International Civil Aviation Organization

THE TENTH MEETING OF AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B SITF/10)

Singapore, 26 -29 April 2011

Agenda Item 6: **Review States' activities and interregional issues on trials and implementation of ADS-B and mulilateration**

ADS-B/GPS ACCURACY

(Presented by Australia)

SUMMARY

This paper provides background information about GPS accuracy.

1. Background

1.1 There is considerable confusion about the accuracy of ADS-B. This paper provides background information to assist future discussion.

1.2 This information is relevant to current discussions on required NUC value for 3 and 5 nautical mile separation standards being discussed by SASP. It is also relevant to discussions on the SA aware requirement for ADS-B.

1.3 The accuracy of ADS-B positional data is determined by the position source. At the current time there are two principal positional sources namely GPS and Inertial. Typically, in Airliner installations, both Inertial data and GPS data are presented to the ATC transponder. The standard MARK 4 AIR TRAFFIC CONTROL TRANSPONDER (ATCRBS/MODE S) ARINC CHARACTERISTIC 718A defines that GPS has priority in this case. If both data sources are provided, GPS data is used. If the GPS data source is not present for any reason, the inertial data will be used.

2. Inertial position sources

2.1 In this case, the accuracy of ADS-B positional data is determined by the accuracy of the inertial data source. An inertial platform may or may not be updated by other sources including

navaids. Typically the accuracy degrades with time since the last update. In practice the positional data from these systems can drift to be a few miles in error. An inertial data source does not normally generate an integrity value and the ATC transponder will transmit NUC/NIC=0. Such data will not normally be used by ATC systems.

2.2 New products which are based on a hybrid of inertial and GPS technology do generate integrity data and hence ADS-B data with “good” NIC/NUC values will be transmitted eg: The A380 uses such a hybrid technology. The positional accuracy of these systems can be considered at least equivalent to GPS based systems.

3. GPS position source accuracy

It is important to distinguish between GPS accuracy and reported GPS accuracy. The two can be very different.

3.1 GPS Accuracy

3.1.1 GPS accuracy is dependent on a number of factors such as :

- The user equivalent range errors (UERA) including Ionspheric effects, Ephemeris errors, satellite clock errors, multipath etc; and

- Satellite geometry

The accuracy is a function of HDOP * UERE where HDOP is the horizontal dilution of precision, a measure of the position accuracy degradation due to satellite geometry.

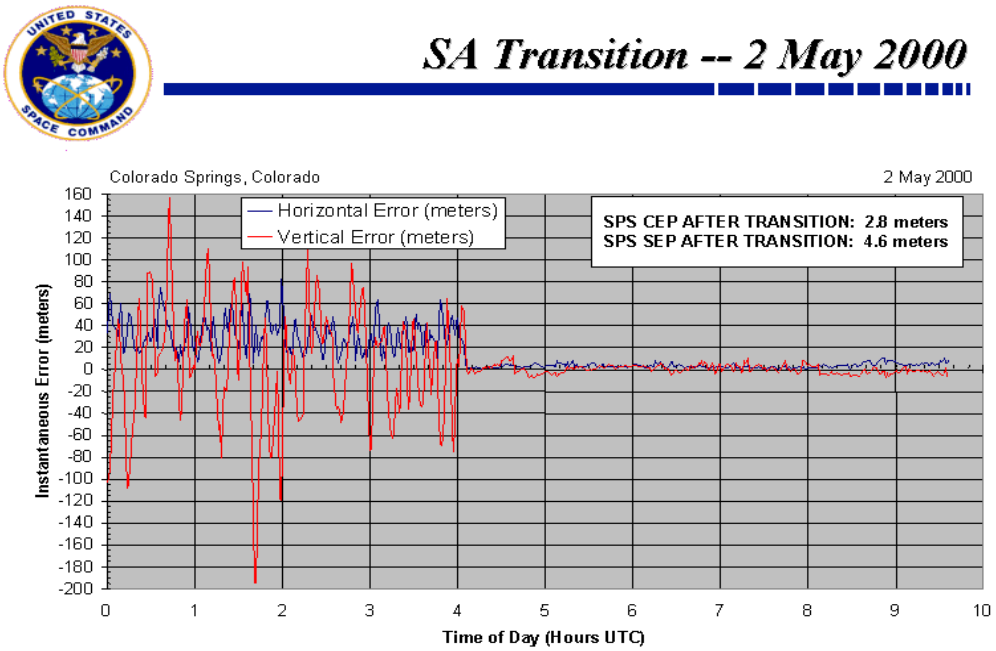
3.1.2 Typical GPS errors (95%) are as follows depending on the number and geometry of satellites received :

