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GLOBAL IONOSPHERIC MONITORING AND NAVIGATION SYSTEMS

J. Feltens[*], M. Angling[†], N. Jakowski[º], M. Hernández-Pajares[+] and R. Zandbergen[#]

[*] HP c/o European Space Agency/European Space Operations Centre/OPS-GN
Robert-Bosch-Str. 5
D-64293 Darmstadt, Germany
e-mail: Joachim.Feltens@esa.int
web page: http://www.esa.int/esaNA/SEMY3ZEFWOE_index_0.html
[†] QinetiQ Ltd., Centre for RF Propagation and Atmospheric Research
Malvern
Worcestershire, WR14 3LG, United Kingdom
e-mail: mjangling@qinetiq.com
web page: http:// http://www.qinetiq.com
[º] German Aerospace Centre (DLR), Institute for Communication and Navigation (IKN)
Kalkhorstweg 53
D-17235 Neustrelitz, Germany
e-mail: Norbert.Jakowski@dlr.de
web page: http://www.dlr.de
[+] Technical University of Catalonia (gAGE/UPC)
C/Jordi Girona, 1-3, Campus Nord, UPC, Edificio C3, Despacho 209
E-08034, Barcelona, Spain
e-mail: manuel@ma4.upc.edu
web page: http://www.gage.es
[#] European Space Agency/European Space Operations Centre/OPS-GN
Robert-Bosch-Str. 5
D-64293 Darmstadt, Germany
e-mail: Rene.Zandbergen@esa.int
web page: http://www.esa.int/esaNA/SEMY3ZEFWOE_index_0.html

Key words: GNSS based methods to monitor the ionosphere, analysis of pros and cons of different ionospheric techniques, identification of optimal modeling methods to meet especially navigation requirements.

Summary: This abstract highlights navigation-relevant aspects of the ESA TRP study "GNSS Contribution to Next Generation Global Ionospheric Monitoring" performed by a

study team of Hewlett-Packard (HP), QinetiQ Ltd., DLR and gAGE/UPC.

1 INTRODUCTION

Within a study team of four partners recommendations for a new ionosphere monitoring system were identified and formulated, meeting the requirements of different types of potential users, e.g. for operational now/forecasting but on the other hand also for scientific applications. A general overview of the study is presented in Ref. [3]. Here, those aspects of the study which are of special relevance for navigation shall be highlighted.

2 GNSS BASED METHODS TO MONITOR THE IONOSPHERE

There exist different global and regional GNSS networks allowing to monitor the ionosphere from ground through TEC observables derived from dual-frequency GNSS data:

- IGS: about 400 sites, data availability with 1 day, 1 hour and 15 minutes latency.
- EUREF: about 220 sites (some at the same time IGS sites), 1 day, 1 hour and 15 minutes latency.
- CORS: Continental US and some in the Pacific, Caribbean, Middle East, 1-2 hours latency.
- GEONET: more than 1200 sites in Japan, about 6 hours latency. In addition: DORIS, currently about 60 sites, 2 days latency if interest is indicated.

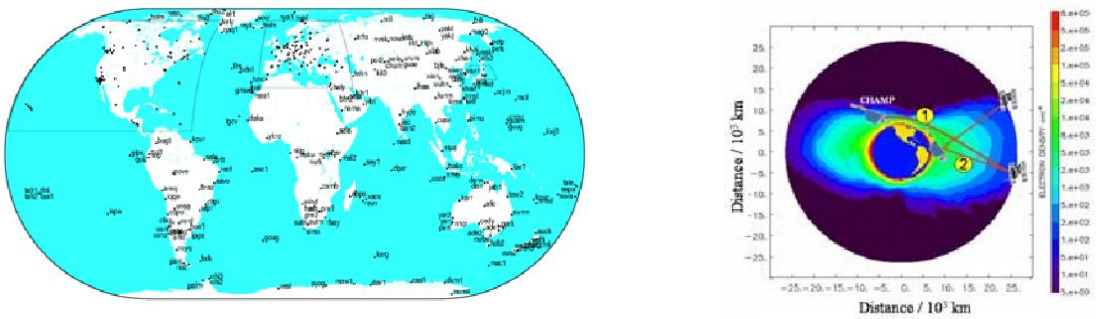

Figure 1: The global IGS GPS Network (left); ways of ionosphere monitoring with GNSS on LEOs (right)

Space based GNSS can be used to:

- Derive electron density profiles from LEO altitude down to the bottom of the ionosphere.
- Record TEC data from the LEO up to the GNSS spacecraft.

Future:

- About 1000 GNSS ground sites and about 90 GNSS spacecraft.
- Enhanced global coverage.
- More frequencies.

