ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

Agenda Item 6 : Aeronautical navigation issues

EXTENDING EGNOS COVERAGE FOR NAVIGATION AND SURVEILLANCE OPERATIONS

(Presented by Sweden)

SUMMARY

The EGNOS Terrestrial Regional Augmentation Network (EGNOS TRAN) is an European Commission (EC) sponsored programme to develop a methodology to extend the EGNOS satellite coverage in northern latitudes and difficult terrain via terrestrial networks and to conduct flight tests to validate the concept and potential benefits. This paper briefly describes the project and presents a summary of trials conducted in Kiruna (latitude 67 N) to validate the concept.

Proposed action by the Conference is in paragraph 4.

1. INTRODUCTION

1.1 The European Space Agency (ESA) is conducting a study called the European Global Navigation Overlay System – Terrestrial Regional Augmentation Network (EGNOS TRAN). The EGNOS TRAN concept is to broadcast parts of the EGNOS data through terrestrial links, for example by using existing communication networks, which will compensate for the lack of a “line of sight” visibility to the geostationary satellites. Complementary dissemination of the EGNOS data is made by means of terrestrial networks (e.g. by mobile phone networks, local differential networks such as VDL Mode 4 broadcasts, Loran C broadcasts via Eurofix etc.) where the EGNOS satellite signal is not available. Thus it is expected that EGNOS services will be provided in areas where signal availability is limited or lacks continuity such as in difficult terrain, urban areas and in northern latitudes etc. so as to achieve the same performance characteristics as that provided by using raw EGNOS broadcasts. Thus ETRAN could potentially provide an improved EGNOS service to an increased number of users, and to a larger geographical area than originally envisioned. This paper is limited to EGNOS TRAN applications used by civil aviation.

1.2 The application "Civil Aviation" addressed by EGNOS TRAN is used to analyse the performance that can be achieved and the phases of flight which can be supported. For requirements not met by EGNOS due to the application criticality, local augmentation may be needed. The focus of EGNOS TRAN is explicitly on the navigation and surveillance performance in the terminal area, for approach and landing, as well as on the en route and airport surface operations. Together these operations could provide a gate-to-gate coverage. For requirements not met by EGNOS due to the application criticality, local augmentation may be provided. The NLTB (Northern Latitude Test Bed) provides a possibility of testing bundled service with local augmentation as backup or to improve the services, e.g. due to such limitations.

1.3 Requirements for advance surface movement guidance and control systems (A-SMGCS) are still under development, however; it could be envisioned that EGNOS Service Level 2 should support the surveillance elements of an A-SMGCS. This could be achieved through Level 2 which is intended for approach and landing (APV-I, II, CAT-I). This EGNOS TRAN application will be used to analyse the performance that could be achieved and the parts of A-SMGCS, which could be supported.

2. BRIEF DESCRIPTION OF THE SYSTEM AND THE RESULTS OF THE TRIALS

2.1 Figure 1 shows the block diagrams of the ETRAN network. The network consists of communication, navigation, surveillance (CNS) ground station (GS). There are two types of networks that are employed in the ETRAN concept for civil aviation. There is a local ground network that is also referred to as the Wide Area Network that connects the CNS GS with each other as well as with the EGNOS Control Processing Facility (CPF), receiving the EGNOS messages and converting them into ground-based augmentation system (GBAS)-like messages, and broadcasting them to the user. The other method uses an EGNOS Receiver System (ERS) that receives EGNOS and GPS signals and processes them and generates GBAS-like differential messages which are broadcast on the data link. In the tests conducted to prove the system concept, the second network described was used.

