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RESEARCH OF EGNOS RELIABILITY IN KIEV

A research of EGNOS work was conducted with a help of a receiver, working in the mode of receiving differential corrections, to find if EGNOS can be used in Ukraine without building a ground station.

Introduction

EGNOS - European Geostationary Navigation Overlay Service is a system of space functional augmentation type SBAS intended to improve performance of GPS, GLONASS and GALILEO on the territory of Europe.

Starting from October 1 2009, EGNOS Open Service provides signal transmission on a satellite navigation receiver with EGNOS option. EGNOS Safety of Life service has become available from March 2nd 2011. Space signals are used for typical safety-critical operation like APV-1, APV-2 and CAT-1 on the territory of Western Europe.

The goal of this work is experimental estimation of EGNOS system performance quality in Ukraine(Kiev particularly) after it has been declared availiable. The processing of the experimental data is performed with PEGASUS software.

Setting the goal of the research

The goal of the research consists in_receiving of the experimental data from GPS and corrections from geostationary satellites AOR-E, IOR-W and Artemis, which are used in EGNOS.

The received messages are processed by PEGASUS software. Using the results conclusions are made if the characteristics of the navigational system fit to the safety requirements of the aviation users.

The coordinates of the receiving station were measured with 5 cm accuracy and considered_as the basic point.

The screen of the receiving station is shown on the Fig. 1.

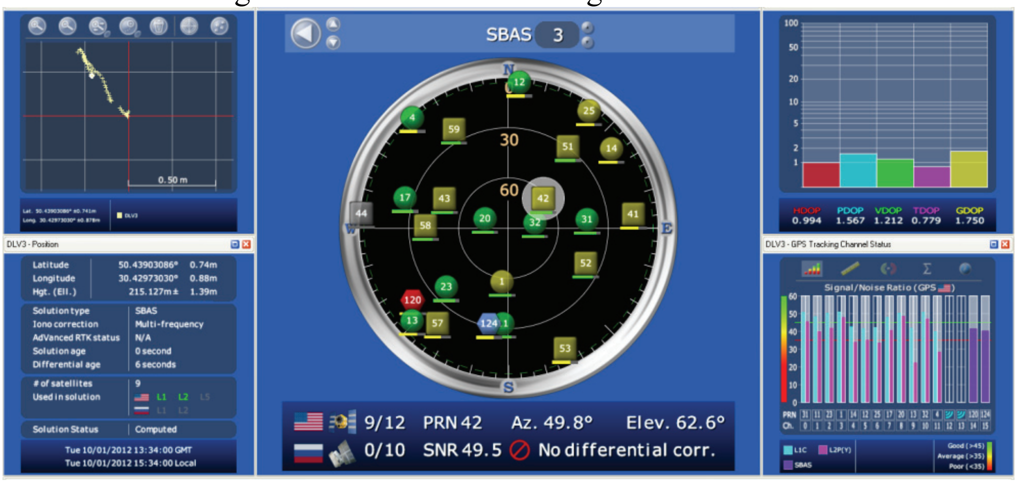

Fig. 1 Station screen.

At the screen GPS satellites and geostationary 120 and 124 satellites, which transmit the messages with corrections, are seen. GLONASS satellites can also be seen on the picture, but they do not use the EGNOS system and therefore are not considered as the part of experiment.

The main characteristics were researched, such as: accuracy (the deviation of coordinates in horizontal and vertical planes from the coordinates of the basic point), the availability of ionospheric corrections(the piercing points of ionosphere), integrity of data and continuity.

Research results

The research of 12th march 2011 is given as an example as typical result.

In order to assess the results general safety requirements for SBAS are presented in table 1.

