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*Assessment and monitoring of
GPS/EGNOS navigation performances
in Ukraine:
plans and initial results*

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ABSTRACT

The tasks of experimental estimation and organization of monitoring the performances of GPS/EGNOS navigation service on the territory of Ukraine are being examined. Methodical and organizational problems of investigations, deployment of the monitoring subsystem, basic technologies, test equipment and software means that are planned to be used during the creation of the monitoring subsystem are determined. The preliminary structure of organizations–participants of the development is established. The first results of testing the GPS/EGNOS performances in Kharkov and Evpatoria by use of NovAtel equipment and PEGASUS 4 software are briefly described.

In the present report there are used the results which have been achieved during the current developments in 2004-2005 under the contracts, which have been financed by the

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3. Planning the development of research subsystem for autonomous quality monitoring of GPS/EGNOS/GALILEO navigation services in Ukraine

**1. Proposed stage-by-stage strategy of
EGNOS/GALILEO
navigation/positioning services
implementation in Ukraine**

STAGES

- 1. Carrying out experimental researches and development of the system of monitoring the quality of GPS/EGNOS navigation service (2006 – 2007)
Conclusion of the Agreement with the European Community of RIMS
EGNOS stations deployment on the territory of Ukraine (2006 – 2007)
Organization of staff training for support of functioning and development of the future Ukrainian GPS/EGNOS and GALILEO segment (2006 – 2007)**
- 2. Deployment of the elements of EGNOS ground infrastructure on the territory of Ukraine (2007 – 2008)**
- 3. Organization in Ukraine of information and consulting services centers for support of EGNOS users (2007-2008)**
- 4. Updating the Ukrainian EGNOS segment for the purpose of its functioning by use of GALILEO signals (from 2008)**

2. An experimental estimation of characteristics of GPS/EGNOS navigation services:

- ❖ methodical and organizational issues**
- ❖ the first results summary of testing the GPS/EGNOS performances in Kharkov and Evpatoria using NovAtel's equipment and PEGASUS v.4 software**

PROBLEM ISSUES

- ❖ **How to estimate objectively EGNOS characteristics or the characteristics of GPS/GNSS other functional augmentations**
- ❖ **How many RIMS EGNOS points it is necessary to deploy and where**
- ❖ **Methodical service: how and what parameters to estimate**
- ❖ **What kinds of measuring means are to be used**

WHAT(WHAT PARAMETERS) IS SUBJECTED TO INVESTIGATE

- ❖ **First there shall be carried out the truthful experimental estimation of EGNOS signal and quality with the further analyses and recommendations on positioning the places of the best deployment of RIMS EGNOS stations**
- ❖ **It is set the task of estimating the quality of not only GPS/EGNOS positioning (PVT) but also of estimating the quality of WADGPS-corrections separate components (ionospheric, ephemerides and “fast” wide area corrections)**
- ❖ **In the process of analyses are also estimated horizontal and vertical Navigation System Errors by using high-precision positioning technologies, horizontal (HPL) and vertical (VPL) protection levels and their errors**

PLANNED FOR USING BASIC TECHNOLOGIES AND MEANS OF GPS/EGNOS CHARACTERISTICS EXPERIMENTAL ESTIMATION

- ❖ using the observation data of the network of **IGS/EPN** permanent reference stations of Ukraine and the results of their processing in **CODE IGS** - satellite precision ephemerides, stations coordinates, current parameters of the troposphere and ionosphere models etc.
- ❖ using conventional geodetic GPS-technologies and equipment
- ❖ using OmniSTAR/FUGRO high precision **WAD/VRS/HP**- technologies
- ❖ using scientific and special software:
 - **BERNESE 4.2** software complex (Main Astronomical Observatory of National Academy of Sciences of Ukraine (MAO NASU));
 - specialized software complex **“OCTAVA_PPA”** of data preliminary processing and analyses (development of MAO NASU);
 - commercial software complex **GrafNav/GrafNet** (Waypoint Consulting Inc., Canada);
 - software complex **"PEGASUS ver. 4"** and, perhaps, **“BRUS”** (by the agreement with the developer)

Preliminary results of GPS/EGNOS positioning accuracy estimation in East of Ukraine (November 2004 – May 2005)

Used Equipment and Software:

- ❖ GPS/EGNOS station (NovAtel CPUPAK – OEM4 –L1/L2-W), Kharkov
- ❖ GPS/EGNOS station (NovAtel MPC/CORS – OEM4 –L1/L2-W), Evpatoria
- ❖ PEGASUS ver. 4 software

