<u>*International Civil Aviation Organization*</u>

THE FOURTH MEETING OF IONOSPHERIC STUDIES TASK FORCE (ISTF/4)

New Delhi, India, 05 – 07 February, 2014

Agenda Item 4: Review of progress of tasks and related action items

f) Task 6 - Space Weather

CONSIDERATIONS ON SPACE WEATHER FOR GNSS IMPLEMENTATION IN THE LOW MAGNETIC LATITUDE REGION

(Presented by Japan)

SUMMARY

This working paper briefly reviews the Space Weather Concept of Operations (Space Weather ConOps) being developed by ICAO and presents some considerations on the use of space weather information for GNSS implementation in the low magnetic latitude region.

1. INTRODUCTION

1.1 Utilization of space weather information has recently been noteworthy in terms of its application into safe and efficient aircraft operations. *Concept of Operations for International Space Weather Informationin Support of Aviation* (hereafter referred to as Space Weather ConOps) [1], which are under review by an ICAO meteorology expert group, suggests that space weather information can be exploited to mitigate HF communication disruption, GNSS failure, or radiation dose by high-energy particles.

1.2 The 23rd meeting of APANPIRG adopted a Decision inviting CNS and MET Sub Groups to review the impact of Space Weather on their areas. The CNS SG meeting reviewed the impact of Space Weather on aeronautical Communication and Navigation Services.

1.3 The 17th meeting of CNS subgroup of APANPIRG decided that, the Terms of Reference of Ionospheric Studies Task Force be modified to include Space Weather studies particularly with reference to its effects on aeronautical Communication and Navigation (Decision 17/13).

1.4 In response to the decision 17/13 adopted by the CNS-SG/17, the third meeting of ISTF revised it terms of reference to include investigate the effects of space weather on CNS systems in the APAC Region and created a new task, Task No. 6 "Space Weather".

2. DISCUSSION

2.1 Space weather can be defined as "*the conditions on the sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health of aviation flight crews and passengers"* [2]. Thus space weather phenomena have a wide range of varieties. For practical use of space weather information for aviation, classes of space weather phenomena that may impact on aviation need to be identified.

2.2 The Space Weather ConOps identifies functional and performance requirements for space weather for aviation. According to the Appendix C of Space Weather ConOps, five classes of space weather phenomena are identified.

1) geomagnetic storms
2) solar radiation storms
3) radio (HF) blackout events
4) galactic cosmic rays
5) ionospheric activity

2.3 Among the five classes, solar radiation storms and garactic cosmic rays causing enhanced radiation dose of the have impact aviation mainly in polar region. They enhances the radiation dose of passengers and crew at high altitudes in the polar route. solar radiation storms can also cause HF radio blackouts over the polar region (Polar Cap Absorption Event). These are global scale phenomena affecting the aviation in the high latitude region, which should be treated at the global level in ICAO.

2.4 Intensity of radio (HF) blackout events caused by solar flares is stronger when the solar zenith angles are high. Thus, it is more intense in the low latitude region near the sub-solar point. However, this is also a global scale phenomena which should be treated at the global level.

2.5 Geomagnetic storm is a global phenomena and should also be treated at the global level. Geomagnetic storm is closely related to ionospheric activity. And the effects of geomagnetic storm on the ionosphere are different for latitudes. Even in the low latitude region, the effects are very different. For example, during the magnetic storms, eastward electric field is sometimes enhanced in the dayside and transport ionospheric plasma poleward. This cause decrease in the ionospheric density inside the Equatorial Ionization Anomaly (EIA) crests and enhancement outside the EIA crests. Geomagnetic storm can cause the decrease in the ionospheric density, called the negative storm, and lower the maximum useable frequency of HF communications. It is caused the thermospheric composition changes induced by enhanced auroral activities in the high latitude region and propagates lower latitudes. It is noteworthy that the area of the negative storm is not global and relatively localized. Thus, the effects of geomagnetic storms on the ionosphere have local variabilities.

2.6 The ionospheric activity is NOT always related to geomagnetic storms. Especially in the low and lower mid-latitude region, ionospheric variability occurs without geomagnetic storms. For example, latitudinal locations of EIA crests changes day-by-day to cause the significant shift in locations of Ionospheric delay gradients. Plasma bubble is a low latitude ionospheric phenomenon that accompanies very sharp (local) ionospheric delay gradients and also causes scintillation in VHF to L-band trans-ionosphere propagating radio waves. Although some plasma bubbles are excited by geomagnetic storms, the most of plasma bubbles are generated without geomagnetic storms. It is believed that the thermospheric dynamics play an important role in EIA variation and plasma bubble generation. The thermosphere is a part of space weather [1], but needs quite different treatment compared with other classes of space weather phenomena listed in the Space Weather ConOps.

2.7 From the point of view of the low latitude region, ionospheric activity is of the special interest. Focusing on local effects of geomagnetic storms on the ionosphere and EIA variation and plasma bubbles without geomagnetic storms could be effective, because the current Space Weather ConOps that is globally oriented may not cover them.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information presented in this paper

b) discuss any relevant matters as appropriate.

4. References

[1] Concept of Operations(ConOps) for theProvision of Space Weather Information in Support of International Air Navigation, Draft Version 2.2, December 2012.
[2] Office of the Federal Coordinator for Meteorology (OFCM), The National Space Weather Program. The Implementation Plan: 2nd Edition, July 2000. Committee for Space Weather, Office of the Federal Coordinator for Meteorological Services and Supporting Research, Washington, D.C., 2000.

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