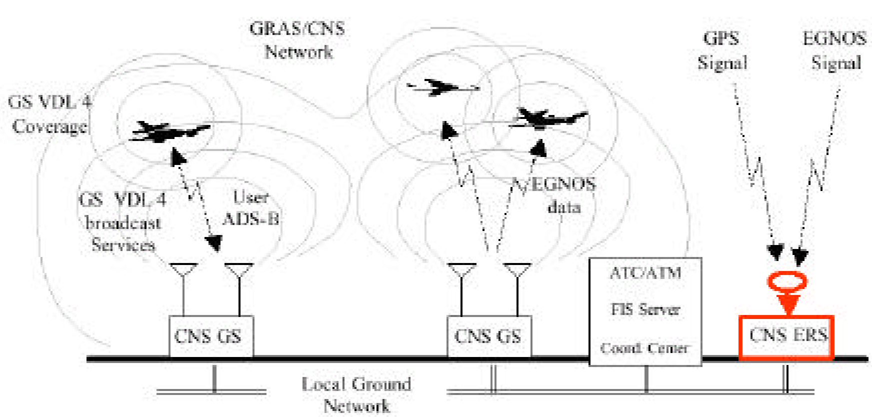

Figure 1. Block diagram of ETRAN network

2.2 The same type of mobile CNS user equipment was used by aircraft and ground vehicles during the trials. The equipment included a VDL-4 transponder (1 transmitter, 2 receivers), a communication processor and a differential GPS receiver; however, the aircraft pilots and the ground vehicle drivers have different displays and associated human machine interface.

2.3 The VDL-4 transponder provided the mobile positions calculated with the EGNOS TRAN information as the test tool. The user equipment was installed in both cars/vehicles and aircraft. The VDL Mode 4 mobile transponder consists of a VDL Mode 4 radio subsystem, which provides VHF data link communications to and from the mobile transponder, while the global navigation satellite system (GNSS) subsystem provides navigation data and UTC timing. The transponder contains an embedded computer subsystem, which performs data reformat management, monitoring and control, as well as management of communication, navigation and surveillance operations. The test tool data analysis steps are:

a) a kinematic post processing of the mobile raw data using the ERS as a fixed reference generates a reference "true path". The 95 per cent accuracy of the obtained trajectory is about 15/20 cm, which is good enough to assess the EGNOS TRAN performance requirements, which are in the order of few meters;

b) the ETRAN horizontal and vertical errors vs. time are generated by comparing the log of the ETRAN position with the true path;

c) the "straight" GPS trajectory that the mobile receiver would have reported in the absence of ETRAN corrections is computed by post processing the mobile raw data only;

d) the relevant GPS solution horizontal and vertical errors are generated by comparing the GPS trajectory position with the true path;

e) the horizontal and vertical protection levels (HPL and VPL) are computed using the sigma prgnd in the GBAS message type 1 log of the ERS and the mobile receiver raw data; and

f) finally, navigation errors and protection levels are plotted vs. GPS time or in the summary Stanford diagrams to verify the compliance with approach with vertical guidance (APV) II performance requirements.

2.4 The trials, which included test flights and ground vehicles operations, took place in the true northern latitude environment of the Kiruna Airport (Sweden, 68°N) from January till April 3003. Currently the EGNOS system is not operational; therefore, regional corrections coming from the EGNOS System Test Bed (ESTB) geostationary satellites were used during the trials.

2.5 To extend the service coverage the ESTB corrections are generated taking into account also the raw measurement coming from an additional ranging and integrity monitor station (RIMS), installed at the test site and interconnected to ESTB through the Mediterranean test bed (MTB).

2.6 The measurement files collected during the trials were processed by the test tool to calculate the navigation system errors of the straight GPS position, and of the position obtained with the EGNOS TRAN demonstrator. The protection levels obtained by mapping the EGNOS integrity information in the GBAS message were also computed.

2.7 Table 1 summarizes the typical accuracy results obtained during the flight trials; similar results were obtained during trials with surface vehicles.

Table 1. EGNOS TRAN vs. GPS horizontal and vertical statistics

	ETRAN H ERR (m)	GPS H ERR (m)	ETRAN V ERR (m)	GPS V ERR (m)
Min	0,1	0,0	0,0	0,0
Max	1,2	4,3	2,2	8,9
average	0,6	1,1	0,7	3,0
50%	0,6	1,0	0,6	2,9
95%	0,9	2,0	1,4	5,5
99%	1,0	2,6	1,7	6,5

2.8 Figure 2 and Figure 3 show the vertical protection limits i.e. the integrity achieved during the surface movement and flight trials. The results show performance reaching the requirements set in ICAO SARPs for APV-II.

