EGNOS EXTENSION TO EASTERN EUROPE. TRAIL FLIGHTS IN REPUBLIC OF MOLDOVA

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Abstract: *This paper present the preparation procedure and results of flight trials conducted in the frame of FP7 Project EEGS2 «EGNOS Extension to Eastern Europe: Applications» in order to demonstrate possibility of EGNOS extension to Eastern Europe in the field of aeronautics by using the magicSBAS message generated by GMV Aerospace and Defence (Madrid, Spain). The analyses of trail flights results show the Horizontal Protection Level (HPL) and Vertical Protection Level (VPL) are fitting International Civil Aviation Organization (ICAO) requirements. Evaluation of the aircraft landing accuracy using L1 GNSS receiver in comparison with post-processing kinematic measurements using L1/L2 GNSS receiver on board during trail flights had shown around 2 meters of Horizontal Position Error (HPE) and around 5 meters of Vertical Position Error (VPE). The results of this activity will provide to the pilots and service providers a clear idea of the performances and benefits that will be obtained with EGNOS and procedures that will be flown in the coming future.*

Keywords: *GNSS, SBAS, trail flights, Horizontal Protection Level (HPL), Vertical Protection Level (VPL), Horizontal Position Error (HPE), Vertical Position Error (VPE).*

1. Introduction

Since March 2011 European Geostationary Navigation Overlay Service (EGNOS) is certified for Safety of Life applications and EGNOS Data Access Service (EDAS) is available since July 2012. Taking in account limited EGNOS coverage area in the eastern part of Europe it is necessary to develop new augmentation methods and to demonstrate possibility of EGNOS services extension to Eastern Europe countries [1,2].

Starting from January 2012, the Technical University of Moldova has been involved, as a partner, in a collaborative FP7 Project EEGS2 «EGNOS Extension to Eastern Europe: Applications» aimed to demonstrate the benefits of EGNOS, EDAS and Galileo through applications in the Eastern countries of Europe (http://www.eegs2-project.eu/).

The main objective of the project is to demonstrate possibility of EGNOS extension to Eastern Europe in the field of aeronautics by using the magicSBAS message generated by GMV Aerospace and Defence (Madrid, Spain).

2. Selected airports and aircraft

Four international airports were selected for the flight trials in Moldova: Chisinau (LUKK), Marculesti (LUBM), Balti (LUBL), and Cahul (LUCH). The selection was done based on the main criteria, to evaluate horizontal and vertical protection levels the in the North, Central and South parts of Moldova (fig. 1). All the decisions regarding the airports were carefully analyzed together with the experts of the subcontractor for the trials flights State Enterprise Flight Training Organization (FTO). After the workshop held in Chisinau on

13-14 March 2013 in the frame of the EEGS2 project, the Moldavian Civil Aviation Authorities offered their support and confirmed their interest in the project, the final decision was to use all four airports opened for civil aviation. It is important to underline the efforts, the availability and the support provided by the local authorities during the trials and during the preliminary activities as well. The main geographical and administrative characteristics of the selected airports and the services provided are included in Report on SBAS Trail Preparation in Moldova [3]

