SC209-WP05-11
December 5 - 7, 2006
RTCA, Washington DC

RTCA Special Committee 209

Transponder MOPS

Meeting #5

Mode S Specific Services Test Procedures

(Proposed Appendix C to DO-181D Mode S Transponder MOPS)

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SUMMARY

This working paper presents the Mode S Specific Services (MSSS) test procedures in the form of a proposed Appendix C to DO-181D. The test procedures in this working paper cover those requirements for the MSSS in Appendix B with the exclusion of the GICB test procedures. GICB test procedures are planned for subsequent versions of Appendix C.

C.1 MODE S SPECIFIC SERVICES TEST PROCEDURES

The test procedures set forth below constitute a satisfactory method of determining required Mode S Specific Services performance. Although specific test procedures are cited, it is recognized that other methods may be preferred. Such alternate methods may be used if the manufacturer can show that they provide at least equivalent information. Therefore, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

C.1.1 General Characteristics

The test configuration (Figure C-1) provides a means of validating the information content of any message received from the Aircraft Application Entity (AAE), as well as the Ground Application Entity (GAE), which is processed and managed by both the Aircraft - Specific Services Entity (A-SSE), and the Ground – Specific Services Entity (G-SSE).

The test configuration should be capable of generating or accepting messages in the form of MSPs, Broadcast and GICB. The test configuration should be able to format and populate the data content for MSSS type messages.

The test configuration should be capable of generating the entire content of a Long and Short Mode S uplink message, and accept the entire content of a Long and Short downlink message according to the following:

(1) Long Mode S messages are 112 bits, encoded per RTCA/DO-181C (Ref. 3), Subsections 2.2.14 and 2.2.17. Short Mode S messages are 56 bits, also coded according to RTCA/DO-181C (Ref. 3), Subsections 2.2.14 and 2.2.17. When required, the coding of these messages is contained in the appropriate test procedure of this Appendix.

(2) For uplink Extended Length Messages (ELM)s, the test configuration should be able to convey a control field called Interrogator Identification Subfield (IIS) to the A-SSE independently of the messages described in (1) above.

(3) The test configuration should be able to convey delivery status of Mode S downlink messages to the A-SSE independently of the messages described in (1) above.

(4) The test configuration should be able to accept from the A-SSE a Mode S frame cancellation message independently of the messages described in (1) above.

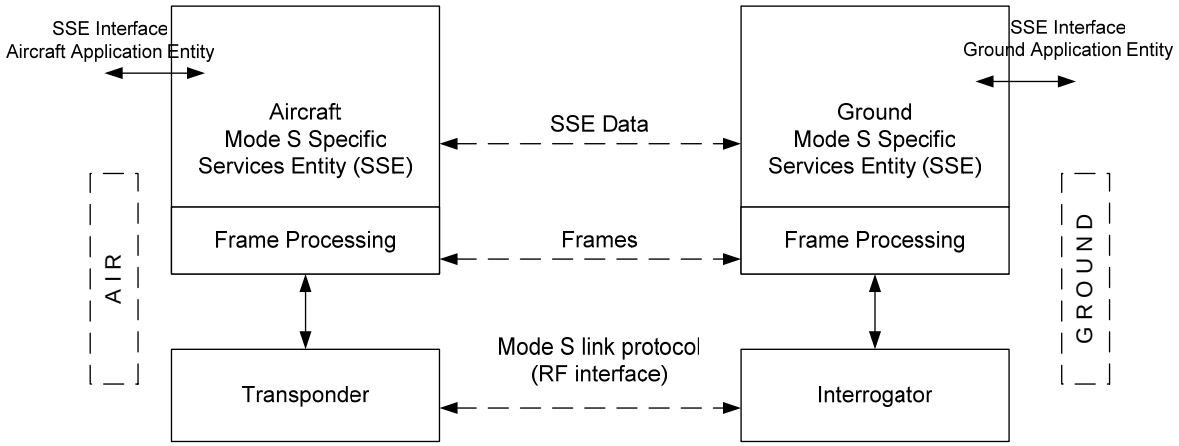

Figure C-1: Mode S Specific Services Test Configuration

C.1.2 Detailed Test Procedures

C.1.2.1 Downlink Processing

C.1.2.1.1 Broadcast Processing

(§B.2.2.6.1.1.2 – General)
(§B.2.2.6.1.1.2 – Broadcast Processing)
(§B.2.2.6.4 – Broadcast Format)