Table 1

Basic safety requirements for SBAS

Typical Operation	Horizontal Accuracy (95%)	Vertical Accuracy (95%)	Integrity	Time-To-Alert (TTA)	Continuity	Availability
En-route	3.7 km (2.0 NM)	N/A	1 – 1 × 10-7/h	5 min	1 – 1 × 10-4/h to 1 – 1 × 10-8/h	0.99 to 0.99999
En-route Terminal	0.74 km (0.4 NM)	N/A	1 – 1 × 10-7/h	15 s	1 – 1 × 10-4/h to 1 – 1 × 10-8/h	0.99 to 0.99999
Initial approach, Intermediate approach, Non-precision approach (NPA), Departure	220 m (720 ft)	N/A	1 –1x10-7/h	10 s	1 – 1x10-4/h to 1 – 1x10-8/h	0.99 to 0.99999
Approach operations with vertical guidance (APV-I)	16 m (52 ft)	20 m (66 ft)	1 – 2 × 10-7 per approach	10 s	1 – 8 × 10-6 in any 15 s	0.99 to 0.99999
Approach operations with vertical guidance (APV-II)	16 m (52 ft)	8 m (26 ft)	1 – 2 × 10-7 per approach	6 s	1 – 8 × 10-6 in any 15 s	0.99 to 0.99999
Category I precision Approach	16 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft)	1 – 2 × 10-7 per approach	6 s	1 – 8 × 10-6 in any 15 s	0.99 to 0.99999

Accuracy in horizontal plane(fig. 2) is displayed as the deviations on North-South and East-West from the basic point.

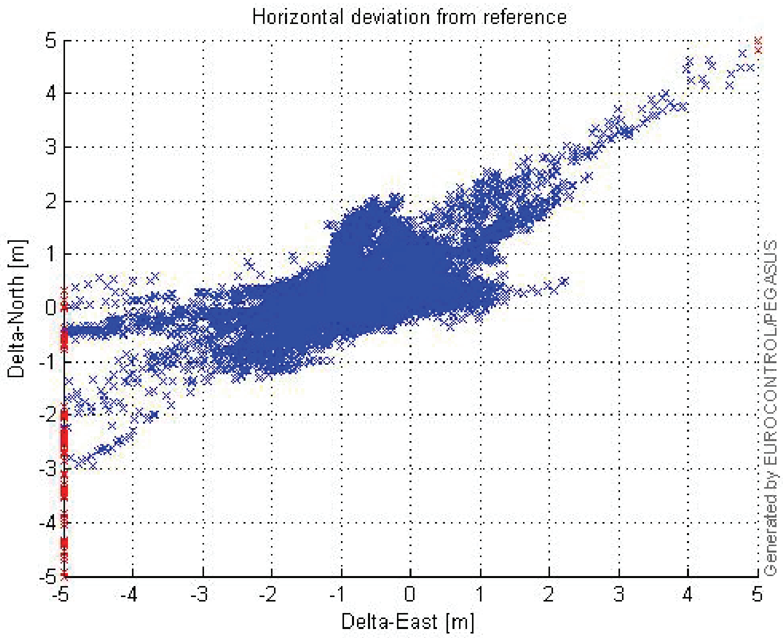

Fig. 2 Accuracy in horizontal plane

The horizontal accuracy of APV-1 category is 1.89 m. Vertical accuracy of APV – 2 is 1.49 m. Both measures were defined from the epochs when APV – 1 was available for normal operation by statistical methods and fit to the requirements for accuracy in table 1.