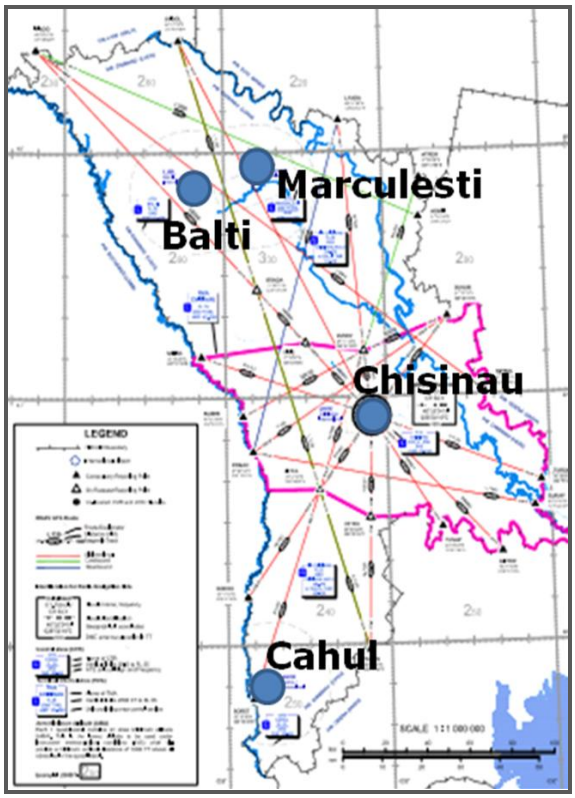

Fig. 1. Map of selected airports

In order to conduct trail flights in Moldova State Enterprise Flight Training Organization (FTO) was subcontracted using R40 Festival aircraft (fig. 2). The main technical characteristics and performances of the selected aircraft are included in Report on SBAS Market Trial for Aviation in Moldova [5]

Fig. 2. Selected R40 Festival aircraft

3. Ground and air segments

The magicSBAS Server generates messages based on the information available from satellites and ground stations network. MagicSBAS messages were sent to the airfield via

Internet using Unite 3G Modem and from airfield to the aircraft via transmitter radio modem. (fig. 3).

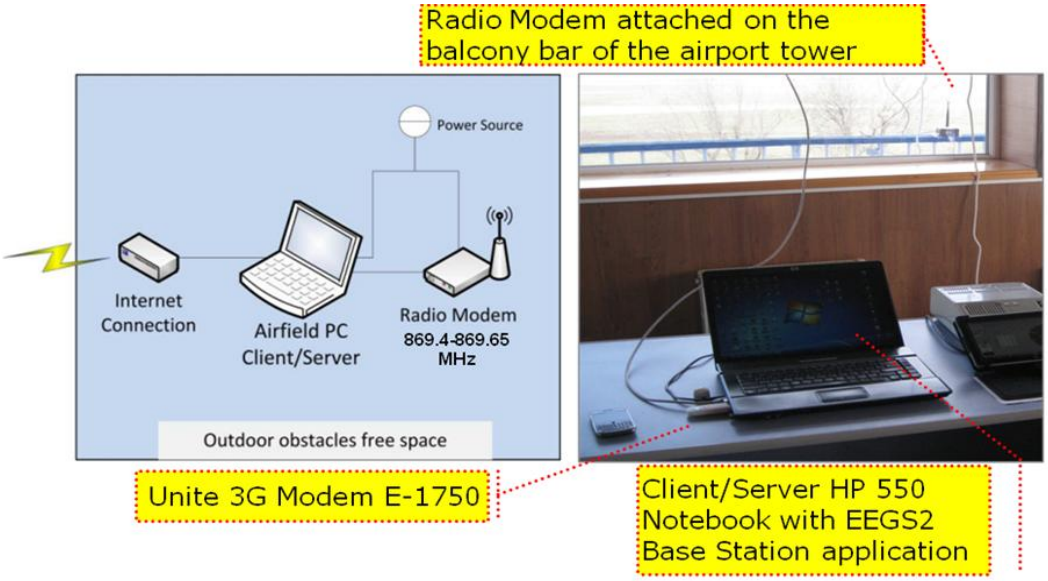

Fig. 3. General configuration schema of ground segment.

MagicSBAS messages were received by the onboard radio modem. Simultaneously, the GNSS signals were received onboard by the L1 GNSS receiver. MagicSBAS messages and GNSS observations were sent to Tablet PC through the access point via Wi-Fi (fig. 4).

