performed using observables taken from several GNSS receivers from different European locations.

The EGNOS OS laboratory prototype works in post-processing mode and at observable level: enabling results to be obtained for the same position and date using different candidate algorithms. This has permitted the discarding of some candidate algorithms in the light of the results.

This work has confirmed that the existing SBAS standards for GNSS receiver design are not fully applicable to Open Service receivers.

The paper is structured as follows. First of all, an overview of the EGNOS system and the EGNOS OS in particular are presented. A study of current standards and implementations follows. Then, the candidate improvements derived from the previous study for OS are detailed. A section devoted to the results obtained using these candidate algorithms in the prototype receiver follows. To finalize, some conclusions based on the results obtained so far and the way forward are also presented.

EGNOS SYSTEM OVERVIEW AND EGNOS OPEN SERVICE

This section describes the EGNOS system and gives performance figures for the EGNOS Open Service.

As any other SBAS, EGNOS is composed of a network of ground stations and facilities and a space segment. As depicted in Figure 1 the EGNOS ground segment consists of:

- A network of 37 reference stations called Ranging Integrity Monitoring Stations (RIMS). The RIMS collect the raw measurements from the GPS satellites and send it to the Mission Control Centers (MCC). Figure 1 shows a map of the current and future RIMS sites.

- Four Mission Control Centers (MCC) that contain the Central Processing Facility (CPF) in charge of processing the raw data from the RIMS and generating the differential corrections and integrity data.

- Six Navigation Land Earth Stations (NLES) that uplink the data generated by the MCC to the geostationary satellites.

- A communication network linking these elements, the EGNOS Wide Area Network (EWAN).

- The Service Operations Unit (SOU) and the Service Provision Unit (SPU) to support system operations and service provision.

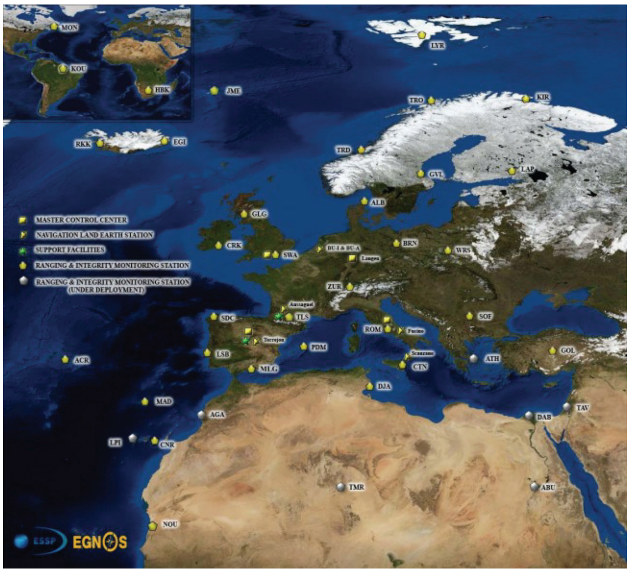

Figure 1 EGNOS ground segment.

The EGNOS data is broadcasted to the end users using three geostationary satellites. These satellites are listed in Table 1 **EGNOS Geostationary satellites.**

(at the time of writing).

Table 1 EGNOS Geostationary satellites.

Satellite Name	PRN Number	Orbital Slot	Status
INMARSAT AOR-E	120	15.5 W	Operational
ARTEMIS	124	21.5 W	Operational
INMARSAT IOR-W	126	25.0 E	Test

EGNOS provides differential corrections and integrity to GPS signals over Europe. EGNOS services to end users comprise: the Open Service (OS), which this paper applies to and is freely available; the Safety of Life service (SoL), that provides corrections and integrity for user communities needing safety of life performances (for example, civil aviation); and the Commercial Data Distribution service (CDDS) for commercial and professional user requiring enhanced performance.

The EGNOS GEO satellites transmit signals in the L1 (1575.42 MHz) band. The broadcast signal is a combination of a 1023-bit PRN navigation code of the GPS family and a 250 bits per second navigation data message carrying the corrections and integrity data elaborated by the EGNOS ground segment.

The EGNOS raw data rate is 250 bits per second. The data is convolutionally encoded with a Forward Error Correction (FEC) thus providing a symbol rate of 500 symbols per second. Every second a 250 bit message is available to the user with the following format:

- 8 bit preamble distributed over three successive messages (24 bit in total). The 24 bit preamble will be made up of the sequence of bits 01010011 10011010 11000110. The start of every other 24-bit preamble will be synchronous with a 6-second GPS subframe epoch.