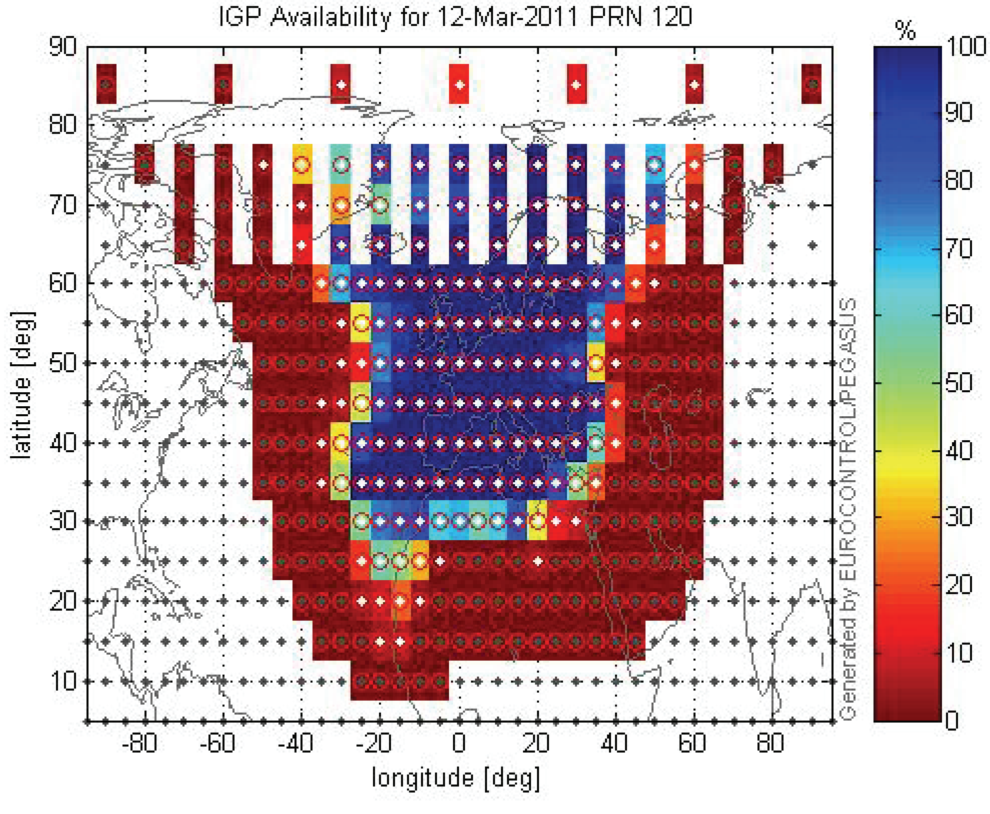

Fig. 3 Availability of piercing points of Ionosphere

The map of availability of the atmosphere piercing points is displayed on fig.3 . Coordinates of Kiev are 30° 30' east 50° 27' north. Availiability for piercing points: 100 % for sattelites to the west, decreasing to the south and north, rapid fall to 30-40 % for satellites to the east.

In order to analyze integrity Stanford plot is used. The measurements which correspond to typical operations of APV-1, APV-2 and CAT-1 for horizontal and vertical planes are shown on fig.4 and fig.5.

