International Civil Aviation Organization

THE SIXTH MEETING OF IONOSPHERIC STUDIES TASK FORCE (ISTF/6)

Bangkok, Thailand, 19 – 21 January 2016

Agenda Item 4: Review of deliveries of Tasks and related Action Items

e) Task 5 – Iono Models

IONOSPHERE THREAT MODEL FOR SBAS

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SUMMARY

This paper presents the discussions on Ionosphere Threat Model for SBAS at webconferences held after ISTF/5. Operational hazards related to the ionospheric threats and factors influencing the mitigation strategy are identified. The structure of Guidance Material is discussed and the table of contents is proposed.

1. INTRODUCTION

1.1 Various ionosphere models, both theoretical and empirical, have been developed to provide information on ionospheric activities and ranging delays. Augmentation systems need to generate ionospheric corrections meeting integrity requirements.

1.2 Ionosphere Threat Model is used to meet integrity requirements. This means safety margin against to possibilities of the ionospheric irregularities ‘unobserved’ (spatially and/or temporarily) from the ground stations.

1.3 Each existing SBAS has its own ionosphere threat model to generate ionospheric correction information meeting integrity requirements. Each threat model should fit to its own service region. For our cases, we need the threat model for Asia Pacific Region.

1.4 SBAS Ionospheric Correction and Integrity Parameters. Vertical ionospheric delay information at IGPs (ionospheric grid point) is broadcast to users by SBAS. It includes integrity parameters called GIVE (grid ionosphere vertical error) representing uncertainty involved in the associate ionospheric correction. It should be noted that GIVE has to be computed with consideration of spatial and temporal threats, which means local and/or short-term irregularities not sampled by any ground stations. SBAS must protect users against such irregularities.

1.5 Creation of Threat Model. The ionospheric threat model may be created based on the historical severe ionospheric storm data. For this purpose, creation of threat model requires archive of GNSS data for a whole solar cycle (11 years), or at least during the latest peak of solar activity. A way to create the spatial threat model available for SBAS is 'data deprivation'.

2. Discussion

2.1 Operational Hazards related to the ionospheric threats are identified as follows:

- Mainly the problem is spatial threats. The threat means local ionospheric irregularities observed from some users, but NOT observed from ground stations. Temporal threat may also be a problem; But we should take care of this kind of threat with enough archive data.

- In general, the ionospheric error roughly relates to vertical position error. In approach modes with vertical guidance, an insufficient ionospheric threat model may cause a safety problem.

- Integrity events of operational systems: So far, no integrity event due to ionosphere is reported for the operational SBAS systems. We can check integrity, if GIVE always overbounds the actual ionospheric error everywhere, using 'Triangle Chart' for this purpose. If integrity is not met, we can increase the threat model; Larger threat model means safety, but resulting less availability.

- A concern may be 'Plasma Bubble' because for example the ionosphere model for some SBAS does not contain information about plasma bubble explicitly. It can be interpreted that plasma bubble events are implicitly bounded by the safety margin thanks to ionospheric threat model.

2.2 Factors influencing the mitigation strategy are identified as follows:

- **Observability of ionosphere**
  - The mitigation strategy is influenced (or constrained) by:
    - ✧ The number and distribution of ground stations.
    - ✧ The number of signal sources and the number of core constellations in use.
  - The dense observation of ionosphere reduces the spatial threat.
  - Some external network may be used for generation of the threat model.
    - ✧ Threat model might be refined if a larger network is available.

- **Ionosphere model for correction**
  - Accurate ionosphere model (with enough observations) reduces the threat.
  - Is the planar ionosphere model adequate for the equatorial regions?
    - ✧ What model can represent equatorial anomaly?

- **Archive data available for creation of threat model**
  - Basically, the threat model is created from the residual of corrections with regard to given algorithms and parameters for generation of SBAS ionosphere messages.
  - For creation of the threat model, we need archive data for a certain period.
    - ✧ Hopefully for a whole solar cycle.
  - The quality of resulted threat model depends upon the period and region of the archive data used.
    - ✧ More data makes the threat model accurate.

- **Implementation issue**
  - The SBAS already exists; Some SBAS are in development phase.
  - The mitigation strategy needs to be adaptable to the existing SBAS systems.
    - ✧ Simply change of the threat model if the algorithm is same.
    - ✧ Different model for the different correction algorithm.

2.3 Guidance Material. The structure of guidance material for ionosphere threat model for SBAS is discussed. The table of contents is proposed as:

(1) GNSS overview

(2) Ionospheric correction by SBAS
- Broadcast information
- Protocol of ionospheric correction and protection levels computation
- Generation of ionospheric correction information inside SBAS

(3) Necessity of the threat model
- Overbounding uncertainty; Spatial and temporal threats

(4) Creation of the threat model
- Function of observability of ionosphere and ionosphere model used
- Necessary to archive data for a certain period: How long?

(5) Threat mitigation strategy
- Improvement of availability and continuity of the system
- The smaller threat model, the better performance
- Meeting integrity requirements is essential property for threat models

3. ACTION REQUIRED BY THE MEETING

3.1 The meeting is invited to do the following:

a) Adoption of discussions at the webconferences shown above;

b) Adoption of proposed contents of Guidance Material shown above; and

c) Discussion on schedule to have the draft Guidance Material

End of March, 2016	Prepare and circulate a draft to ISTF members.
End of April, 2016	Expect feedback by this date
Mid of May, 2016	Complete the draft Guidance Material.

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