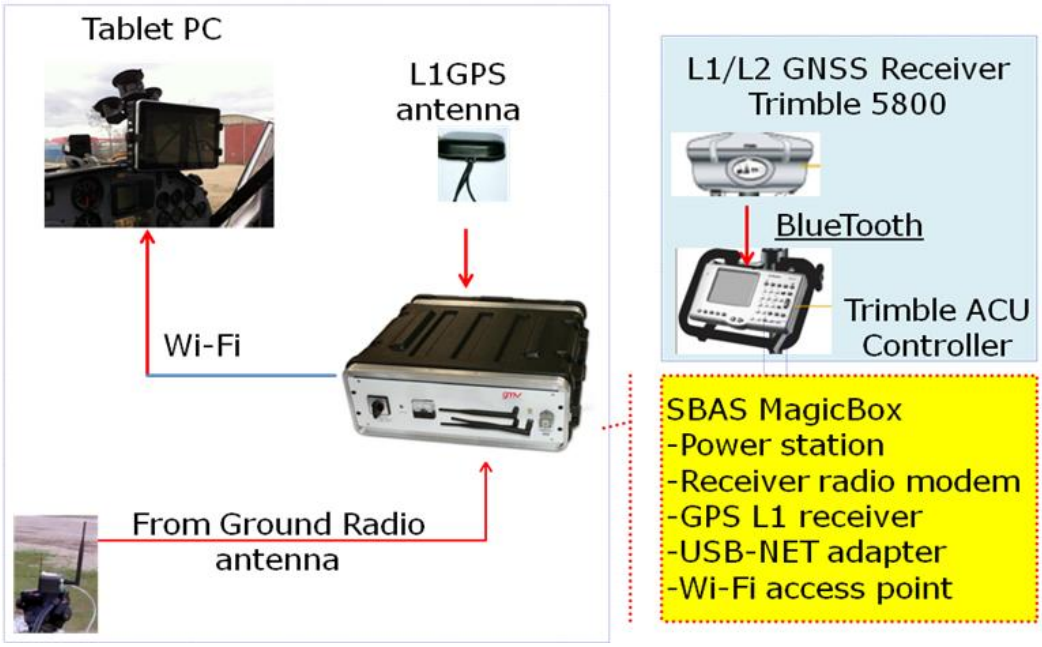

Fig. 4. General configuration schema of air segment.

All received data in the tablet PC were processed by the EEGS2 Console software developed by GMV. Installed in the tablet PC, this software application processes all the data received and calculates necessary information to fly the trials such as the navigation solution, trajectories and SBAS protection levels, saving raw data and results for future post-processing. Also displays useful information for pilots and engineers such as a course deviation indicator, satellite constellation information, protection levels, etc. (fig. 5).

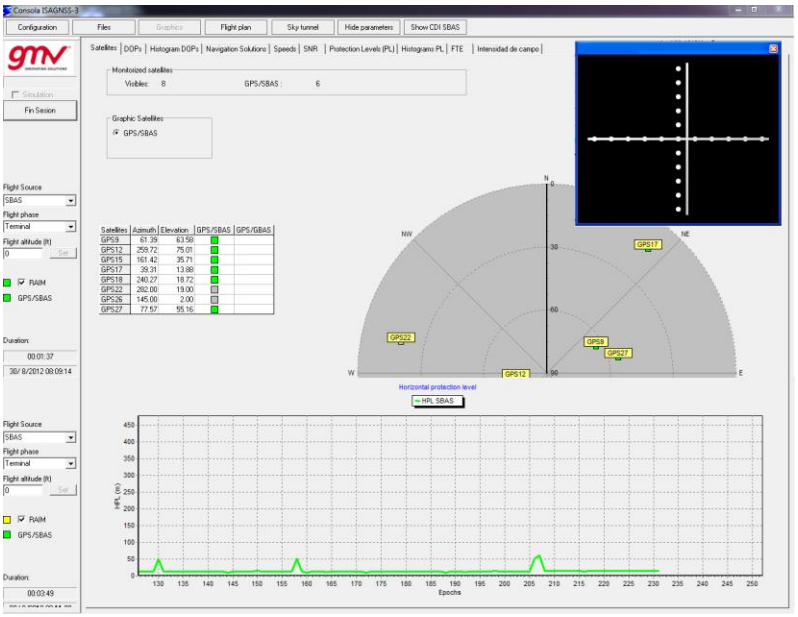

Fig. 5. EEGS2 Console software developed by GMV

EEGS2 Base station client/server application connects ground segment to the magicSBAS SISNeT Server, checks that the messages received are correct and transmits all the information to the radio modem in order to broadcast the messages. In order to allow several clients to share common serial resources the Serial2TCP Splitter application, developed by GMV, has been installed on Tablet PC (fig. 6).