- 6 bit message type identifier that unequivocally marks the message to one particular type of message (see Table 2).

- 212 bit data field that contains the actual EGNOS corrections.

- 24 bit CRC parity field that provides protection against burst and random errors.

The messages are interrelated using Issue of Data (IOD) parameters present within the data bit field. EGNOS corrections can be roughly divided in three groups:

- Fast corrections: used to correct for the quickly changing orbit and clock errors of the GPS satellites.

- Slow corrections: used to correct for the slow changing orbit and clock errors of the GPS satellites.

- Ionospheric corrections: used to correct for the slowly changing ionospheric delays.

The EGNOS corrections are broadcasted using a set of predefined messages. The SBAS standards include provisions for a total of 64 message types. However, only 20 of the messages are defined as of today and 18 are used by EGNOS. The EGNOS message types and their purpose is presented in Table 2.

Table 2 EGNOS Message Types

Message Type	Contents
0	Don't use for safety applications (SBAS test mode)
1	PRN Mask

2 to 5	Fast corrections
6	Integrity information
7	Fast correction degradation factor
9	GEO ranging function parameters
10	Degradation Parameters
12	SBAS Network Time/UTC offset parameters
17	GEO satellite almanacs
18	Ionospheric grid point masks
24	Mixed fast corrections/long term satellite error corrections
25	Long term satellite error corrections
26	Ionospheric delay corrections
27	EGNOS Service Message
63	Null Message

The EGNOS OS provides improved positioning accuracy compared to GPS standalone. This is achieved using a set of differential corrections freely available to all receivers compatible with the EGNOS signal and data. The EGNOS OS has been available to the public since October 2009.

The EGNOS OS performance requirements in terms of positioning accuracy is provided in Table 3 [3].

Table 3 EGNOS OS minimum position accuracy.

Accuracy	Definition
3 m horizontal	Corresponds to a 95% confidence bound of the bi-dimensional position error in the horizontal local plane for the worst user location.
4 m vertical	Corresponds to a 95% confidence bound of the unidimensional unsigned position error in the local vertical axis for the worst user location.

It must be noted that depending on the receiver implementation and the environment the actual performance of a receiver using EGNOS OS may vary.

An EGNOS receiver designed to support the EGNOS OS is expected to [3]: use the geostationary satellite ranging function if available, decode and apply satellite clock corrections, decode and apply satellite ephemeris corrections, decode and apply Ionospheric corrections, consider major warnings broadcast through the EGNOS messages, and use the time-offset parameters between different system times if the receiver is intended for time determination.

Translating these requirements to particular EGNOS messages an EGNOS OS receiver designed to support EGNOS OS should process the following messages: MT1, MT2-MT5, MT6, MT24, MT25, MT18, and MT26.

The GEO ranging functionality is currently not implemented in EGNOS. If this functionality is enabled in the future it will also require the processing of MT9 and MT17.

STUDY OF CURRENT IMPLEMENTATIONS

SBAS standards [1] were originally created to support civil aviation applications. As a consequence the receiver processing of the SBAS messages have also been developed with civil aviation applications in mind. This translates in a large set of requirements and implementations needed to ensure integrity of the position provided by the SBAS receivers. The standards contain several functional and operational equipment classes. For each of them the SBAS messages that are applicable and how they are processed varies.

Although these standards have proven to be extremely valuable for the civil aviation community their direct applicability to other areas is unclear. At the moment of writing there are no SBAS standards targeting OS and non-avitation applications.

The most common approach followed by EGNOS OS receiver manufacturers has been to apply or partially apply [1] when designing their products. According to [3] “The system performance shall be met with any receiver that implements the MOPS DO-229 navigation weighted solution and message processing (equivalent to Class 3 GPS/WAAS receiver requirements) but which does not take into consideration the protection level criteria to declare that a solution is available”. However, operational Class 3 applies the most demanding of the aviation operations: oceanic and domestic en route, terminal, approach (LNAV, LNAV/VNAV, LP, LPV), and departure operation. No functional class is mentioned but without loss of generality Class beta will be assumed throughout this paper.

It is understood that this statement is just a means to ensure that receivers meet the EGNOS OS performance previously identified while leaving the door open for other implementations knowing that the performance in those cases may be different.