3 NAVIGATION-CRITICAL FEATURES OF THE IONOSPHERE

For navigation applications, the following major ionospheric features must be captured with sufficient temporal and spatial resolution:

- The major regions of the ionosphere: equatorial anomaly, midlatitude trough, auroral oval, Polar Regions.
- The typical variations of ionized layers: diurnal, seasonal, with solar cycle, latitudinal.
- The ionosphere's layered structure including the plasmasphere.
- Ionospheric disturbances: storms, Travelling Ionospheric Disturbances (LSTIDs & MSTIDs), scintillations.
- The ionosphere's coupling with other geo-spheres: namely magnetosphere, thermosphere, but also lithosphere, hydrosphere and atmosphere.

In turn GNSS systems could be used for:

- Solar flare monitoring.
- TIDs monitoring.
- Investigations into the so called 2^{nd} and higher order ionospheric terms.

4 EXISTING IONOSPHERE MODELLING TECHNIQUES

The study team models are:

- Electron Density Assimilative Model (EDAM), QinetiQ – different types of ionospheric observation data are assimilated into a background model. Currently IRI2007 is used as background.
- IONosphere MONintoring Facility (IONMON) Version 2, HP – Closed function approach describing ionospheric structures by vertical profiles combined with horizontal surface functions, no background, TEC and electron density data are processed.
- TOMographic IONosphere model (TOMION), UPC – The ionosphere is represented by two or more layers of voxels. In each voxel, electron density is assumed to be constant, no background, fed with different types of ionospheric observation data.

- Neustrelitz TEC Model (NTCM), DLR – This is a family of empirical TEC models developed for European and Polar cap regions so far. The TEC reconstructions used in this study are obtained by assimilating ground based TEC measurements into the European TEC model NTCM-EU. A global TEC model is planned to be developed.

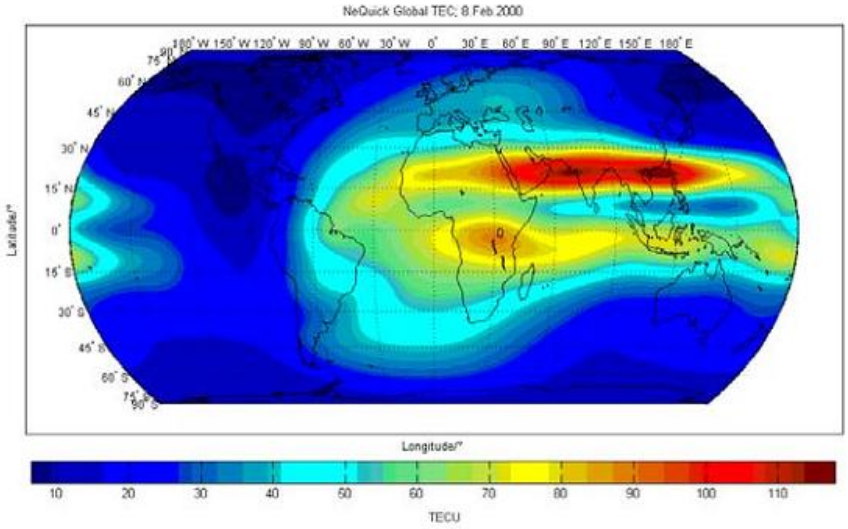

Figure 2: Global TEC map based on NeQuick model computations for the 8 February 2000.

Reference models considered in the study:

- NeQuick.(3-d global model, official ionospheric corrections model for Galileo users).
- IGS TEC Maps (2-d global TEC representations).

Further external modelling techniques were analyzed, e.g.: USU-GAIM, USC/JPL-GAIM, IonoNumerics, PRISM, PIM …

5 REQUIREMENTS ON NEW IONOSPHERE MODELING METHODS TO MEET NAVIGATION NEEDS

A new system should combine the advantages of different methods. Important appears to be a background model to create a median ionosphere, especially to create also good median TEC representations. This median ionosphere will then be upgraded by an assimilation technique with actual observation data, where available. These input data can be GNSS based and non-GNSS based (e.g. ionosondes, space based beacons, altimetry, DORIS). The new

system should describe the ionosphere 3-dimensionally and inhere to a certain extent some physics and allow for future extensions into the direction of a real physics-based model. The new system should be able to run in real-time and allow for ionospheric predictions.

Two major groups of potential users were identified:

1) Practically oriented users,
2) Scientific users.

Typical GNSS users belong to the first category. To fulfil their needs, a new ionosphere monitoring system should provide especially:

- Accurate ionospheric information.
- Near-real-time or real-time availability of ionospheric corrections & predictions.

6 CONCLUSIONS

Principally, the development of a New European Ionosphere Monitoring System should follow two strategic lines:

I) Development of a pragmatic solution for near-real-time data provision based on current near-real-time GNSS measurements.
II) Preparation of future oriented physics-based modelling techniques.

Both activities should be established and supported by ESA and European Commission simultaneously.

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