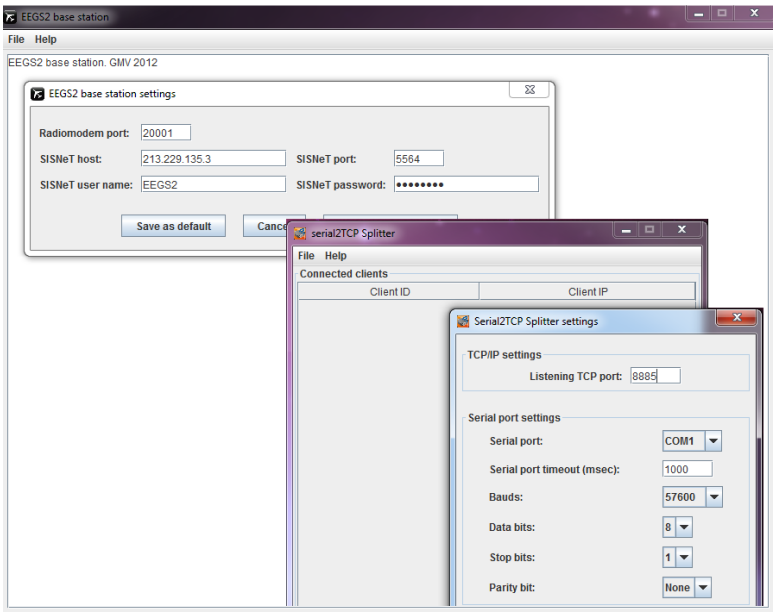

Fig. 6. EEGS2 Base station and serial2TCP Splitter software developed by GMV

4. Flight trails preparations

The flights in Moldova were initially scheduled for second part of March, but, due to bad weather conditions, the trials had been conducted on the beginning of April.

TUM ensured that both the Moldavian Civil Aviation Authority (MCAA) and the Air Navigation Service Provider (MOLDATSA) were involved in the trials as observers in order to emphasize the project's impact at national level. In this direction, TUM submitted letter of

invitations to MCAA and MOLDATSA to participate at preliminary meetings for the trials and at the trials themselves.

From the 12th to the 14th of March 2013, the GMV team was in Chisinau testing and installing the systems in order to perform the flight trails in Moldova. The first day the equipment and software were installed and tested in the FTO. Ground antenna was installed on the control tower balcony (fig. 7).