Totally on the opposite side operational Class 1 has the least demanding requirements. For Class 1 equipment some of the corrections may be optional under certain circumstances although it is encouraged to use them. Some manufacturers design their receivers for EGNOS OS according to this class. While this may be regarded as a proper choice for EGNOS OS it may in fact provide poor performance if not correctly tailored.

In general what it is important to note is that these classes and consequently the implementations based on them are just a collection of choices among the corrections used and how they are used. It is clear that these classes originally derived for civil aviation applications are not directly applicable to non-Safety of Life applications and other recommendations must be found.

CANDIDATE IMPROVEMENTS

Instead of starting from scratch, the current SBAS standards [2] have been used as a starting point for this work. Four areas of study have been identified where improvements may be made specifically tailored for EGNOS OS:

- Proper combination of corrections.
- Derivation of new timeout values.
- Mixing of corrected and uncorrected satellites.
- Ionospheric interpolation.

Proper combination of corrections

As previously said EGNOS provides corrections in the form of Fast Corrections (FC), Slow Corrections (SC) and Ionospheric Corrections (IC). According to the SBAS standards [1] different combinations are possible depending on the equipment class. For example, it is possible to use EGNOS FC and SC and use GPS IC instead of EGNOS IC.

It is expected that the best performance will be obtained when using all EGNOS corrections. However, when not using a full set of corrections (FC+SC+IC) the chosen combination may provide a poor performance. In the next section several combinations will be presented and benchmarked against each other.

Selection of timeout intervals

A set of timeout intervals is defined in [1] for the corrections previously identified. The beginning of the timeout interval is the end of the reception of a message. The timeout intervals are a function of the navigation mode. After this interval the corrections should not be used. However, it is important to note that these navigation modes as well as the timeout intervals have been defined for use in aviation equipment. Therefore, they may not be suitable for all applications.

Moreover, even if [1] specifically states that the corrections should not be used after the timeout period, it does not clearly state what should be the behavior of a receiver in all situations. Depending on the correction that reaches a time-out several options are possible as will be explained later. As a result manufacturers of EGNOS receivers have come up with different implementations. For example, some non-avition manufacturers decide to setup a range of timeout intervals in their receivers while other implementations use the values defined in [1].

Some receivers allow selecting between the “en-route” and “precision approach” intervals defined in [1]. Others even allow using other time-out values not present in [1]. More importantly, the time-out values give the maximum time the EGNOS corrections can be used since the last one was received, and while some manufacturers chose to use this period until the very end others drop the corrections earlier than the time-out has been completed. Both approaches are allowed in [1]. However, for the EGNOS OS case it is reasonable to extend the time-out values as much as possible, i.e. increase EGNOS OS solution availability without impacting accuracy. In the next section a preliminary study on the extension of the time-outs beyond the ones described in [1] is presented.

It is important to understand that the whole purpose of the timeout intervals is to avoid using an old correction message that contains outdated information and may degrade the position solution. Taking this into account different applications may use different values for the timeouts.

It should be noted that prior to the time-out the corrections can be interpolated based on an estimated RRC (depending on the degradation factor). Even more important than the value of the timeouts is the behavior of the receiver once the timeout has been reached and the EGNOS correction is discarded. Depending on the correction several possibilities arise:

- Use GPS own corrections (if applicable).
- Fall back to a GPS only solution.
- Stop providing position altogether.

Again, it is strongly recommended that the manufacturers of EGNOS OS receivers decide on the behavior of their receivers in these situations depending on the application that these are intended for. In general, the less safety critical the application is the less stringent should be the behavior of the receiver. As an example, the case of an EGNOS OS receiver intended for car navigation (turn-by-turn navigation) the following behavior could be safely assumed:

- Use long timeout values, especially if urban navigation is a target application.
- In case EGNOS ionospheric corrections timeout use GPS ionospheric corrections until new EGNOS corrections are received.
- In case EGNOS Fast or Slow Corrections timeout stop using them but continue using EGNOS ionospheric corrections.
- In case all EGNOS corrections timeout fall back to a GPS only solution.

This example should not be considered as the best possible implementation but just as an example that tries to maximize availability while maintaining a high degree of accuracy (desired performance goals in the target application).

Mixing of corrected and uncorrected satellites

In normal conditions within the coverage area of EGNOS all satellites in view should have EGNOS corrections available. However, for some reasons it may well happen that some satellites do not have corrections available. If the number of satellites in view without corrections is high, the EGNOS PVT solution may be worse than the GPS only one. This may be the case in the very edge of coverage regions where the EGNOS solution will have a much higher dilution of precision (DOP) due to low number of monitored satellites.

