



Sixth Meeting of CNS/MET Sub-Group of APANPIRG

Bangkok, Thailand, 15 – 19 July 2002

Agenda Item 6:

Review:

- a) **Strategy for the provision of Precision Approach and Landing Guidance Systems**
- b) **GNSS strategy**
- c) **GNSS implementation**
- d) **GPS measurement campaign**

d) GPS measurement campaign

ICAO REGIONAL GNSS MEASUREMENT CAMPAIGN

(Presented by Singapore)

SUMMARY

This paper presents the findings of an ICAO Regional GNSS Measurement Campaign that was carried out on 11 and 25 September, and 9 October 2001 over the Asia/Pacific Region.

1. INTRODUCTION

1.1 The Asia-Pacific Air Navigation Planning & Implementation Regional Group (APANPIRG) of the International Civil Aviation Organization (ICAO) at its meeting in October 2000 decided to initiate a Regional GNSS Measurement Campaign for determination of normal and peak excursion of GPS performance. Singapore was assigned to develop and co-ordinate this Measurement Campaign which was carried out on three days, namely:-

- (a) 11 September 2001;
- (b) 25 September 2001; and
- (c) 9 October 2001,

with each measurement lasting 24 hours from 0000 hours UTC to 2359 hours UTC.

2. PARTICIPATION

2.1 5 countries namely Australia, China, India, Singapore and the United States of America participated in this Measurement Campaign. Their final processed results were sent to Singapore for compilation and these are attached at Annexes A, B and C.

3. STUDY

3.1 A 12-channel dual frequency GPS receiver was used for the data collection, with antenna mounted at a WGS-84 surveyed location of accuracy of less than a metre. GPS positions were sampled every second for 24 hours for all the locations on the 3 days mentioned except for India which participated on 25 September and 9 October only. The large volume of GPS positional data were saved in a computer linked to the GPS receiver, for post-processing later on.

3.2 The data collection in 2001 coincided with the near peak of the 11-year sunspot cycle. The sunspot numbers obtained from the National Geographical Data Center of the US' National Oceanic & Atmospheric Administration ¹ for the three days were as follows: -

(a)	11 September 2001	:	126
(b)	25 September 2001	:	193
(c)	9 October 2001	:	79

In comparison, the monthly mean sunspot number for September and October 2001 were 150.7 and 125.6 respectively.

3.3 The horizontal and vertical errors of all the locations, except for New Delhi, are less than 5 m, with a narrower spread for horizontal error as compared to the vertical error. Although the absolute horizontal and vertical errors of New Delhi are higher than those of other sites, its Horizontal Dilution of Precision (HDOP), Vertical Dilution of Precision (VDOP) and Position Dilution of Precision (PDOP) are very low, being less than 2. (Small values of PDOP are good for positioning while higher values produce less accurate position solutions). Generally all the PDOPs on the three days are less than 3, thus satisfying requirement for non-precision approaches. One interesting observation noted is the mean vertical errors for Singapore, Mauna Loa and Honolulu are lower than those of their horizontal errors. This is contrary to usual observations when vertical position suffers approximately one and a half times more inaccuracies than the horizontal. Also no significant GPS performance degradation was noticed between 9 October (low sunspot number) and 25 September 2001 (high sunspot number).

4. CONCLUSION

4.1 The data collected in this measurement campaign did not show that sunspots activities had significantly affected GPS performance. The PDOPs measured for all the sites were low, indicating accurate position solutions were found on all the three days despite sunspots activities. However as the data was collected for 3 days only, data collection over longer period would be required to further verify this. Also the mean horizontal and vertical errors measured were found to be low. These further confirmed that the removal of Selective Availability (SA) in May 2000 had significantly improved the accuracy of GPS positions (before SA removal, the published accuracy of GPS positions was 100m).

4.2 It must, however, be noted that the DOPs/errors measured in this campaign could not be taken as representative of regional annual DOPs/errors since seasonal effects had not been accounted for and there was no determination that September and October were months with the highest regional ionospheric activities in year 2001.