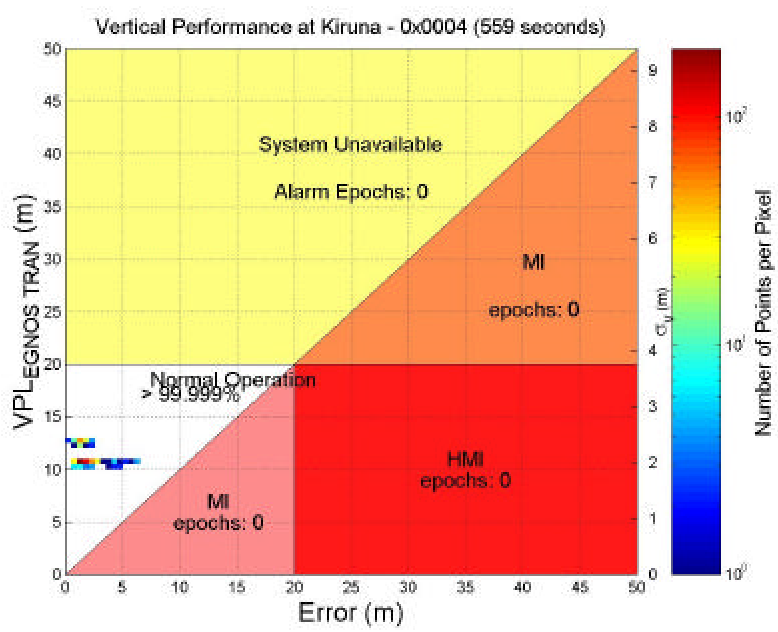

Figure 2. Vertical performance for a typical surface movement trial

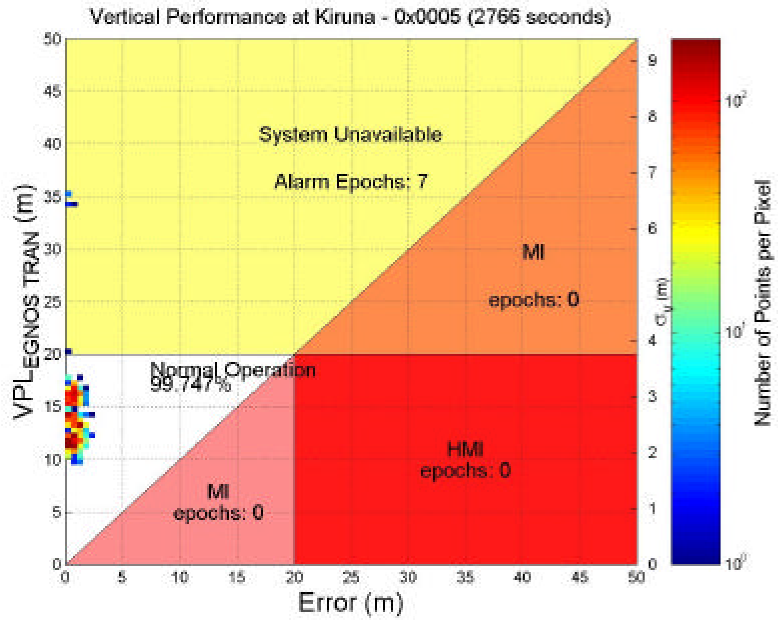

Figure 3. Vertical performance for a typical flight trial

3. SUMMARY

3.1 From the trials it can be seen that the ETRAN performance is comparable with "direct EGNOS" performance and compatible with APV-II requirements.

3.2 Through the EGNOS TRAN the availability of EGNOS corrections is increased significant in high latitude where the GEO visibility is easily lost due to obstacles or low signal levels.

3.3 So as not to require any changes to mobile equipment the concept used during the trials was to broadcast GBAS messages derived from SBAS data. This concept was also validated, demonstrating that ETRAN can be implemented without changes to the existing GBAS mobile equipment.

3.4 The demonstration included both navigation and surveillance operations. An air traffic control (ATC) interface was provided for surveillance/situation awareness. The test also included runway incursion scenarios, which were conducted successfully.

4. ACTION BY THE CONFERENCE

4.1 The Conference is invited to:

a) consider the EGNOS TRAN and ground-based regional augmentation concepts for the early introduction of surveillance and navigation operations;

b) agree that broadcasting surveillance and navigation data on VDL Mode 4 datalink without any adverse effects, and achieving APV-II performance, demonstrates the viability and cost effective use of the technology; and

c) recommend the use of VDL Mode 4 for communications, navigation and surveillance and that appropriate standards and recommended practices are developed future work programmes.

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