INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA/PACIFIC OFFICE

WORKSHOP ON IONOSPHERIC DATA COLLECTION, ANALYSIS AND SHARING IN SUPPORT OF GNSS IMPLEMENTATION

(BANGKOK, 5 – 6 MAY 2011)

REPORT ON OUTCOME

1. INTRODUCTION

1.1 In response to the outcome of CNS/MET SG/14 and APANPIRG/21, a Workshop on Ionospheric Data Collection, Analysis and Sharing in Support of GNSS implementation was held at ICAO Regional Office, Bangkok, Thailand from 5 to 6 May 2011.

1.2 The Workshop was attended by 20 participants from nine Administrations. The list of participants is provided in the **Attachment 1** to this Report.

1.3 In his welcome remarks, Mr. Li Peng, Regional Officer CNS, ICAO Asia and Pacific Regional Office provided the background information on the Workshop and highlighted the need for the characterization of ionosphere throughout the Region. Dr. Susumu Saito, Senior Researcher, Japan Electronics Navigation Research Institute (ENRI) underlined the objective of the Workshop. Mr. Jeffrey Bollard, Chairman of the CNS/MET Sub-group of APANPIRG provided guidance to the Workshop from the perspective of the Sub-group.

1.4. Dr. Susumu Saito, nominated expert by Japan as Technical Lead for the Workshop, was the facilitator of the Workshop. Messrs. Li Peng and Sujan Saraswati, Regional Officers for Communications, Navigation, and Surveillance, were the Secretaries for the Workshop.

1.5 The objective of the Workshop was as follows:

- to enhance understanding of ionospheric issues in GNSS operations;
- to exchange information and experience gained on GNSS and ionosphere related activities by each Administration;
- to understand the need to carry out the ionospheric studies;
- to discuss a common procedure for collecting ionospheric data by Administrations;

- ultimate outcome is a standard ionospheric model for GNSS operations applicable throughout the Region; and

- the final goal is to facilitate GNSS implementation in the Asia and Pacific Regions by mitigating ionospheric issues.

2. DISCUSSIONS

2.1 A list of presentations and papers is provided in **Attachment 2** to this Summary Report. 8 presentations from the Secretariat, Japan, India, Australia, Hong Kong China, Singapore and Thailand and 2 information papers were presented to the Workshop under the work programme adopted for the Workshop.

2.2 The Secretariat provided introduction to the Workshop and highlighted the importance of coordination and cooperation on ionospheric data collection, analysis and sharing, particularly during the approaching solar maximum period, with an objective to achieve the goal of developing an ionospheric model for the Asia and Pacific Regions in support of GNSS implementation.

2.3 Presentations made by Japan, Australia and India comprehensively discussed Ionospheric Effects on GNSS operations and informed the meeting about the work that has already been carried out in their administrations. Hong Kong China, Singapore and Thailand provided information on their GBAS roadmap and/or activities for ionospheric study that are being carried out in their administrations. Hong Kong China proposed that GNSS data collected by other organizations should also be used for the study. Hong Kong China advocated the concept of sharing of GNSS data not only within civil aviation community but also with other community in the Asia and Pacific Regions. To this end, support from APEC and UN agencies on sharing of GNSS data collected by other communities should be sought (such as the Permanent Committee for GIS Infrastructure for Asia & the Pacific working on The Asia-Pacific Reference Frame Project).

Initial discussion on the sharing of data collected

2.4 The Workshop initially discussed what is necessary and what is missing for the requirement of SBAS and GBAS. The Workshop also reviewed the type of GPS receivers, data fields, sampling interval and different level of data to be shared as proposed by Japan, and the willingness of each Administration to share data at levels 0, 1 or above etc. The data sharing levels/format proposed by Japan is provided in **Appendix A** to this Report. Singapore highlighted that it might not be possible for the States to share all raw data due to the huge size and suggested to share the worse case data only. However, Japan explained that the nominal background condition which would contribute much for availability of the system needs to be defined in addition to the worse case scenario which represents anomalous ionospheric condition.

2.5 The advantages of analysis using historic data since year 2000 were discussed. Different GNSS data sharing scenarios were also explored. There are data sharing and processing mechanism in place for data exchange between Australia and New Zealand. Australia proposed that sharing the collected data at sub-regional level or at the level of couple of States rather than sharing by the whole Region may also be considered.

2.6 India expressed that sharing raw data collected would be a tremendous work for the group. India also agrees with Singapore to collect critical data if sharing all raw data is not necessary and suggested to establish a core group to steer evaluation of the data. The results of analysis should be shared among States contributing their GNSS data. A common regional model to be developed should be provided to all GBAS vendors to fine tune their products for use in the Asia and Pacific Regions. Australia identified a need to evaluate if there is an ionospheric threat in the Asia and Pacific Regions, which is not contained in the US CONUS model.