In such cases depending on the target application it may be beneficial to:

- Fall back to a GPS only solution.
- Compute a solution mixing corrected and uncorrected satellites.

It is important to note that in general doing this will in fact degrade the position solution and it is not advised. In the case that it is decided to compute a mixed solution it must be considered that EGNOS and GPS timescales differ and an additional unknown corresponding to the time offset between the two should be accounted for in the receiver navigation models. If this is not done the position solution can be degraded by up to 10 to 20 meters [3] thus defeating its original purpose.

Ionospheric interpolation

The way SBAS systems and in particular EGNOS apply ionospheric corrections is very strict. When three or four ionospheric grid points (IGP) surrounding the ionospheric pierce point (IPP) of a given line-of-sight are monitored, the estimated slant delay and model variance due to ionosphere can be obtained. The details on how to perform this computation can be found in Appendix A of [1].

In order to increase availability and potentially also accuracy three proposals will be studied:

- Instead of switching back to GPS only when EGNOS ionospheric corrections cannot be applied according to [1] a mixed solution using EGNOS FC+SC and GPS ionospheric model will be computed.
- Use EGNOS old ionospheric corrections even after the time-out values in [1] have been reached
- According to [4] mixing in the slant delay and model variance computation the values provided by EGNOS, in the monitored IGPs, with the values extrapolated from surrounding EGNOS IGPs, for the non-monitored points can highly increase the availability. Assuming a smooth ionosphere electron distribution, the degree of availability gained can compensate the committed error with respect to a nominal situation.

RESULTS

This section presents preliminary results for the candidate improvements identified in the previous section using a laboratory prototype receiver. The main focus for the receiver is flexibility in the implementation of EGNOS corrections. For this purpose the prototype has been implemented as a software tool that works in post-processing mode at observable level using RINEX data and obtains corrections from the EMS. Figure 2 gives a high level overview of the interfaces of the receiver prototype.

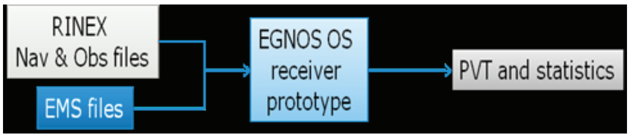

Figure 2 EGNOS OS receiver prototype interfaces overview.

The software receiver prototype can be configured to generate the following outputs:

- GPS LSA (least squares algorithm) PVT.
- GPS + Full EGNOS corrections PVT.
- GPS + Any combination of Fast, Slow and IONO EGNOS corrections PVT.

The reference positioning algorithm is based on the method of weighted least squares. The method is applied on an epoch by epoch basis (snapshot least squares) and is applied to carrier smoothed and corrected pseudorange observations. It must be noted that the selection of this algorithm does not intend to restrict EGNOS OS receivers to solely a snapshot least squares solution, for example a Kalman filter based solution could also be used. However defining a reference positioning algorithm enables correction application and potential accuracy performance to be illustrated.

Moreover, it is important to note that the relevancy of these results is the possibility to compare the relative gain in performance between them. Therefore, the absolute accuracy should be considered only as an indication and the actual performance may vary for other receivers.

The following results give an overview of the accuracy that can be achieved using a subset of the corrections provided by the system, i.e. combination of corrections. Example accuracy results using a 4 days of 1 Hz data are shown in Table 4 using the reference positioning algorithm and for the reduced complexity cases (using only a subset of the EGNOS corrections). The data was collected at European Navigation Laboratory in ESTEC, The Netherlands. The EGNOS corrections used were the ones transmitted by EGNOS PRN 120. To illustrate the improvement resulting from EGNOS corrections, the corresponding GPS-only accuracy is also included.

Table 4 95% Horizontal and Vertical Accuracy (metres) summary for different combinations of corrections

H	V	FC	SC	EIC	GIC
1.18	2.03	✓	✓	✓	×
1.64	2.77	✓	✓	×	✓
2.69	4.40	×	✓	✓	×
1.55	2.41	×	×	✓	×
1.94	3.70	×	×	×	✓

Table 5 Accuracy improvement vs. GPS only case

H	V	FC	SC	EIC	GIC
39%	45%	✓	✓	✓	×
15%	25%	✓	✓	×	✓
-39%	-19%	×	✓	✓	×
20%	35%	×	×	✓	×

As expected the application of a full set of EGNOS corrections (FC+SC+EIC) provides the best possible accuracy. Looking at the relative differences provides other interesting conclusions:

- All the cases with EGNOS corrections (except one) provide better accuracy than GPS only case.
- Applying SC without FC highly degrades the accuracy (worse than GPS only). This confirms that FC and SC are matched and they should always be used jointly.
- Applying EGNOS orbit and clock corrections only (FC+SC) or EGNOS Ionospheric corrections (EIC) separately still provides improved accuracy compared to GPS only. It is also noted that the contribution to the improvement of the EIC is bigger than FC+SC only.

