

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #7

**Draft 1 of Appendix I:
UAT Timing Requirements**

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SUMMARY

This is Draft 1 of a proposed Appendix I, whose purpose is to document the expected total installed end-to-end timing performance as guidance to UAT installers and to developers of ADS-B validation applications, and to provide rationale for the timing related requirements given in the UAT MOPS in the context of the expected total installed performance.

Appendix I UAT Timing Requirements

I.1 Background

This UAT MOPS contains timing requirements related to both the transmission of ADS-B messages and reception of ADS-B and Ground Uplink messages. These requirements are intended primarily to support applications that use knowledge of the precise Time of Message Transmission (TOMT) and Time of Message Receipt (TOMR) to determine a range to the ADS-B transmitter. An *ADS-B validation* application can compare this one-way time of propagation range measurement with the range determined from the ADS-B message to increase confidence that the message came from a bona fide transmitter.

This ADS-B validation procedure is only available in cases where both the transmitting and receiving stations are *UTC coupled*, that is, they are receiving time from a GPS/GNSS source. This UAT MOPS allows for GPS/GNSS timing sources that are either *external* or *internal* to the UAT equipment. Whether the timing source is external or internal, the UAT MOPS requires UTC coupling as the normal operational condition. A non-UTC coupled condition can occur due to a temporary unavailability of the GPS/GNSS source. At any given time, a UAT transmitter is obligated to announce whether or not it is in the UTC coupled state.

I.2 Purpose

The purpose of this Appendix is not to design or specify an ADS-B validation application. Instead, the purpose of this Appendix is the following:

1. Document the expected total installed end-to-end timing performance as guidance to UAT installers and to developers of ADS-B validation applications.
2. Provide rationale for the timing related requirements given in this MOPS in the context of the expected total installed performance.

I.3 Installed End-End Timing Performance

Listed below are the identified components of possible timing errors and their assumed worst-case values.

- a) Errors due to the GPS signal in space: This is assumed bounded by the performance specifications of the GPS Standard Positioning Service with SA ON. Uncertainty range = **-334ns to +334 ns**.
- b) GPS antenna and coax effects. This is assumed bounded by a 20 meter maximum installed cable length. Uncertainty range = **-0 to +66 ns**
- c) GPS-UTC time offsets: This is applicable to GPS receivers that output GPS time instead of UTC time. Since GPS sensors that may be used for ADS-B

are not required to make the UTC correction, this offset must be included. GPS specifications allow GPS time to deviate from UTC time by up to 1 microsecond. Uncertainty range = **-1000 ns to +1000 ns**.

- d) Delays due to interconnection of GPS sensor and UAT: This component applies to installations with external UTC coupled time source. Allowance is needed for delays induced in lightning protection filters and interconnect cable capacitance between the GPS/GNSS sensor and the UAT. Total uncertainty range based on tests has been determined to be = **-0 to +800 ns**.
- e) UAT Tx/Rx time errors: errors due to control of transmitter turn on and in marking message time of arrival within the receiver. An uncertainty range specifically for this component has not been established.
- f) UAT antenna/coax effects: This is assumed bounded by a 20 meter maximum installed cable length. Uncertainty range = **-0 to +66 ns**

While some of the timing errors are of a fixed offset nature, it was determined that any form of timing calibration procedure required of the UAT system installer would be impractical.

The figures below show the components of the total end-end timing uncertainty relative to the installed equipment for both cases. The first case is where the GPS/GNSS sensor is internal to the UAT. The second case is where the GPS/GNSS sensor is external to the UAT.

