RTCA Special Committee 186, Working Group 3

ADS-B 1090ES MOPS Maintenance

Proposed Changes to the ADS-B MOPS to accommodate operational needs of surface applications
Revision 1

Summary
This Working Paper proposes changes to the requirements and testing of the maximum received power level that an ADS-B receiver must meet.

Introduction to the proposed changes to DO-260B

Attached below are sections in the requirements and test sections of DO-260B that are affected by these changes.

Proposed changes to DO-260B

2.2.4.2.2 Re-Triggerable Reply Processor

The TCAS Mode S reply processing function shall use a Mode S reply processor that will re-trigger if it detects a Mode S preamble that is at least 3 dB stronger than the reply that is currently being processed if the signal level of the reply currently being processed is at or below -24 dBm in order to ensure that the stronger signal is processed.

Note: *Care must be taken to ensure that low-level squitters (i.e., those below the nominal TCAS MTL) do not interfere with the processing of acquisition squitters for TCAS. This may happen if the low-level squitter is allowed to capture the reply processor. This may be prevented by using a separate reply processor for each function, or by requiring the reply processor to be re-triggered by a higher level squitter message.*

2.2.4.3.1.1 In-Band Acceptance

The requirements provided in the following subparagraphs are specified at the Antenna end of an Antenna to Receiver transmission line having loss equal to the maximum for which the receiving installation is designed.

a. The MTL of an ADS-B receiver processing signals over the frequency range of 1089 to 1091 MHz **shall** comply with the MTL limits provided in Table 2-79 for the applicable receiver Equipment Class.

Table 2-79: ADS-B Class "A" Equipment Receiver Sensitivity

EQUIPMENT CLASS	A0	A1S/A1	A2	A3
MTL	**-72** dBm	**-79** dBm	**-79** dBm	**-84** dBm

Note: *The MTL limits of Table 2-79 must be complied with over the entire environmental operating range specified by the manufacturer of the receiver (e.g., receiver performance variations over temperature and other conditions must be taken into account).*

b. In the absence of interference or overloads, each ADS-B receiver **shall** properly detect and decode at least 99% of all ADS-B Messages received at an input signal level between the levels of MTL + 3 dB and -~~21~~ 0 dBm.

c. In the absence of interference or overloads, each ADS-B receiver of equipment Class A3 **shall** properly detect and decode at least 15% of all ADS-B Messages received at an input signal level of -87 dBm.

Notes:

1. This requirement need only be tested under ambient conditions.

2. *The intent of this requirement is to emphasize the desirability of taking advantage of signals received below the required MTL.*

2.2.4.3.1.2 Re-Triggerable Capability

ADS-B receivers having Equipment Class A1, A2 or A3 capability shall re-trigger if such receivers detect an ADS-B Message having a preamble that is at least 3 dB stronger than that of the message that is currently being processed if the signal level of the message currently being processed is at or below -24 dBm.

Note: This requirement is required in order to ensure that the ADS-B processor will properly detect and process the stronger signal.

2.3.2.4.2 Dynamic Range (§2.2.4.3.1.1.b)

Purpose/Introduction:

This test verifies that the ADS-B receiver can detect and decode valid ADS-B Messages over the equipment's specified dynamic range.

Input:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-68 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B Input Messages

Apply **Input** at the receiver input port.

Step 2: Establish UUT Receiver MTL

Decrease the input power level and determine the minimum RF signal level required to produce 90 percent ADS-B Message reception rate by the UUT receiver. This value plus the loss line value represents the measured MTL of the UUT ADS-B receiver.

Step 3: Verify UUT Receiver Dynamic Range

Increase the input signal power level to MTL + 3 dB. Verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received. Increase the input signal power level in 10 dB steps up to a signal level of -~~21~~ 0

dBm. At each step, verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Step 4: Verify Class A3 UUT Receiver Performance

Decrease the input signal power level to –87 dBm. Verify that the receiver properly detects and decodes at least 15% of all ADS-B Messages input.

Step 5: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.3 Re-Triggerable Capability (§2.2.4.3.1.2)

Purpose/Introduction:

The following procedures verify the capability of the Stand alone ADS-B receiver to detect overlapping ADS-B broadcast messages.

Input:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-50 dBm

Followed by a second Valid Mode S Extended Squitter:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address address different from the first one
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-42 dBm

Starting 6.0 ±1.0 µsec later than the leading edge of the first ADS-B Message.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Re-Trigger Capability - Part 1

Apply **Input** at the receiver input and verify that at least the reply ratio in the following table of the second valid ADS-B Messages are correctly decoded.

Receiver Class	**Class A1S/A1**	**Class A2**	**Class A3**
Minimum Probability, Step 1	0.49	0.93	0.93
Minimum Probability, Step 1	0.49	0.93	0.93
Minimum Probability, Step 1	0.49	0.93	0.93

Step 2: Re-Trigger Capability - Part 2

Repeat Step 1 with the **Input** signal power level at MTL + 6 dB for the first ADS-B Message and MTL + 14 dB for the second ADS-B Message.