- GPS system with SA activated ± 100 Metres (no longer relevant because SA is deactivated)

- GPS system with SA deactivated ± 15 Metres

- SBAS augmented GPS ± 1 - 3 Metres

3.1.3 When Selective availability was discontinued in the year 2000, the accuracy of ALL GPS receivers improved. This includes receivers that are both “SA aware” and those that are “SA ON”. The following diagram shows the impact on accuracy (expressed as circular error probability) :



3.2 Reported Accuracy & Integrity

3.2.1 For GPS receivers which are not SA aware, the accuracy and integrity REPORTED and then used in ADS-B messages is based on an ASSUMED value of UERE, corresponding to the period when SA was active. This value is grossly larger than the accuracy of the positional data delivered now that SA is inactive.

3.2.2 For SA off/ SA aware receivers, some report accuracy and integrity values based on the assumed UERE in the SA inactive environment and some determine the UERE from the GPS message contents. Thus SA aware systems report more realistic accuracy and integrity values.

3.3 ADS-B Implementation of Integrity & Accuracy reporting

3.3.1 GPS accuracy is reported by GPS receivers in a value called Horizontal Figure of Merit (HFOM). ATC transponders compliant with DO260A & DO260B use this to report accuracy category (NAC)

3.3.2 GPS integrity is reported by GPS receivers in a value call Horizontal Protection Limit (HPL). ATC transponders compliant with DO260A & DO260B use this to report integrity category (NIC) and DO260 ATC transponders use it to report Uncertainty Category (NUC).

3.3.3 Work by Boeing, previously reported to the task force, shows that an accuracy limit can be inferred from the reported NUC value, namely the 95% accuracy is < 0.25 the HPL value.

3.3.4 Accuracy & integrity are reported separately in DO260A or DO260B ADS-B messages. Accuracy is not reported in DO260 messages.

3.3.5 The reported accuracy and integrity are further modified by the DO260, DO260A & DO260B encoding of the values. This is particularly relevant for surface squitters (aircraft on ground) when reported integrity values > 182 metres are considered as “integrity unknown”.

3.3.6 The following table attempts to summarise :

	DO260	DO260A/B
SA aware GPS (airborne)	NUC value reports integrity based on HPL data. Accuracy values can be inferred from the HPL data, in particular that 95% accuracy is < HPL/4.	NAC value reports accuracy which closely matches actual accuracy. SA aware receiver uses realistic UERE
SA aware GPS (surface)	If integrity > 182 metres, then transponder reports that integrity is unknown. This is not frequent for SA aware GPS.	If integrity > 182 metres (1,111 metres in DO260B), then transponder reports that integrity is unknown. This is not frequent for SA aware GPS.
SA ON GPS (Airborne) Same actual accuracy as SA aware GPS	NUC value reports integrity. NUC is based on HPL, which is reported unrealistically high because SA ON receiver assumes that selective availability is still ON.	NAC value reports accuracy much worse than reality, because SA ON receiver assumes that selective availability is still ON. It assumes an unrealistically large UERE
SA ON GPS (Surface) Same actual accuracy as SA aware GPS	If aircraft is “on ground” and integrity > 182 metres, then transponder reports that integrity is unknown. This is often the case with SA ON GPS avionics	If integrity > 182 metres (1,111 metres in DO260B), then transponder reports that integrity is unknown. For DO260A, this often the case with SA ON GPS avionics, but much less frequent with DO260B avionics.

3.3.7 DO260 and DO26A avionics report often report “no integrity” for surface squitters when used with SA ON GPS systems, even though positional data is accurate due to the conservative HPL values transmitted by the GPS and due to the encoding of the transponder.

3.3.8 DO260B avionics allow a much larger integrity value (> 1Km) before reporting “no integrity”

3.3.9 DO260A & DO260B report accuracy separately, which is a particular advantage when using ADS-B for surface movement operations.

3.3.10 SA Aware avionics have a much higher probability of being able to support surface operations, because they do not report excessively large positional error or integrity values.

4. Conclusions

4.1 SA aware GPS receivers do not provide higher accuracy positional data as a result of being SA aware. However, SA aware GPS receivers do (correctly) report that they achieve higher accuracy & integrity. The reported accuracy and integrity from SA ON GPS receivers is excessively conservative. Care is needed to distinguish between accuracy and reported accuracy. If states wish to use ADS-B for surface operations, careful consideration of the differences between actual accuracy and reported accuracy, as well as the different DO260 variants must be considered.

5. Recommendation

5.1 The meeting is invited to note the paper.

– – – – – – – – – – – – –