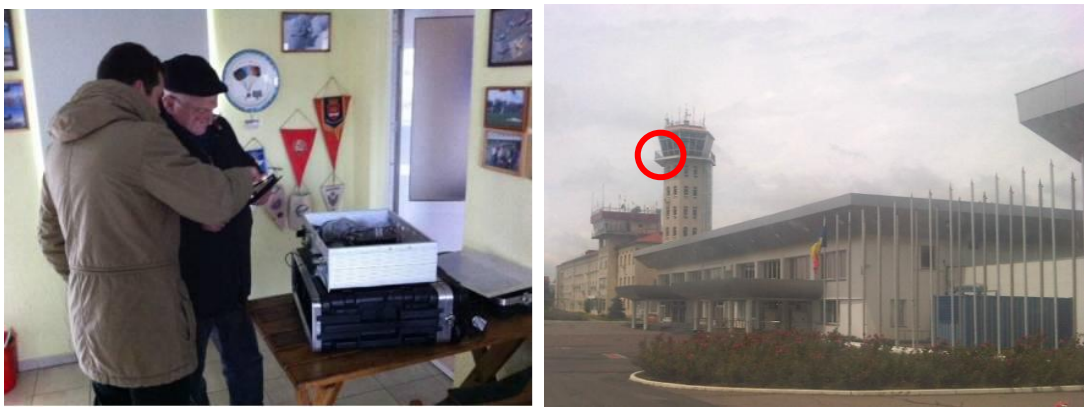

Fig. 7. Preliminary equipment testing at Chisinau International Airport premises

The second day the equipment was installed on the board of F40 Festival aircraft at Vadul lui Voda airport premises in order to verify radio link between ground and on board segments (fig. 8).

Fig. 8. Preliminary equipment testing at Vadul lui Voda airport premises

5. Results of flight trails conducted in Moldova

In order to demonstrate performances and benefits of EGNOS flight trials were conducted in Chisinau, Balti (from Marculesti) and Cahul international airports (fig. 9-11).

