International Civil Aviation Organization

THE SECOND MEETING OF IONOSPHERIC STUDIES TASK FORCE (ISTF/2)

15 – 17 October 2012, Bangkok, Thailand

Agenda Item 5: **Review Progress of Tasks**

a) Task 1 – Data Collection

DATA FORMAT FOR SHARING IONOSPHERIC DELAY MEASUREMENTS

(Presented by Japan)

SUMMARY

This paper presents an example of data format for sharing ionospheric delay measurements. The data format is proposed as a common data format to share ionospheric delay data in ISTF activities.

1. INTRODUCTION

1.1 The first Ionospheric Studies Task Force (ISTF/1) meeting identified five tasks with their sequence. Task 1 is "Data Collection" which is responsible for collection, integration, administration and distribution of data collected from States and Administrations (Ref. WP8, APANPIRG CNS/MET SG-16).

1.2 The Task Details of the Data Collection task include defining data sharing format.

1.3 The data sources identified by the Data Collection Templates include various kinds of receivers (Ref. WPX, ISTF/2) both for ionospheric delay and ionospheric scintillation. To facilitate data sharing among parties involved in the ISTF activities, common data formats need to be defined.

2. DISCUSSION

2.1 There are two kinds of ionospheric data relevant to the ISTF activities. One is the ionospheric delay (or equivalently the ionospheric total electron content: TEC) data, and the other is the ionospheric scintillation data. Because these are totally different items, two different data formats are necessary to record the ionospheric delay and ionospheric scintillation data.

2.2 The data format can be either in binary or human readable text format. Binary data formats generally have smaller file size, however, it is difficult for humans to read binary data directly without a special software. Text data formats are directly human readable, though they generally need bigger file size than binary formats. Considering that the disk space is getting cheaper and the network bandwidth is getting more affordable, text data formats would be preferable to share data among a number of parties involved in the ISTF activities.

2.3 National Institute of Information and Communication Technology (NICT), Japan has been developing a format of ionospheric TEC data named "GNSS TEC Exchange Format (GTEX)". It records slant TEC data for each satellite in a format similar to the RINEX (Receiver Independent Exchange). The draft of the GTEX format is described in Attachment 1 of this paper.

2.4 Because the GTEX format has a similar look as the RINEX (Receiver Independent Exchange) format, which is commonly used in GNSS related works to record GNSS data, it would be friendly to those who have been involved in GNSS related studies because the data are human readable and meanings of data fields are clearly defined.

2.5 A tool to convert RINEX data into GTEX is available from NICT which can be used to generate TEC data from shared data in RINEX or receiver specific formats as well as to generate TEC data to share in such a case where sharing of raw GNSS measurement data are not permitted.

2.6 To define a ionospheric TEC data format suitable for ISTF activity, feedback from the ISTF members is absolutely necessary. It would be useful to discuss the data format through the ISTF Forum on the ICAO portal website.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) review the data format of ionospheric delay measurements presented in this Working Paper; and

b) consider the data format as a basis of the common data format for sharing ionospheric delay measurements; and

c) participate in discussion on data format on ionospheric delay data through the ICAO ISTF Forum.

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ATTACHMENT

GTEX: The GNSS-TEC Exchange Format

Draft 0.1

5 October 2012

1. Background

The purpose of the GTEX (GNSS-TEC Exchange Format) is to share slant TEC data from each receiver. By sharing slant TEC data which are not converted to vertical TEC, various ionospheric studies may be possible without affected by specific analysis procedures such as satellite/receiver bias estimation, or different mapping heights. Thus, slant TECs include biases arising from inter-frequency bias of satellites and receivers.

The structure of GTEX is designed in such a way that the structure is as close to RINEX 2 as possible, because RINEX 2 is a *de facto* standard in exchanging GNSS observation data and potential users of GTEX would be familiar with RINEX 2.

GTEX may include more data relevant to TEC analysis in the later revisions. The format is designed to allow future extension.

2. General Description

The GTEX data file consists two parts, the header and the TEC data blocks.

The header block structure is similar to that of RINEX 2. All the header items defined in RINEX 2 can be used in GTEX as well. Two observation type descriptors, “TR” for slant TEC including bias (“raw TEC”) and “TF” for TEC status flag, are introduced. There is an additional header item to describe the unit of TEC.

The TEC data block starts from a line(s) with a time stamp and list of satellites with the same format as “EPOCH/SAT” field of RINEX 2. Following the EPOCH/SAT field, TEC data as defined in “# / TYPES OF OBSERV” are recorded. After the record of TEC data for all the satellites, data set of the next epoch follows.

3. Example of data in GTEX

An example of TEC data in GETX is shown below. The data was obtained from 0 GPS Time on 11 May 2012 at “0132” station, one of the GEONET stations and analyzed by NICT. The sampling rate is

30 sec. The file name format is similar to the RINEX format and defined as follows: {SSSS}{DDD}0.{YY}_TEC ; where SSSS is the four-character marker name, DDD is the day of year and YY is two-digit year. In this case, the file name is 01321320.12_TEC.

First 18 lines describe the header. Two observables, raw slant TEC and TEC status flags, are recorded. The TEC data block starts from the 19th line. The first epoch is 00:00:00 GPS Time on 11 May 2012. 9 GPS satellites (PRN 21, 9, 18, 15, 28, 5, 27, 8, and 26) were tracked. From 20th to 28th lines describe slant TEC and TEC flags. Slant TEC values are negative, because of satellite and receiver biases. All the TEC flags are 0, meaning that all the slant TEC data are normal.

Example of GTEX data

(Filename: 01321320.12_TEC)

```
     2              TEC DATA            GPS                 TEC VERSION / TYPE
RNX2TEC V2.5       NICT, JAPAN                             PGM / RUN BY
     0                                                     EXPONENT OF TECU
     TEC values in 10^16 el/m^2 (1 TEC Unit)               COMMENT
     TEC Status Flag = 0 : Normal data                     COMMENT
                       = 1 : Lack of observables (TEC=999.)COMMENT
                       = 2 : Too large TEC (TEC=999.)      COMMENT
                       = 4 : Cycle slip (TEC discontinuity)COMMENT
                       = 5 : Cycle slip (LLI)              COMMENT
                       = 6 : Beginning of arc              COMMENT
     TYPES OF OBSERV = TR : Raw slant TEC including bias   COMMENT
                       TF : TEC Status Flag                COMMENT
01321310.12o  01321320.12o  01321330.12o                   RINEX FILE NAME
0132                                                       MARKER NAME
00000               TPS NETG3           3.4 EG3 Jul,02,2010 REC # / TYPE / VERS
                    TRM29659.00     GSI                    ANT # / TYPE
 -3690821.3891  2897721.3097  4305504.4426                APPROX POSITION XYZ
       42.7294      141.8640        0.0486                POSITION LAT LON ALT
     6    L1    C1    L2    P2    S1    S2                COMMENT
     2    TR    TF                                        # / TYPES OF OBSERV
    30.000                                                 INTERVAL
  2012    5     11     0     0    0.0000000     GPS        TIME OF FIRST OBS
                                                           END OF HEADER
 12  5 11  0  0  0.0000000  0  9G21G 9G18G15G28G 5G27G 8G26
 -61.7242  0
 -33.4733  0
 -49.7988  0
 -55.8391  0
 -43.6837  0
 -38.7060  0
 -44.8228  0
 -31.3004  0
 -48.7904  0
 12  5 11  0  0 30.0000000  0  9G21G 9G18G15G28G 5G27G 8G26
 -61.6869  0
```