The results of positioning accuracy estimation

Mode of navigation solution		Kharkov			Evpatoria	
		session 1.11.2004	session 5.11.2004	session 9.11.2004	session 24.12.2004	session 11.05.2005
Without ESTB/EGNO S corrections	Horizontal Error, m (95%)	3,5	2,4	2,9	3,2	3,6
	Vertical error (95%), m	9,2	10,6	4,4	5,4	7,0
With use of ESTB/EGNO S corrections	Horizontal error (95%), m	1,9	1,6	1,6	1,7	1,9
	Vertical error (95%), m	2,5	1,7	3,7	2,2	3,4

RESUME

- 1) Accuracy improvement: Horizontal – 1,5 ÷ 1,9 times; Vertical – 1,2 ÷ 6 times
- 2) At present in East of Ukraine is achieved GPS/ESTB-EGNOS positioning accuracy at level:
 - ~ 2 m (95%) Horizontal;
 - ~ 4 m (95%) Vertical

3. Planning the development of research subsystem for autonomous quality monitoring of GPS/EGNOS/GALILEO navigation services in Ukraine

Subsystem of quality monitoring of GPS/EGNOS navigation services

Principles:

- maximum coverage of the territory of Ukraine
- continuity of functioning
- arrangement of monitoring stations in the regions with developed infrastructure
- using the navigation equipment and software of the world leading producers
- using the information of the network of permanent reference GPS-stations of Ukraine

Functions:

- operative data gathering and processing
- the formation of conclusions on quality of GPS/EGNOS navigation service

Experiments on quality estimation of GPS/EGNOS navigation service

Tasks:

- estimation of distribution of positioning accuracy on the territory of Ukraine using stationary stations of the monitoring system and permanent reference GPS-stations of Ukraine
- navigation service quality estimation by use of a mobile laboratory
- verification of the troposphere models EGNOS- corrections recommended by SARPS ICAO

Regions of experiments:

- the whole territory of Ukraine – by use of stationary GPS/EGNOS stations
- in the regions of the arrangement of monitoring stations– by use of mobile laboratory

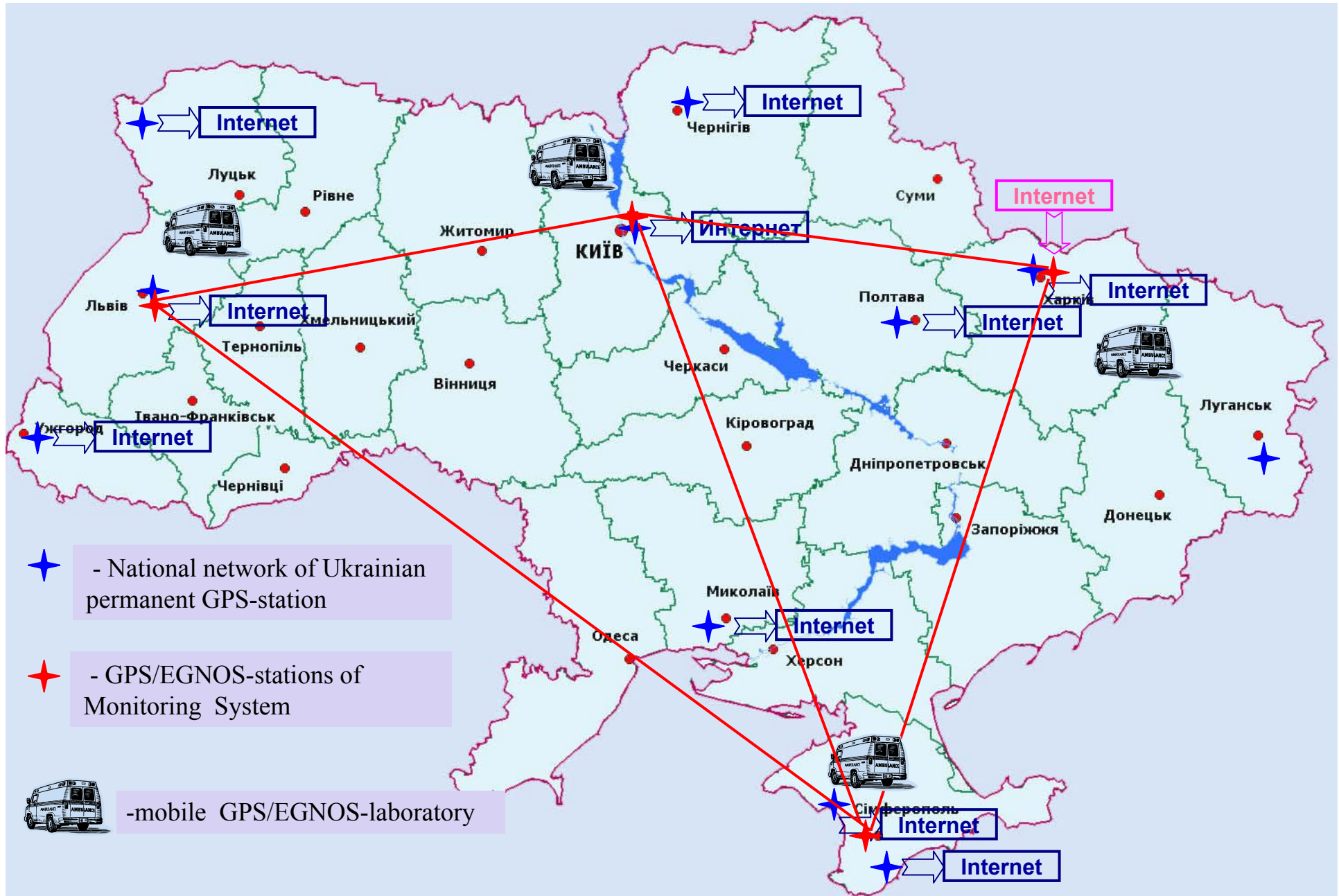
The equipment (structure of the ground equipment):