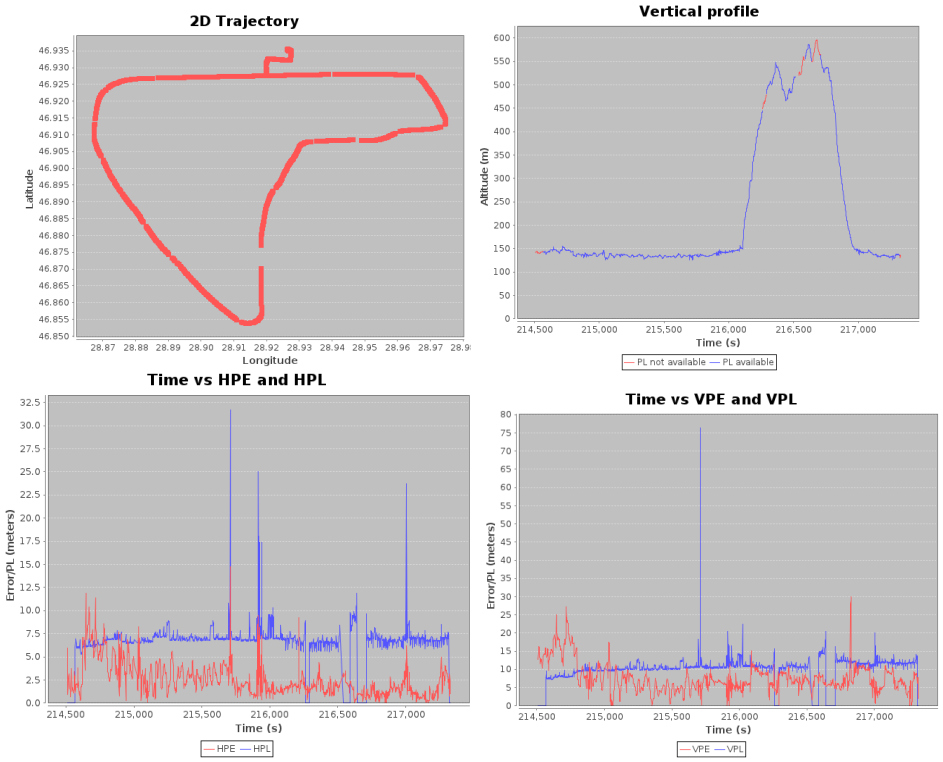

Fig. 9. Results of trial flight in Chisinau International Airport

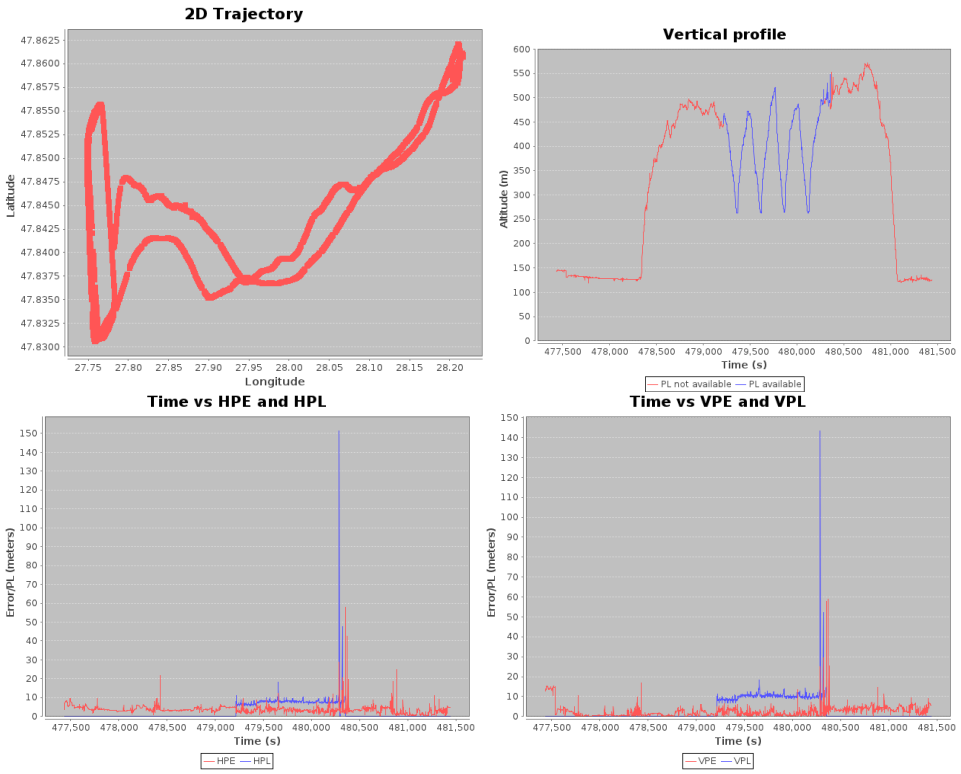

Fig. 10. Results of trial flight in Balti International Airport (from Marculesti Airport)