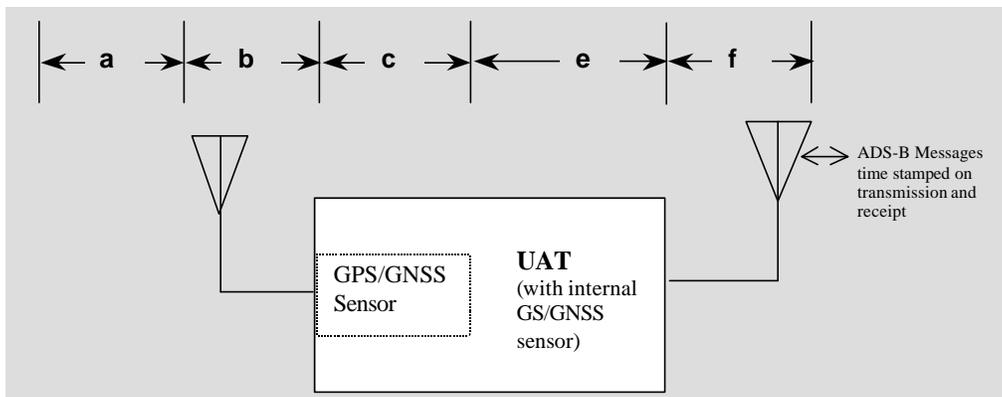


Figure I-1: Components of the Timing Error Budget--Internal UTC Coupled Time Source

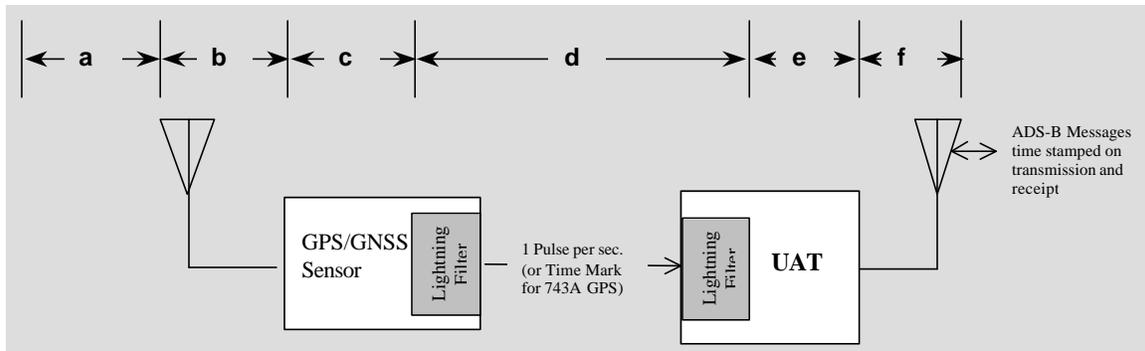


Figure I-2: Components of the Timing Error Budget--External UTC Coupled Time Source

I.4 MOPS Timing Requirements and Rationale

There are essentially two UAT MOPS requirements related to timing: one related to control of ADS-B message transmission, and one related to time stamping of message receipt. In each case the actual performance requirements are treated separately depending on whether the UTC coupled time source is internal or external. Timing requirements are specifically limited to items that are testable independent of any other installed equipment.

Message Transmission Timing

Section 2.2.6.2.2 “Relationship of the MSO to the Modulated Data” specifies the requirement for ADS-B message transmission timing.

- ⇒ When an internal UTC coupled source time source is used, the requirement and test is designed to account for uncertainty components **c)** and **e)**. This is accomplished by applying an actual or simulated GPS input to the UAT such that the GPS signal presents minimal timing uncertainty. The maximum timing uncertainty specified is **500 ns**.
- ⇒ When an external UTC coupled time source is used, the requirement and test is designed essentially to account only for part of component **d)** and component **e)**. This is accomplished by applying a test 1PPS or Time Mark input that is essentially free of uncertainty components **a)**, **b)**, **c)**, and most of **d)**. The maximum timing uncertainty specified is **500 ns**

Accuracy of Time Stamping on Message Receipt

Section 2.2.7.8 “Time of Message Receipt” specifies the requirement for time-stamping of received messages.

- ⇒ When an internal UTC coupled source time source is used, the requirement and test is designed to account for uncertainty components **c)** and **e)**. This is accomplished by applying an actual or simulated GPS input to the UAT such

that the GPS signal presents minimal timing uncertainty. The maximum timing uncertainty specified is 500 ns.

⇒ When an external UTC coupled time source is used, the requirement and test is designed essentially to account only for part of component **d)** and component **e)**. This is accomplished by applying a test 1PPS or Time Mark input that is essentially free of uncertainty components **a)**, **b)**, **c)**, and most of **d)**. The maximum timing uncertainty specified is 500 ns