2.7 Japan agreed to take the technical lead for regional data analysis and ionospheric model development.

3. RECOMMENDATIONS

3.1 As a result of discussions, the Workshop developed following recommendations for consideration by the fifteenth meeting of the CNS/MET Sub-group of APANPIRG to be held from 25 to 29 July 2011 in Bangkok. These recommendations are to be addressed by the Sub-group, ICAO and States, as appropriate.

a) States are urged to coordinate with their relevant national organizations for sharing the available GNSS data collected to facilitate characterization of ionosphere to support the implementation of GNSS applications for civil aviation purpose;

b) A Task Force needs to be established with an objective to identify the need for Regional Ionospheric Threat Models for GBAS and SBAS and create them if required; and

c) ICAO Regional Office should coordinate with APEC GIT for the initiative being carried out for ionospheric data collection, analysis and sharing. APEC Economies should be requested to support this initiative by encouraging relevant agencies in each Economy to share GNSS data collected with the civil aviation community.

4. ACTIONS ITEMS

4.1 The Workshop also developed following action items to be progressed by the participating administrations and ICAO Secretariat:

i) Japan to develop Template for Ionospheric Data collection in coordination with the other States and get it distributed through ICAO APAC Office before first week of June 2011;

ii) Secretariat to explore with UN agencies (such as the Permanent Committee for GIS Infrastructure for Asia & the Pacific working on The Asia–Pacific Reference Frame Project) on the possibility of sharing their GNSS data collected; and

iii) Mechanism for analysis of the GNSS data to be decided in the next Task Force meeting. Japan to host the next Task Force meeting should the establishment of Task Force be endorsed by CNS/MET Sub-group of APANPIRG.

— END —

Workshop on Ionospheric Data Collection, Analysis and Sharing to Support GNSS Implementation

Bangkok, Thailand
5 – 6 May 2011

Attachment 1 to the Summary Report

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Attachment 2 to the Summary Report

International Civil Aviation Organization

Workshop on Ionospheric Data Collection, Analysis and Sharing to Support GNSS Implementation

Bangkok, Thailand, 5 – 6 May 2011

LIST OF INFORMATION PAPERS AND PRESENTATIONS

IP/SP No.	Subject	Presented by
	INFORMATION PAPERS	
1	Meeting Bulletin	Secretariat
2	Ionospheric Effects on SBAS Performance	India
3	Ionospheric Data Collection Focal Point of Contact	Secretariat
	PRESENTATIONS	
0	Brief Background and Objective of the Workshop	Japan
1	GNSS for Aviation – a Brief Background	Secretariat
2	Ionospheric Effects on SBAS Performance – Indian perspective	India
3	Ionospheric Effect on GBAS and Mitigation Techniques	Japan
4	Low-Latitude Ionospheric Disturbances with a Special Emphasis on Equatorial Anomaly and Plasma Bubbles	Japan
5	GBAS Ionospheric Threat Evaluation in the Mid-latitude Australian Region	Australia
6	Activities for Ionospheric study for Ground Based Augmentation Systems (GBAS) in Singapore	Singapore
7	GBAS Road Map – Hong Kong, China	Hong Kong, China
8	Ionospheric Data Collection in Thailand	Thailand

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What is necessary and what is missing

SBAS

- Large-scale ionospheric variability associated with Equatorial Anomaly
  - Wide-area ionospheric delay map in this region
- Estimation of potential error due to ionospheric gradients associated with plasma bubbles
  - Size, gradient, velocity, total delay difference, occurrence frequency
- Scintillation monitoring for plasma bubble detection
  - Occurrence frequency, drift velocity

* GBAS
  - Ionospheric gradient associated with plasma bubbles
    - Gradient, velocity, total delay difference, occurrence frequency, number of bubbles at the same time
  - Background ionospheric variability associated with Equatorial Anomaly
    - Occurrence probability distribution of gradients

* Other ionosphere related data (e.g. ionosonde, etc.) are helpful for data screening and understanding of anomalies

Example of observations

* Ionospheric delay
  - Multi-point observations with dual-frequency receivers (How many receivers?)
  - Single point observation with a dual-frequency receiver
  - Gradient observations with receivers with short baselines (how many sets?)
* Scintillation
  - Multi-point observations of scintillation receivers (How many receivers?)
  - Single point observation with a scintillation receiver
  - Irregularity drift velocity observations with closely separated receivers (how many sets?)
* Other supporting parameters
  - Ionosonde
  - ...

How data to be collected and shared

* Data collection procedure
  - Receiving antenna geometries (number of receivers, distance, alignment, etc.)
  - Sampling interval
  - Receiver performance (for delay estimation and scintillation observation)
* Data analysis procedure
  - Delay estimation with a dual-frequency method including inter-frequency biases (satellite and receiver) estimation
  - Gradient estimation
  - Scintillation index and drift velocity estimation
* Data exchange format
  - RINEX (Receiver INdependent EXchange) format for rawdata
  - Other formats for delay and scintillation

Levels of data to be shared

* Ionospheric delay
  - Level 3
    - Vertical delay at grid points
    - Delay gradient
  - Level 2
    - Slant delay (slant delay for each satellite, satellite positions, biases)
  - Level 1
    - Human readable (e.g. RINEX) raw data (pseudo-range, carrier-phase and C/N0 and locktime for each satellite, ephemeris)
  - (Level 0)
    - Receiver specific raw data

* Scintillation
  - Level 3
    - Irregularity drift velocity
  - Level 2
    - Scintillation indices (amplitude and phase, and correlation coefficients and lag times, if applicable)
  - Level 1
    - Receiver independent raw data (time-series of C/N0 and carrier-phase for each satellite, ephemeris)
  - (Level 0)
    - Receiver specific raw data

Exact receiver positions are necessary for Level 0-2