- stations of quality monitoring of GPS/EGNOS navigation service (NovAtel receivers)
- permanent reference GPS-stations of Ukraine
- a mobile laboratory equipment with NovAtel receivers

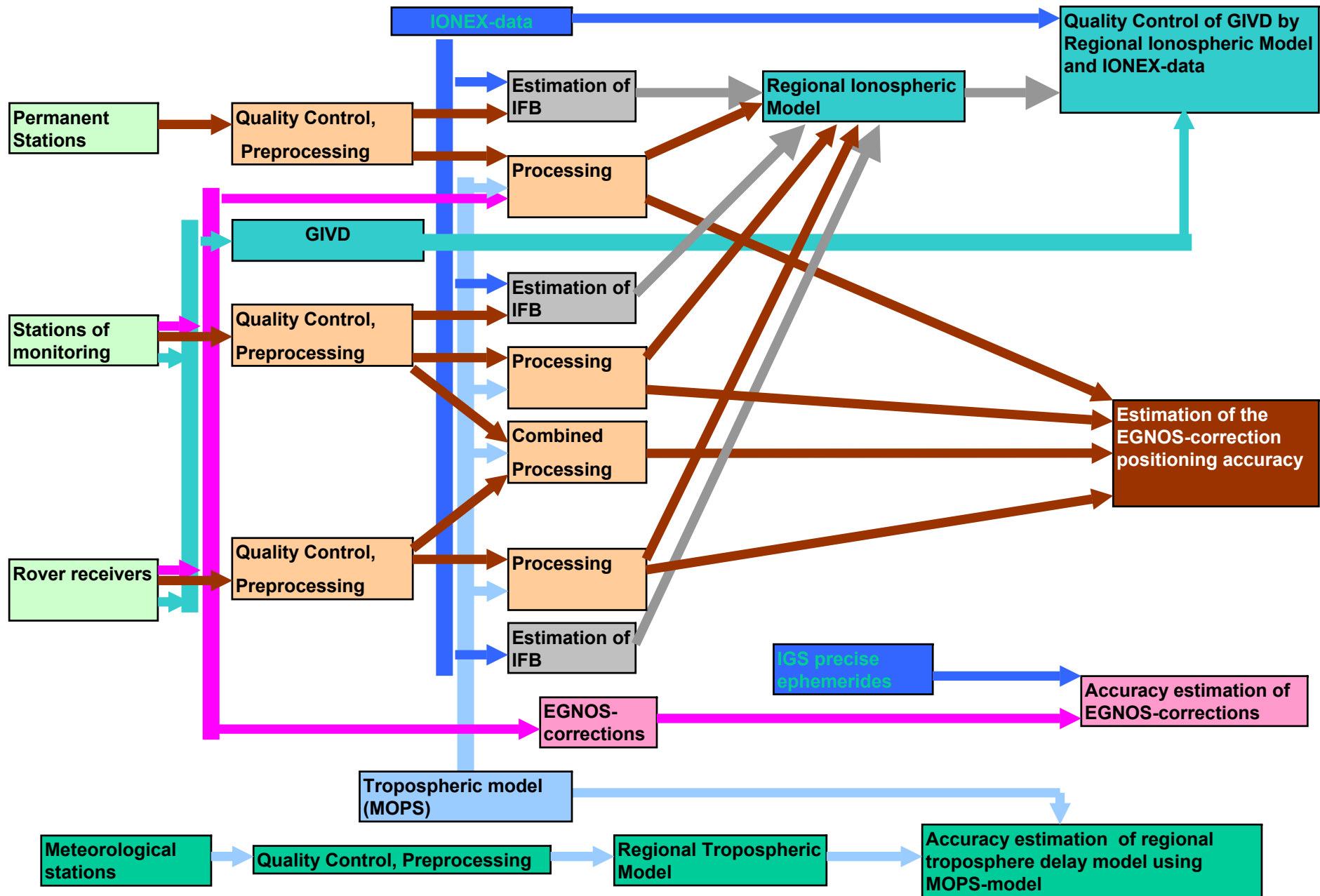
Gathering and processing of the results of experiments :