Step 3: Re-Trigger Capability - Part 3

Repeat Step 1 with **Input** level at -~~32~~ -24 dBm for the first ADS-B Message and -~~24~~ -16 dBm for the second ADS-B Message.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.5 Dynamic Minimum Trigger Level (DMTL) (§2.2.4.3.3)

Purpose/Introduction:

This test verifies that, when DMTL control is implemented (see §2.2.4.3.3), then the ADS-B receiver DMTL is capable of rejecting low level signals during a valid squitter reception and that DMTL is capable of recovering in not more than 128 microseconds after the leading edge of the first preamble pulse of a valid ADS-B Message.

Note: *This test procedure is only applicable to equipment that do not use the enhanced reception techniques. That is, it is not applicable to equipage Classes A1S, A1, A2 and A3.*

Input A:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-61 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 ±1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-69 dBm

Starting 0.7 ±0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input B:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-40 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 ±1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-49 dBm

Starting 0.7 ±0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input C:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	0 ~~21~~ dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 ±1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-30 dBm

Starting 0.7 ±0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input D:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	0 ~~21~~ dBm

Followed by a second Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 129 ± 1 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

2.3.2.4.6.1 Criteria for ADS-B Message Transmission Pulse Detection for Receivers not using Enhanced reception techniques

Purpose/Introduction:

These test procedures verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Note: *This test is not applicable to equipment which uses the enhanced reception techniques. That is, it is not applicable to equipage Classes A1S, A1, A2 and A3. The enhanced preamble detection requirements for this equipment are tested in §2.4.4.4.2.2.*

Reference Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-23 dBm

Input A:

(remainder of test remains unchanged)

2.4.4.2.2 Verification of Re-Triggerable Reply Processor (§2.2.4.2.2)

Purpose/Introduction:

The following procedures verify the capability of the TCAS shared ADS-B receiver to detect overlapping Mode-S replies or ADS-B Messages in the TCAS level range.

Inputs:

All Intruder Aircraft:

Frequency = 1090 MHz.

Altitude Rate = 0 FPM

Intruder Aircraft 1:

Equipage	=	Mode-S ADS-B
Squitter Power	=	-50 dBm
Altitude	=	8000 ft.
Range	=	2 NM at T=0 sec.

Intruder Aircraft 2:

Equipage	=	Mode-S ADS-B
Squitter Power	=	-44 dBm
Altitude	=	8000 ft.
Range	=	Maintained such that the leading edge of the first preamble pulse from Intruder 2 occurs 12 ±1.0 μs later than the leading edge of the first preamble pulse from Intruder 1 throughout the scenario.

TCAS Aircraft:

Altitude	=	8000 ft.
Altitude Rate	=	0 FPM
Range	=	0 NM
Sensitivity Level Selection	=	Automatic

ADS-B Message Format (Intruder 1):

All ADS-B Message transmissions **shall** have the following standard data field values:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address

Mode-S Squitter Format (Intruder 2):

All Mode-S squitter transmissions **shall** have the following standard data field values:

"DF"	=	11~~7~~
"CA"	=	0
"AA"	=	Any discrete address

Conditions:

TCAS initialized and operating at T = 0 seconds. Intruders 1 and 2 **shall** each transmit squitters during the squitter listening period following each whisper-shout sequence and **shall** reply with a short special surveillance format (DF=0) to each TCAS discrete interrogation.

Scenario Description:

Both Intruders are co-altitude with TCAS and each transmits squitters when TCAS is in squitter listening mode and replies to discrete interrogations from TCAS. Intruder 2 is overlapping the Intruder 1 reply window.

Measurement Procedure:

The receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B and Mode-S Input Messages

Apply the message inputs specified above to the receiver input port.

Verify that the TCAS receiver detects intruder #2.

Step 2: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 on all other applicable receiver RF input ports of the UUT.

Step 3: Vary Signal Power Levels

Repeat Steps 1 and 2 with the following additional squitter power levels:

a. Intruder Aircraft 1 – Squitter Power = -30 dBm

Intruder Aircraft 2 – Squitter Power = -24 dBm

b. Intruder Aircraft 1 – Squitter Power = MTL + 3 dB

Intruder Aircraft 2 – Squitter Power = MTL + 9 dB

Verify that the TCAS receiver detects Intruder Aircraft #2 for each case.

2.4.4.3.1.1.2 Verification of Dynamic Range (§2.2.4.3.1.1.b, §2.2.4.3.1.1.c)

Purpose/Introduction:

This test verifies that the ADS-B receiver can detect and decode valid ADS-B Messages over the equipment's specified dynamic range.

Input:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-68 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B Input Messages

Apply **Input** at the receiver input port.

Step 2: Establish UUT Receiver MTL

Decrease the input power level and determine the minimum RF signal level required to produce 90 percent ADS-B Message reception rate by the UUT receiver.

