Performance evaluation of SBAS Systems due to Magnetic Storms in the Solar Cycle 24

Surendra Sunda[1*], Mahesh Lanka[1], Vineet Gera[1], L S R Mohan Rao[2]
[1]*Airports Authority of India, GNSS R & D Centre, Ahmedabad, India, ssunda@gmail.com*
[2] *Airports Authority of India, CHQ, New Delhi, India*

The maximum solar activity in the current solar cycle 24 (~2008 - 2019) was of moderate intensity, well below the predicted level. It is characterized by frequent Geomagnetic storms on Earth due the Coronal Mass Ejection (CME) and coronal holes. The severe geomagnetic storms can cause electrical power outages, failure of communication/navigation satellites, loss of HF communication links, Ionospheric disturbances affecting satellite navigation services (GPS, SBAS) etc. The Satellite Based Augmentation Systems (SBASs) have emerged as the robust navigation system especially for civil aviation and safety critical applications. Now, there are four operational SBAS systems worldwide after the commissioning of Indian SBAS-GAGAN. GAGAN helps in bridging the gap between coverage area of Europe's EGNOS and Japan's MSAS, and thus these four SBAS systems (including US WAAS) provides seamless air navigation in the northern Hemisphere. Apart from the enroute navigation service, these SBAS systems (excluding MSAS) are certified for providing precision approach services (APV1) to guide the aircraft for landing.

The present paper evaluates the performances of worldwide SBAS systems during the severe storms of the solar cycle 24. There are total 4 storms of severe intensity according to the Dst index exceeding -100 (nT). These are – 17 March 2015; 22-23 June 2015; 8 September 2017; and 26 August 2018. The impact of these storms on SBAS is quantified in terms of the availability of the prescribed navigation service, especially for APV1 service. The navigation service is termed as unavailable when horizontal or vertical protection limits exceeds their respective thresholds. This happens especially due to higher ionospheric gradients during ionospheric disturbances, which increases the error bound to maintain the integrity of the system. The underlying ionospheric phenomenon is investigated to understand the impact of storm induced ionospheric disturbances. It is observed that there is immediate impact on WAAS and EGNOS systems in terms of degraded availability during the onset of storm. The WAAS availability of LPV service reduces to ~80% during the peak time of 17 March storm. The storm on 22-23 June had lesser impact on SBAS systems compared to 17 March storm, although both storms were of equivalent category. The impact of storm on GAGAN system was observed to be lesser than the EGNOS and WAAS systems. In fact, availability of GAGAN precision approach service (APV1) remained unaffected during the geomagnetic storm of 22-23 June 2015. The results indicate that the geomagnetic storms do not have much impact on SBAS systems over equatorial and low latitude region as compared to those in mid and high latitude region.

The TEC maps using GAGAN corrections were generated over Indian region and compared to TEC maps obtained from dense network of 25 TEC and Scintillation monitoring receivers (GSV4004A). The differences between modeled and true measurements were evaluated to be within the bounding of GIVE (Grid Ionospheric Vertical Error). This is more critical requirement for safety-of-life applications like civil aviation.

The detailed analysis of ionospheric response to these storms over SBAS coverage areas will be presented in the paper. The validity or the suitability of Kp index and Dst index as the

indicator of storm activity in terms of SBAS performance will be also investigated.

In addition to that, the status of implementation of GBAS and SBAS over Indian region will also be presented.

Keywords: SBAS, Ionosphere, Geomagnetic Storm, GAGAN, Navigation