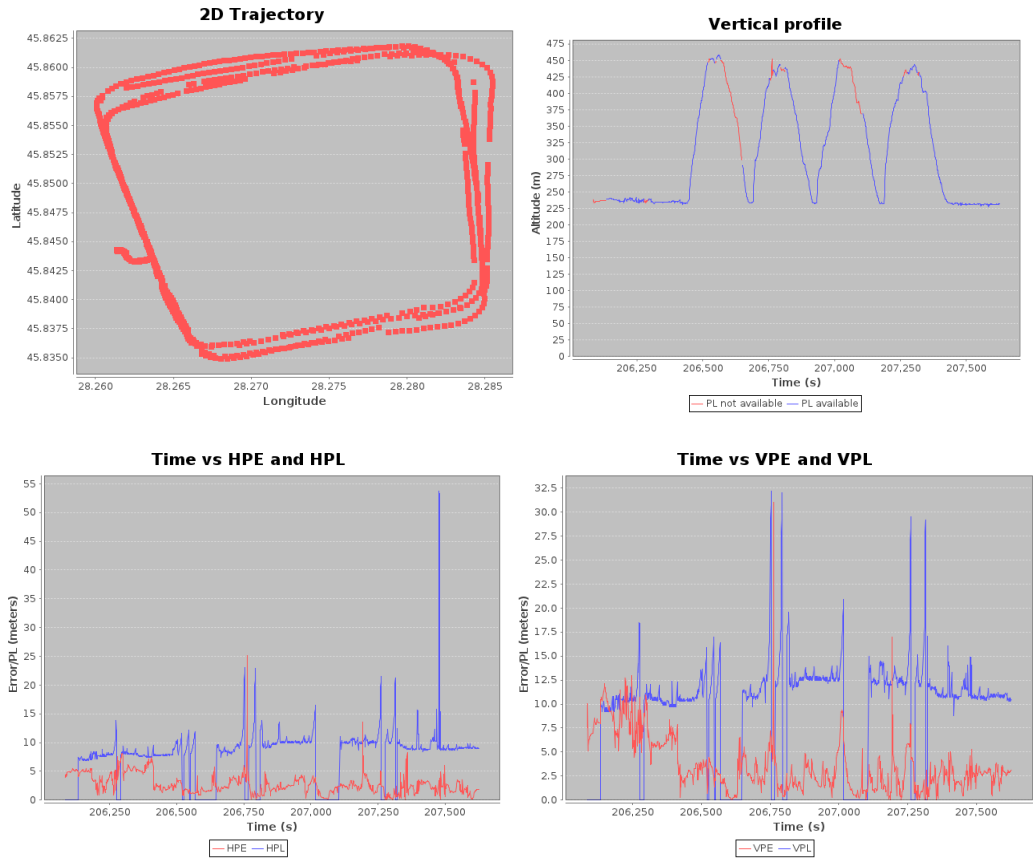

Fig. 11. Results of trial flight in Cahul International Airport

The 2D trajectories and vertical profiles provide the availability of the protection levels and it may be observed that during the flight trail sections. Furthermore, the following plots provide the results obtained for the horizontal and vertical protection levels and the associated errors during the four sessions.

During flights conducted in the Chisinau International Airport the protection levels were computed during the whole trajectory except small gaps. During the approaches the coverage was full and the protection levels where computed all the time. The number of monitored satellites by magicSBAS signal was from 9 to 11. That fact was translated into a good DOP and good trajectory accuracy (fig. 9).

The trail flights in Balti International Airport were carried out from Marculesti International Airport (30 km far from Balti). Because Balti Airport was not operational, the trail flights consisted of installing ground antenna and server in Balti Airport and flying from Maculesti Airport. All approaches were done during the flight to the Balti Runway with full coverage of the magicSBAS signal. (fig. 10).

During flights conducted in the Cahul International Airport the protection level where computed during the whole trajectory excepting landing because low installation of ground antenna (fig. 11).

The analyses of trail flights results shows the Horizontal Protection Level (HPL) and Vertical Protection Level (VPL) is fitting International Civil Aviation Organization **(**ICAO**)** requirements. The main spikes on the graphics were related to poor visibility between radio modem on the ground and antenna on the aircraft. In case the antenna will be installed outside of aircraft and radio modem will be installed on the top of the airport control tower control tower the data integrity will be much higher.

Additional post processing kinematic continuous observations were carried out using Trimble L1/L2 5800 GNSS Receiver. Comparison with data processed with RINEX files from permanent reference GNSS stations Network (MOLDPOS) shows around 2 meters of Horizontal Position Error (HPE) and around 5 meters of Vertical Position Error (VPE).

6. Conclusions

All four selected airports were used for trail flights according GMV EEGS2 SYSTEM requirements using R40 Festival Aircraft of State Enterprise "Flight Training Organization".

The analyses of trail flights results shows the Horizontal Protection Level (HPL) and Vertical Protection Level (VPL) is fitting International Civil Aviation Organization **(**ICAO**)** requirements. Tthe main problems are related to poor visibility between radio modem on the ground and antenna on the aircraft.

Additional post processing kinematic continuous observations during all trail flights using Trimble L1/L2 5800 GNSS Receiver gave an opportunity to estimate accuracy around 2 meters of Horizontal Position Error (HPE) and around 5 meters of Vertical Position Error (VPE).

The results of the project will provide to the pilots and service providers a clear idea of performances and benefits that will be obtained with EGNOS procedures that will be flown in the coming future. Introduction of SBAS procedure for Moldavian airlines comprises more steps starting with the consideration of competitive systems (such as Instrumental Landing Systems), a statistical analysis of existing delays, diversions, cancelations, a forecast of costs and savings over a few years timeframe and other intermediate steps [4,5].

EGNOS extension methods and results of the project were included in educational programme using the flight trail materials for research purposes': bachelor degree and Master degree thesis.

7. Bibliography

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