4.3 This measurement campaign would not have been possible without the kind support and co-operation extended by officers from the Airservices Australia, Civil Aviation Administration of China, Airports Authority of India and the US' Federal Aviation Administration.

4.4 The Meeting is invited to note the information presented in this paper.

¹ web address <http://www.ngdc.noaa.gov/ftp/ftp.html>

ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUPPORT_NUMBERS/2001

Annex A**MEASUREMENT RESULTS FOR 11 SEP 2001, 0000 TO 2359 UTC**

Errors Site	Horizontal Error		Vertical Error		HDOP		VDOP		PDOP	
	Mean (m)	Two standard deviations	Mean (m)	Two standard deviations	Mean	Two standard deviations	Mean	Two standard deviations	Mean	Two standard deviations
CANBERRA	2.160	2.354	2.786	7.253	0.995	0.300	1.462	0.586	1.773	0.625
SINGAPORE	2.214	4.531	1.066	7.655	0.865	1.074	1.501	1.845	1.735	2.128
MAUNA LOA	1.997	4.136	0.977	7.507	0.999	1.467	1.578	2.354	1.874	2.687
HONOLULU	2.278	4.342	0.624	8.452	1.059	1.466	1.846	2.750	2.135	3.092
BEIJING	1.323	4.112	2.787	7.184	1.065	0.408	1.597	0.760	1.923	0.834

SiteCo-ordinates

- Canberra S 35° 17' 1'' E 149° 8' 2''
- Singapore N 1° 22' 48'' E 103° 59' 24''
- Mauna Loa N 19° 31' 48'' E 155° 34' 12''
- Honolulu N 21° 18' 36'' W 157° 55' 12''
- New Delhi N 28° 38' 13'' E 77° 10' 18''
- Beijing N 39° 51' 47'' E 116° 27' 24''

Annex B**MEASUREMENT RESULTS FOR 25 SEP 2001, 0000 TO 2359 UTC**

Errors Site	Horizontal Error		Vertical Error		HDOP		VDOP		PDOP	
	Mean (m)	Two standard deviations	Mean (m)	Two standard deviations	Mean	Two standard deviations	Mean	Two standard deviations	Mean	Two standard deviations
CANBERRA	2.247	3.103	1.774	7.596	0.968	0.291	1.399	0.514	1.703	0.567
SINGAPORE	2.182	4.524	0.798	7.791	0.904	1.234	1.561	2.000	1.807	2.283
MAUNA LOA	1.911	3.817	0.864	6.889	1.027	1.386	1.795	2.539	2.075	2.732
HONOLULU	2.143	4.605	0.602	7.608	1.043	1.448	1.806	2.551	2.092	2.806
NEW DELHI	8.850	2.410	12.156	4.056	0.989	0.101	1.514	0.262	1.813	0.257
BEIJING	1.412	5.704	3.473	8.860	1.059	0.398	1.584	0.656	1.908	0.738

Annex C**MEASUREMENT RESULTS FOR 9 OCT 2001, 0000 TO 2359 UTC**

Errors Site	Horizontal Error		Vertical Error		HDOP		VDOP		PDOP	
	Mean (m)	Two standard deviations	Mean (m)	Two standard deviations	Mean	Two standard deviations	Mean	Two standard deviations	Mean	Two standard deviations
CANBERRA	2.017	2.364	3.212	7.321	0.991	0.323	1.443	0.588	1.751	0.642
SINGAPORE	2.254	4.774	0.675	7.480	0.896	1.208	1.552	1.966	1.795	2.253
MAUNA LOA	1.741	3.739	-0.290	5.932	1.022	1.345	1.783	2.502	2.062	2.693
HONOLULU	2.513	4.698	-0.557	6.450	1.044	1.453	1.802	2.544	2.089	2.788
NEW DELHI	5.229	2.259	7.484	2.796	0.968	0.102	1.270	0.144	1.778	0.248
BEIJING	1.585	3.450	2.852	7.442	1.069	0.484	1.595	0.961	1.924	1.052