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IONOSPHERIC MONITORING PLAN AND ITS EFFECTS ON GNSS PERFORMANCE DURING ACTIVE YEARS OF THE SOLAR CYCLE

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Summary: This abstract presents a summary of the plans to monitor the ionosphere during the upcoming active years of the solar cycle for the understanding of its effects on GNSS Performance for European systems (EGNOS & Galileo).

1 INTRODUCTION

The performance of Global Navigation Satellite Systems (GNSS) with safety of life services, such as EGNOS and Galileo, is impacted by signal propagation impairments due to the ionosphere. The understanding of nominal ionospheric propagation behaviour is well established. Ionospheric effects follow variations depending on time-of-day, season, location and solar condition. The Sun activity exhibits a long-term variation following approximately an 11-year cycle, and after a long solar minimum during 2009, it is expected that the coming years will be active, increasing the likelihood to see abnormal effects affect GNSS systems.

Current systems are based on ionospheric models and data for nominal (monthly average) situations, however, exceptional deviations, such as those occurring during geomagnetic storms, are not properly predicted and therefore the effects on GNSS under those situations is not fully characterised. Those deviations are observed more frequently during active years of solar cycle. Ionospheric modelling is a challenging domain, depending on solar activity and its interactions with geomagnetic field; the ionosphere may deviate from its nominal behaviour. In those cases, it is essential for a safety of life system to confirm that the integrity of the computed ionospheric corrections is still maintained while

minimising the impact on availability and continuity of service. For this reason, accurate models or realistic synthetic/measured data of a disturbed ionosphere is needed for a complete system qualification.

The ionosphere information broadcast by EGNOS is a valuable element to estimate the group delay introduce by the ionosphere. Likewise, Galileo Signal-In-Space navigation message include input parameters for a model (based on NeQuick electron density model) in order to correct the delay for single-frequency receivers. Additionally, the availability of multiple signals will allow the receivers to accurately estimate the delay for the receivers with such capabilities.

On top of group delay, other effects are observed. Ionospheric amplitude and phase scintillations are important ionospheric impairments on GNSS signals affecting system performance for user receivers, but also for Sensor Stations in the ground segment of the GNSS system. Strong scintillations can induce cycle slips and loss-of-lock in GNSS receivers. Also large spatial and temporal gradients of electron density are observed in low latitude regions and they may impact the performance of safety-of-life carrier smoothing receivers.

For EGNOS and related Air Traffic Management operations, the assessment of the ionosphere impact over ECAC region (in terms of likelihood, severity, geographical area, duration, etc.) and the validation of mitigations are essential to determine the impact on current air traffic management operations. The adequate monitoring and prediction of the space weather effects affecting GNSS is required for operational systems and implementation of mitigation techniques. Galileo is a global system and the ionospheric effects on user performance at locations where they are more stringent, such as those around Geomagnetic Equator & Polar Regions (North and South) needs to be properly verified.

2 OBJECTIVES AND PRELIMINAR PLAN

The European Space Agency has started an activity to consolidate the knowledge related to the impact of ionospheric effects on the performance of GNSS (EGNOS and Galileo) systems, in particular those effects happening during extreme events during and around solar maximum. At the same time, Eurocontrol has initiated a related activity more oriented to the on GNSS-based aviation applications for different phases of flight over ECAC region.

This includes the plan and execution of an experiment to gather relevant data during active years of solar maximum, including external data providers from various ground-based and space-based instruments, and the installation of ground stations for specific investigations. Experimental stations in ECAC region but also in Equatorial and Polar locations will be considered, including scintillation measurements.

Eventually, the analysis of the observations will be performed providing results, in particular for short term extreme cases, and for long-term statistics, and synthesis into models, recommendations and conclusions useful for analysis of GNSS performance and development of mitigation techniques.