This value plus the loss line value represents the measured MTL of the UUT ADS-B receiver.

Step 3: Verify UUT Receiver Dynamic Range

Increase the input signal power level to MTL + 3 dB.

Verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Increase the input signal power level in 10 dB steps up to a signal level of ~~-21~~0 dBm.

At each step, verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Step 4: Verify Class A3 UUT Receiver Performance

Decrease the input signal power level to –87 dBm. Verify that the receiver properly detects and decodes at least 15% of all ADS-B Messages input.

Step 5: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.1.2 Verification of Re-Triggerable Capability (§2.2.4.3.1.2)

Purpose/Introduction:

The following procedures verify the capability of the Stand alone ADS-B receiver to detect overlapping ADS-B broadcast messages.

Input:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-50 dBm

Followed by a second Valid Mode S Extended Squitter:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address address different from the first one
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-42 dBm

Starting 6.0 ±1.0 µsec later than the leading edge of the first ADS-B Message.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Re-Trigger Capability - Part 1

Apply **Input** at the receiver input and verify that at least the reply ratio in the following table of the second valid ADS-B Messages are correctly decoded.

Receiver Class	**Class A1S/A1**	**Class A2**	**Class A3**
Minimum Probability, Step 1	0.49	0.93	0.93
Minimum Probability, Step 1	0.49	0.93	0.93
Minimum Probability, Step 1	0.49	0.93	0.93

Step 2: Re-Trigger Capability - Part 2

Repeat Step 1 with the **Input** signal power level at MTL + 6 dB for the first ADS-B Message and MTL + 14 dB for the second ADS-B Message.

Step 3: Re-Trigger Capability - Part 3

Repeat Step 1 with **Input** level at -~~32~~ 24 dBm for the first ADS-B Message and -~~24~~ 16 dBm for the second ADS-B Message.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.3 Verification of Dynamic Minimum Trigger Level (DMTL) (§2.2.4.3.3)

Purpose/Introduction:

This test verifies that, when DMTL control is implemented (see §2.2.4.3.3), then the ADS-B receiver DMTL is capable of rejecting low level signals during a valid squitter reception and that DMTL is capable of recovering in not more than 128 microseconds after the leading edge of the first preamble pulse of a valid ADS-B Message.

Note: *This test procedure is only applicable to equipment that do not use the enhanced reception techniques. That is, it is not applicable to equipage Classes A1S, A1, A2 and A3.*

Input A:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-61 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 ±1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-69 dBm

Starting 0.7 ±0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input B:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-40 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 ±1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-49 dBm

Starting 0.7 ±0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input C:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	~~-21~~ 0 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 ±1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-30 dBm

Starting 0.7 ±0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input D:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	~~-21~~ 0 dBm

Followed by a second Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 129 ± 1 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

(remainder of test remains unchanged)

2.4.4.3.4.7.1 Verification of Criteria for ADS-B Message Transmission Pulse Detection (§2.2.4.3.4.7.1 and §2.2.4.3.4.7.2)

Purpose/Introduction:

These test procedures verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Note: *This test is not applicable to equipment which uses the enhanced reception techniques. That is, it is not applicable to equipage Classes A1S, A1, A2 and A3. The enhanced preamble detection requirements for this equipment are tested in §2.4.4.4.2.2.*

Reference Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-23 dBm

Input A:

(remainder of test remains unchanged)

2.4.4.4.2.1.3 Extended Squitter Signal Source Requirements

One RF source **shall** be provided that is capable of generating a 112-bit Extended Squitter transmissions with no more than 1 dB droop as follows:

The Extended Squitter power level **shall** be adjustable ranging from -~~21~~ 0 dBm to –84 dBm within plus or minus 1 dB as required by the test procedures.

The Extended Squitter signal source should be able to sustain a squitter rate of at least 100 squitters per second.

Unless otherwise required, the contents of the Extended Squitter transmission **shall** consist of the five-bit DF field set to 17, an 83-bit field that is set pseudo randomly for each Extended Squitter transmission except for ME Field bits 1 to 5 (the Format TYPE Code) which may be set to a fixed value, and a 24-bit PI field appropriate for the content of this transmission.

Note: *The Four-Pulse Preamble Detection tests and the Preamble Validation Tests do not require pseudo-random message content, all other test procedures do.*

Provision **shall** be made to record the contents of each Extended Squitter transmission

Note: *This information is required to check for undetected errors.*

The Extended Squitter signal source **shall** have the capability to selectively control the width and/or position of individual preamble pulses with at least 25 nanosecond resolution.

The Extended Squitter signal source **shall** also provide the capability of individually omitting preamble pulses or any of the first 5 data pulses from the transmission.

2.4.4.4.2.2 Four-Pulse Preamble Detection Tests

Purpose/Introduction:

These tests verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Reference Input:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-23 dBm

Input A:

(remainder of test remains unchanged)