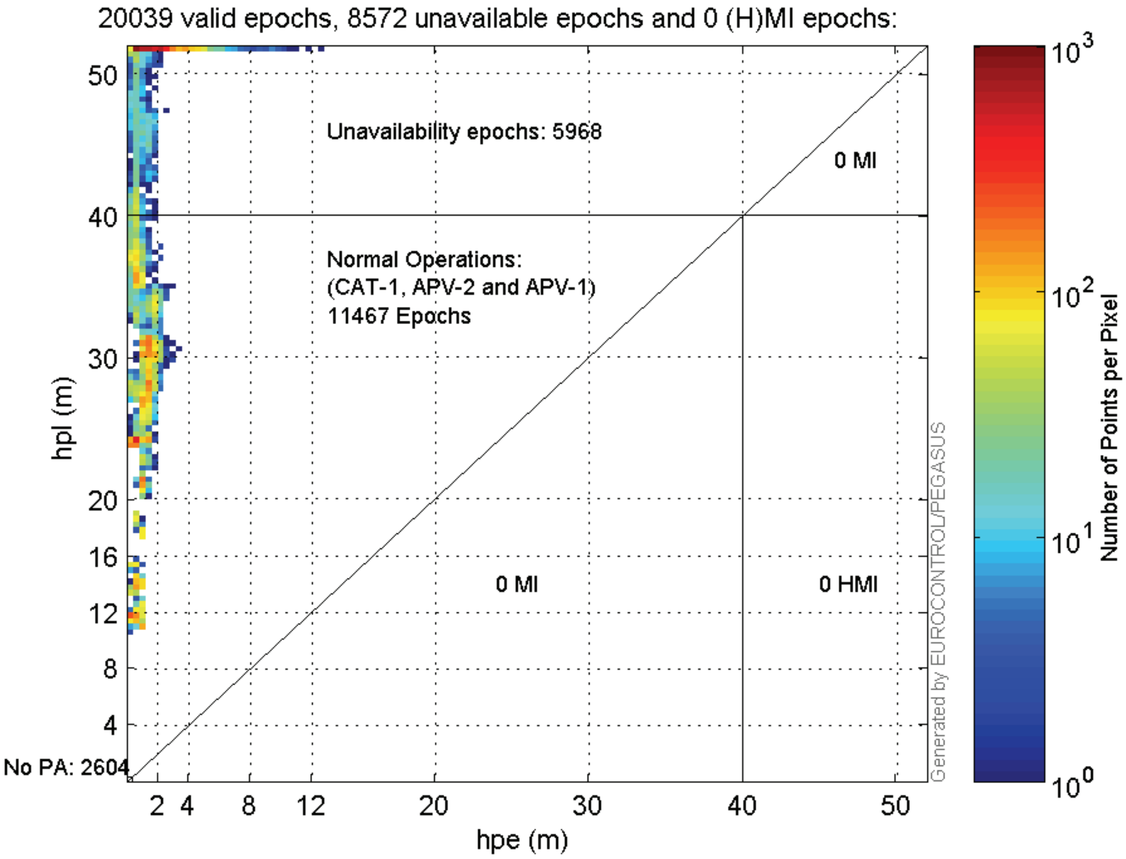

Fig. 4. Horisontal Stanford plot

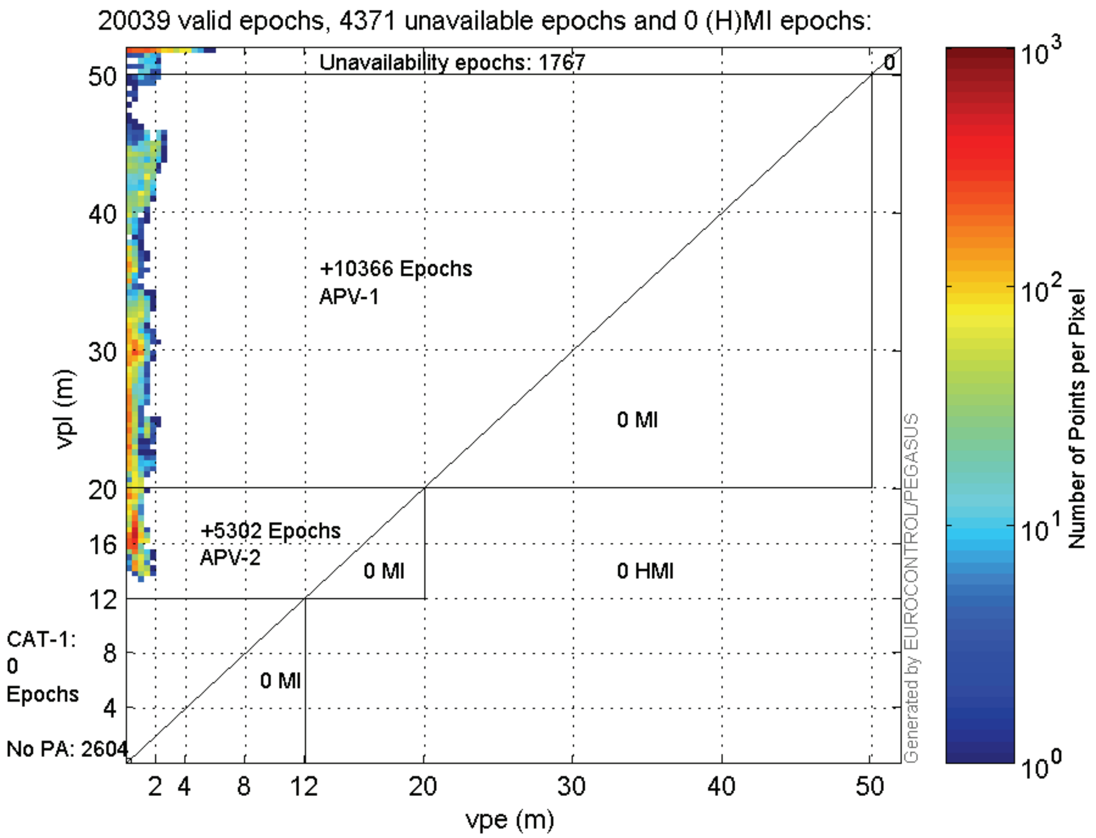

Fig. 5. Vertical Stanford plot

Information about categories is shown in table 2. On the pic 4 and 5 on horizontal axis precision errors are plotted for horizontal (hpe) and vertical (vpe) planes respectfully, on the vertical axes we have alarm limits for horizontal (hpl) and vertical planes (vpl) respectfully. From 20039 valid epochs on pic. 4 11467 epochs are fit for safety critical operations, 5968 epochs exceed the alarm limit of 40 m and 2462 fit only for NPA. From 20039 valid epochs on pic. 5 10366 epochs are fit for APV-1, 5302 for APV-2, no for CAT-1. 1767 epochs exceed the alarm limit of 50 m and 2604 have no precision availiable.

There was no misleading information in the research so according to table 1, integrity requirements are met.

Table 2

ICAO SARPs high level integrity requirements

Typical operation	Time to Alarm	Integrity	Hor. alert limit	Vert. alert limit
NPA	10 s	$1\text{-}10^{-7}$/h	0.3 NM	N/A
APV I	10 s	$1\text{-}2\text{x}10^{-7}$/app	40.0 m	50 m
APV II	6 s	$1\text{-}2\text{x}10^{-7}$/app	40.0 m	20 m
CAT I	6 s	$1\text{-}2\text{x}10^{-7}$/app	40.0 m	15 - 10 m

The most problematic parameter for Ukraine is continuity which is increadibly bad. The discontinuity events for position solution are listed in table 3. Discontinuity events for APV – 1 are listed in table 4.

Duration – time for which discontinuity lasts.