- data gathering of permanent reference GPS-stations of Ukraine and monitoring stations is carried out by use of Internet during twenty-four hours after the observation sessions
- gathering the data registered by the mobile laboratory by Internet
- data processing is done in the center (centers) of processing

Project of Experiments



Estimation scheme of characteristics of GPS/EGNOS navigation services



REFERENCES

1. НДР "Дослідження та визначення задач, способів і засобів технічної та метрологічної підтримки розгортання та експлуатації української частини наземного сегменту систем EGNOS і GALILEO", (шифр "EGNOS–ХНУРЕ/2005"): *"Розробка методів та методики контролю якості (точності та надійності) навігаційного забезпечення по сигналах GPS/EGNOS на території України", Пояснювальна записка; "Методика контролю якості (точності та надійності) навігаційного забезпечення по сигналах GPS/EGNOS на території України" (Проект); "Визначення задач, способів і засобів технічної та метрологічної підтримки розгортання та експлуатації української частини наземного сегменту систем EGNOS і GALILEO. Розробка переліку організаційно-технічних заходів щодо створення системи оцінки та моніторингу навігаційних характеристик GPS/EGNOS (у перспективі – GALILEO) на території України" // Харків, ХНУРЕ МОН України, НДЦ ІРЕСТ ХНУРЕ, червень – вересень 2005 р.*
2. L. Tytgat, F. Gustke, P. Verschueren, et al. *MUSSST, Methodology for GNSS Validation for Safety Critical Transports* // ION GPS 2000, 19-22 September 2000, Salt Lake City, UT, pp. 1807-1812, <http://www.mussst.com>
3. *Analyses of WAAS Performance in Iceland and at High Latitudes in the NAT area*, Icelandic Civil Aviation Administration and Innovative Solutions International, December 1999, <http://www.caa.is/gps/waas.htm>
4. H. Rho, R.B. Langley, *Assessment of WAAS Correction Data in Eastern Canada*, Geodetic Research Laboratory University of New Brunswick
5. M.E. Cannon, S. Skone, Y. Gao, Y. Moon, K. Chen, S. Crawford, G. Lachapelle, *Performance Evaluation of Several Wide-Area GPS Services*, ION GPS 2002, 24-27 September 2002, Portland, OR
6. В.П. Харченко, А.А. Жалило, В.В. Конин, В.М. Кондратюк - *Способы и средства оценки тактико-технических характеристик широкозонных функциональных дополнений GPS (GNSS)* // Аерокосмічні системи моніторингу та керування, Матеріали VI Міжнародної науково-технічної конференції, м. Київ, 26-28 квітня 2004 р., Том 2, с. 21.17 – 21.23
7. Carsten Butzmuehlen, Ralf Stolz, Dr. Richard Farnworth, Dr. Edward Breeuwer, *PEGASUS - Prototype Development for EGNOS Data Evaluation – First User Experiences with the EGNOS System Test-Bed.*
8. A.H. Dodson, W. Chen, H.C. Baker, N.T. Penna, G.W. Roberts, R.J. Jeans, J. Westbrook, *Assessment of EGNOS Tropospheric Correction Model*, ION GPS'99, 14-17 September 1999, Nashville, TN

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