POTENTIAL CONTRIBUTION OF GALILEO TO THE TRF AND THE DETERMINATION OF ERPs

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1. INTRODUCTION

In addition to the existing GPS and GLONASS systems the EC and ESA plan to launch an European Satellite Navigation System (GALILEO) till end of 2009. 30 GALILEO satellites will populate three orbital planes with an inclination of about 56^o. This paper strives to summarize potential improvements in geodetic point positioning and especially in the determination of Earth Rotation gained from the combined use of all three systems or at least of GPS+GALILEO.

We made use of continuous measurements of a global GPS reference station network (about 95 stations, constrained to IGSb00) and estimated Earth Rotation Parameters with daily and hourly resolution. Subsequently we added simulated observations of the upcoming European GALILEO Satellite Navigation System and investigated their impact (decrease of formal errors due to number of observations and geometry) on geodetic point determination, on derived tropospheric delays and on the ERPs. This calculations are performed with the Bernese V5.0 Software and are based on two-frequency GALILEO signals (L1 and L5 frequency bands).

As a first result the geodetic point determination by means of GPS can be improved by about 55% by adding data from a largely interoperable GALILEO system with all remaining intersystem biases modelled correctly. Thus the well-known accuracy currently achievable with GPS positioning in 24 hour sessions of about 2mm in plane and 4mm in height will decrease roughly by a factor of two.

2. CONTRIBUTION OF GALILEO TO THE DETERMINATION OF POLAR MOTION, LOD, NUTATION RATES

Because of the higher altitude (about 23 600 km) of the GALILEO satellites the revolution period is about 14 hours and 5 minutes and far outside of the unpleasant 2:1 resonance of the GPS satellites with Earth Rotation. Thus, the GALILEO data may help to distinguish between orbital effects propagating into the ERP estimates and geophysical variations in high- frequency Earth rotation.

The relations between LOD and Nutation Offset Rates and the time derivatives of the orbital elements read:

$$
\begin{aligned}
(UT1 \dot{-} UTC) &= -LOD = -\rho \cdot (\dot{\Omega} + \cos i \cdot \dot{u}_0) \\
\delta\dot{\Delta}\epsilon &= \cos\Omega \cdot \dot{i} + \sin i \sin\Omega \cdot \dot{u}_0 \\
\delta\dot{\Delta}\psi \cdot \sin\epsilon &= -\sin\Omega \cdot \dot{i} + \sin i \cdot \cos\Omega \cdot \dot{u}_0
\end{aligned}
$$

LOD :

> LOD estimates are related to changes in the orbital nodes Ω and changes in the argument of latitude u_0. Therefore a drift in the node common to all satellites or

a common drift in the argument of latitude will directly propagate into the LOD estimates. Due to the similar inclination of the orbital planes of GPS and GALILEO this effect maps into LOD with almost the same factor for both systems.

Nutation Rates :

For nutation rates changes in u_0 from unmodelled perturbing forces are even more critical ($\sin i \approx 0.82$) but may average out because of the different node values for the different orbital planes. GALILEO offers 3 additional planes sometimes matching the GPS planes, sometimes expanding the variety of orbital nodes.

In summary all parameters are affected by unmodelled perturbing forces most likely stemming from deficiencies in the applied solar radiation pressure models. The quality of the solar radiation pressure model available for the GALILEO satellites will be of crucial importance for the contributions of this Satellite Navigation System to the estimation of LOD and Nutation Rates. Errors in the Earth potential model (possible node drift) affects the higher GALILEO orbits less than the lower GPS orbits.

3. CONCLUSIONS

The future GALILEO satellite navigation system will offer another powerful tool for point positioning and the determination of ERPs. Together with the already existing GPS and GLONASS systems about 80 satellites in MEO orbits will be available for geodynamic studies. GALILEO satellites are not in deep resonance with Earth Rotation.

GALILEO will offer about the same number of observations as GPS. The GPS based point determination can be improved by about 55% if data from a fully interoperable GALILEO system is additionally used.

The GALILEO data may help to distinguish between orbital effects propagating into the ERP estimates and geophysical variations in high- frequency Earth rotation. Especially Ocean Tidal Terms close to the diurnal frequency will be better determined than with GPS.

The quality of the solar radiation pressure model available for the GALILEO satellites will be of crucial importance for the contributions of GALILEO to the estimation of LOD and Nutation Rates.

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