Stable period – time which system run from last discontinuity end to the start of current.

Table 3

Position discontinuity events

Epoch	Duration, s	stable period, s
579503	105	1942
579766	53	158
584309	168	4490
587212	320	2735
591536	1286	4004
595953	1	3131
595955	66	1
596349	160	328

Table 4

Discontinuity events for APV-I

Epoch	Duration, s	stable period, s
579503	105	1942
579766	213	158
581263	800	1284
584309	457	2246
585341	1424	1
587212	320	447
591536	1963	4004
593623	165	3
593793	152	1
594406	12	1
594738	324	320

The low continuity highly influences the overall availability of EGNOS in Ukraine. In the research APV-1 is available only 57.223% and APV-2 – only 26.458% which makes a substantial difference from the standards listed in table 1.

Conclusions

The results state the weak signal quality of EGNOS in Kiev, so that it can not be used for any safety critical operations until a RIMS station is placed.

References

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2. PEGASUS Interface Control Document 10/09/2010 286p provided by Euro control
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4. SARPS Amendment 77, Annex 10 to the Convention on International Civil Aviation, Aeronautical Telecommunications: International Standards and Recommended Practices, Volume 1, Radio Navigation Aids, November 2002.
5. WADGPS Laboratory (Stanford University). "WAAS Precision Approach Metrics. Accuracy, Integrity, Continuity and Availability," http://waas.stanford.edu/metrics.htm. October 1997.