To analyze the impact of age of correction the application of the EGNOS corrections was delayed and the resultant changes in navigation system error statistics were computed. The EGNOS messages broadcasted every second have been stored in the EGNOS Message Server (EMS). Hourly files of corrections were retrieved from the EMS, in order to compute this latency results the application of these corrections was delayed by 60, 300 and 900 seconds, respectively. An example of the implementation of these latency results is presented in Figure 3.

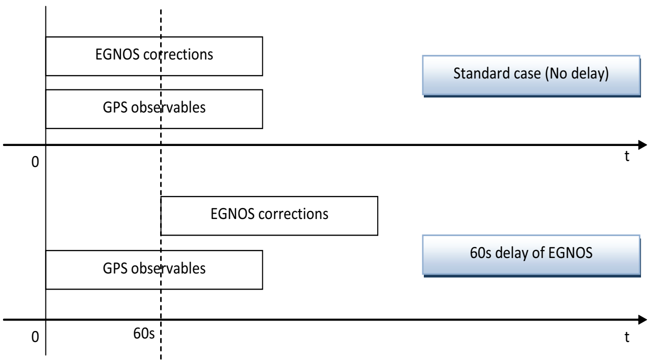

Figure 3 Latency results computation example

In this example data was collected at Turin for one week. The approach taken to analyze the effect of the age of corrections was to continuously delay their application by a fixed latency value (L). As the navigation solution is computed using snapshot least-squares, the approach is similar to fixing correction values at T=0, waiting until T=L and observing the resultant navigation system error. However, in continuously delaying the correction application, a stream of navigation system errors are obtained as if the corrections had been fixed at T=0,1,2,.. and the resultant navigation system errors observed at T=L,L+1,L+2,… .

The changes in horizontal radial and vertical 95 percentiles are given in Table 6. As it can be seen the accuracy starts degrading for the 900 seconds case. The horizontal and vertical 95 percentile values for the GPS only solution was 1.93 m and 3.66 m respectively.

Table 6 Position Accuracy & Correction Latency, Turin 2011 DOY100-106

Latency (s)	0	60	300	900
95% H (m)	1.10	1.05	1.09	1.42
95% V (m)	1.64	1.62	1.70	2.17

Remaining GPS errors are slowly varying (ephemeris and low dynamic clock drift). The ionospheric errors will also be stable during long periods (ICs have the longest time-out values in [1]). Therefore EGNOS corrections remain valid for a very long time except in case of satellite failure or rapid ionospheric changes. In the light of these results it is possible to consider the extension of the time-out values beyond the ones considered in [1].

CONCLUSIONS

EGNOS OS receivers on the market are mainly based on partial implementations of [1]. This has translated into an inconsistent perceived accuracy of the system by the user. In order to provide a common baseline and avoid implementations that may even degrade the final performance, ESA in coordination with the European Commission has put a work plan in place to produce a set of guidelines for GNSS receiver manufacturers on how to implement the EGNOS OS.

This paper has presented this work plan and the first results obtained towards the creation of the guidelines. A flexible software laboratory prototype receiver has been developed to benchmark possible implementations and candidate algorithms. Some examples of what can be expected from the guidelines have also been presented: in general EGNOS corrections provide better accuracy than GPS only but some combinations of corrections will provide the opposite effect; the standard time-out values defined in [1] are too restrictive for OS and it is possible to extend them.

FUTURE WORK

Although the bulk of the work has been done, in order to produce a definitive set of guidelines more data will be analyzed to increase the number of statistics. Moreover, some of the candidate improvements (mixing corrected/uncorrected satellites and ionospheric interpolation) have been identified but more data needs to be studied before producing any conclusions. Not only more data needs to be analyzed but availability figures using standard algorithms in [1] and the candidate algorithms presented need to be obtained. It has been seen that accuracy can be maintained using these candidate algorithms but it is also important to see if these will also improve availability.

REFEREMCES

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