Orbit Determination in GEO using GPS or GALILEO

An interview with European and German control center navigation experts **Prof. Werner Enderle (ESOC)** and **Dr. Oliver Montenbruck (GSOC)** had the purpose to provide an overview and some pointers to more detailed information on the subject of orbit determination using the Global Positioning System (GPS) or GALILEO for satellites in Geostationary Orbit (GEO). The e-mail interview was coordinated by **J. Kehr, Editor SpaceOps News (SoN).**

SoN
What is the overall assessment using GPS for GEO orbit determination?

Oliver Montenbruck
The use of GPS in GEO has been heavily discussed for a long time and a couple of GEO capable GPS receivers have been developed by industry (MosaicGNSS, Topstar3000) already around the year 2000. However, GPS has not really been accepted by "conservative" telecom satellite owners and the matter has only received renewed attention in past two years. Among others, the use of GPS in GEO has been incorporated into the definition of a space user service volume for the next generation GPS III and ESA has initiated numerous studies for GPS/Galileo based navigation of GEOs. So far, to the best of my knowledge, no civil GEO satellite makes use of GPS, but there is a certain probability that some military satellites already use this technique. Within Europe a first flight of the MosaicGNSS receiver is planned on one of the SmallGEO (2012) missions.

SoN
What is the ESOC assessment?

Werner Enderle
As mentioned one has to distinguish between military and non-military applications. For the military part very little is known.
ESA has no own in situ experience yet, however – as also mentioned above – DLR is planning to fly an experiment using a Phoenix receiver receiver.

SoN
What are the methods for using GPS for GEO satellites?

Werner Enderle
There are two methods for using the GPS signal in GEO. Since the GPS satellites fly “below” (approx. 20.000 km) the geostationary orbit (36.000 km) one has to use either the GPS “backbeam” (not available yet) or one has to use the signal on the “opposite” side of the earth of appropriate available GPS satellites (see diagram). That takes advantage of the fact that although most of the GPS signal is “blacked-out” by the earth the beam width of the GPS antenna (27 deg) is wider than the shadow effect of the earth (21,5 deg) hence reduced signals of the GPS main and side lobes can be acquired.
Fortunately the signal strength is not all decisive since the PRN code can be recovered using cross correlation techniques.

SoN
What would be your conclusions and assessments of future developments?

Oliver Montenbruck, Werner Enderle
For LEO applications using GPS is standard. For MEO/HEO automatic applications would have the advantage that no tracking from ground stations is would be necessary (i.e. potential cost savings). GPS is planned as the primary navigation system for the US Magnetosperic Multiscale (MMS) mission which aimes at a launch in 2014.

For GEO applications the big advantage using GPS would be that because of the higher tracking accuracy more satellites could be co-located in one assigned “location box”. The disadvantages are higher cost for receivers because of non-standard and radiation hardened equipment to protect the receivers over the entire life-time of the satellite.

Military applications are classified because of strategic reasons and higher accuracy and security.

The reference papers below could be used for further information, addressing the authors directly.

References:

1) AAS 10-038 PREPARING THE GPS-EXPERIMENT
FOR THE SMALL GEO MISSION Peter Zentgraf, Hannes Filippi, Eveline Gottzein, Ignacio Gutiérrez-Cañas, Peter A. Krauss, Bernhard Lübke-Ossenbeck, Michael Mittnacht, Oliver Montenbruck, Pablo Rueda Boldo, Sten Berge, Camille Chasset, Mark Hartrampf, Christopher Kuehl, Carsten Müller, Attilio Truffi.

2) ESA bulletin 104 — November 2000 TOPSTAR 3000 – An Enhanced GPS Receiver for Space Applications.
J.L. Gerner Electrical Engineering Department, ESA Directorate of Technical and Operational Support, ESTEC, Noordwijk, The Netherlandse
J.L. Issler, D. Laurichesse CNES, Toulouse, France
C. Mehlen, N. Wilhelm Alcatel Space, Valence, France

3) Experience Using GPS For Orbit Determination of a Geosynchronous Satellite
J. D. Kronman, TRW, Inc

4) GPS Receiver Demonstration on a Galileo Test Bed Satellite
Takuji Ebinuma (Surrey Space Centre, University of Surrey)
Martin Unwin (Surrey Satellite Technology Ltd) (Email: M.Unwin@sstl.co.uk)
THE JOURNAL OF NAVIGATION (2007), 60, 349–362. f The Royal Institute of Navigation
doi:10.1017/S0373463307004365 Printed in the United Kingdom

5) AUTONOMOUS ORBIT DETERMINATION FOR FUTURE GEO AND HEO MISSIONS
José F. M. Lorga and Pedro F. Silva DEIMOS Engenharia S.A. Lisbon, Portugal
Fabio Dovis Politecnico di Torino Torino, Italy
Andrea Di Cintio Carlo Gavazzi Space Milan, Italy
Steeve Kowaltschek, David Jimenez, and Roger Jansson
ESTEC- European Space Agency Noordwijk, The Netherlands

6) ATTITUDE DETERMINATION OF AN USER SATELLITE IN A GEO TRANSFER ORBIT (GTO) USING GPS MEASUREMENTS
Werner Enderle
DLR Oberpfaffenhofen, German Space Operations Center, 82234 Wessling, Germany

7) Benefits of Galileo for Future Satellite Missions
Prof. Dr.-Ing. Werner Enderle
European Commission, Galileo Unit G3, Rue De Mot 28, Brussels, Belgium
e-mail: werner.enderle@esa.int

8) New Dimension for GEO and GTO AOCS
Applications Using GPS- And Galileo Measurements
Associate Professor Werner Enderle, Cooperative Research Centre for Satellite Systems, Brisbane, Australia
w.enderle@qut.edu.au
Dr Rodney A. Walker, Cooperative Research Centre for Satellite Systems, Brisbane, Australia
Dr Yanming Feng, Cooperative Research Centre for Satellite Systems, Brisbane, Australia
Will Kellar, Cooperative Research Centre for Satellite Systems, Brisbane, Australia

9) F.H. Bauer, M.C. Moreau, M.E. Dahle-Melsaether, W.P. Petrofski, B.J. Stanton, S. Thomason, G.A Harris, R.P. Sena, L. Parker Temple III, "The GPS Space Service Volume";
Proceedings of the 19th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2006) September 26 - 29, 2006, Fort Worth, TX (2006).

10) William Bamford, Jason Mitchell, Michael Southward, Philip Baldwin, Luke Winternitz, Gregory Heckler, Rishi Kurichh, Steve Sirotzky; "GPS Navigation for the Magnetospheric Multi-Scale Mission"; Proceedings of

the 22nd International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS 2009)
September 22 - 25, 2009; Savannah, GA (2009).

October 2011, Joachim J. Kehr (Editor SpaceOps News)