USE OF GALILEO NEQUICK IONOSPHERIC ESTIMATION FOR SATELLITE OPERATIONAL ORBIT DETERMINATION

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ABSTRACT

Galileo is Europe's own global navigation satellite system, consists of a constellation of 30 spacecraft (24 operational in a Walker 24/3/1 constellation and 2 active spare satellites per plane) in MEO at 23222 km altitude. Four satellites have been already launched and positioned to the operational orbit, as part of the in-orbit validation phase, IOV. 22 more satellites have been contracted for the full operational capability, FOC. The next launches are scheduled in the time frame 2014-2015 from the Kourou Space Port, in French Guyana using the Soyuz/Fregat and Ariane-5 EPS launch vehicles.

The availability of Galileo service performance levels is driven by several factors, among them, the amount of station keeping manoeuvres needed during each of the satellites lifetime. During manoeuvres, the L-band ranging service provided by that particular satellite has to be interrupted as the broadcast ephemeris for the users is not accurate. In order to minimise the service outage, i.e. verify that manoeuvre has performed as expected and that no additional manoeuvres are needed, a fast and precise operational orbit determination has to be done using S-band ranging only.

Two-way ranging measurements can be taken through the TC/TM spread spectrum in S-band link between the ground station and the satellite. These S-band ranging measurements have proven to provide excellent results in terms of stochastic ranging errors. This performance, together with excellent stability of the station and satellite calibrations, makes the S-band ranging a quite accurate means for operational orbit determination.

As a way of further improving the orbit determination, effort will be put on enhancing the ranging modelling, in particular atmospheric correction. Currently, the operational orbit determination models used in Galileo for ionospheric correction rely on climatological models such as IRI. The latency of public updates of the required prediction parameters, together with

the fact that those updates are not under the control of Galileo, often introducing interface changes, motivated the search for alternative models, one of the options, the use of NeQuick model in Galileo, was considered very attractive for operational purposes.

NeQuick is a three-dimensional and time-dependent ionospheric electron density model based on an empirical climatological representation of the ionosphere, which predicts monthly mean electron density from analytical profiles, depending on the solar activity-related input values: R12 or F10.7, month, geographic latitude and longitude, height and UT It is recommended by the International Telecommunications Union for Total Electron Content (TEC) estimation used for radiowave propagation predictions. NeQuick model has been adapted for Galileo single-frequency ionospheric corrections (for convenience, referred to as NeQuick G) in order to derive real-time predictions based a single input parameter, the Effective Ionisation Level, Az, which is determined using three coefficients broadcast in the navigation message using L-band measurements of the whole satellite fleet from a world-wide network of sensor stations. The Galileo operational orbit determination process can, therefore, have direct access to up-to-date and accurate ionospheric corrections for the S-band range measurements. As such, NeQuick G represents an attractive and accurate source of ionospheric information that can be used by other satellite operators as well.

This paper presents the work performed in Mission Analysis Team at the Galileo Project in collaboration with the Wave Interaction and Propagation Section at ESA/ESTEC, in order to characterise the performance of NeQuick used in an operational orbit determination environment. Real S-band ranging measurements retrieved from the current two Galileo TTC ground stations and the four in-orbit satellites, will be processed using the current models and with NeQuick and compared to very precise reference orbits obtained as part of the L-band processing.