Objective: This test is designed to validate the downlink broadcasting function of the MSSS, which includes broadcast processing and formatting of the broadcast messages.

Step 1 Generate two 56 bit downlink broadcast messages. The 56-bit message data field will consist of an alternating one-zero pattern and alternating zero-one pattern for alternate packets. Send the two broadcast messages to the A-SSE.

Step 2 At the G-SSE, verify that the transponder has generated two broadcast Comm-B segments whose MB Fields are equal to the message data fields of the broadcast messages.

Step 3 Generate a downlink broadcast message from the A-SSE with the data field length greater than 56 bits.

Step 4 Verify that an error message to the A-SSE is generated, and that no request for a Comm-B downlink appears at the RF interface.

ADD TESTS According to the broadcast downlink table for formatting, etc. talk about verifying : Broadcast, Control Data, and User Data:

C.1.2.1.2 MSP Processing

(§B.2.2.6.1.1.5 – MSP Processing)
(§B.2.2.7.2.3 – Delivery Status)
(§B.2.2.6.2.1 – Short Form MSP Packet)
(§B.2.2.6.2.2 – Long Form MSP Packet)

Objective: This test is designed to validate the downlink MSP processing function of the MSSS, which includes MSP processing, delivery status and formatting of the short form and long form MSP packets. The tests cover both SLM and ELM capabilities of the Mode S Transponder.

SLM Capable

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field.

Step 2 From the AAE, generate the following MSP packets:

Group	No of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	8	5 bytes	1 segments	48-41
b.	4	12 bytes	2 segments	52-49
c.	4	19 bytes	3 segments	56-53
d.	4	26 bytes	4 segments	60-57
e.	3	29 bytes	see text	63-61
f.	-	165 bytes	-	61

Step 3 For groups a. through d., extract all Comm-B segments, and follow each with a closeout, as necessary. Verify that the control codes are DP=0, MP=0 (indicating the Short form MSP) and M/CH field corresponds to the selected MSP packet group (M/CH=48 to 41 for group a., M/CH = 52 to 49 for group b., etc.). Verify that the status of each downlink is sent to the A-SSE.

Note: The packet from group e is oversize and cannot be transmitted in entirety. This portion of the test requires the A-SSE to use Long Form MSP packets with L-bit assembly.

Step 4 Verify that the first Comm-B message contains 26 bytes of user data identical to the first 26 bytes of the UD Field in the original MSP message, and the L-bit is set. Verify that the second Comm-B message contains one segment with the MB Field identical to the last three bytes of user data in the original MSP message, and the L-bit is not set.

Step 5 Send the data from group f to the A-SSE. Verify that no request for Comm-B downlink appears at the A-SSE RF interface.

ELM Capable

Step 1 <needs some work> Repeat the group e test described in the previous paragraph with the condition that the oversize packets are to be sent in total using downlink ELM containing Short MSP packets.

C.1.2.2 Uplink Processing

C.1.2.2.1 Broadcast Processing

(§B.2.2.6.1.2.1 – General)
(§B.2.2.6.1.2.2 – Broadcast Processing)
(§B.2.2.6.4 – Broadcast Format)
(§B.2.2.7.2.4 – Interrogator Identifier)

Objective: This test is designed to validate the uplink broadcasting function of the MSSS, which includes broadcast processing, interrogator identifier, and formatting of the broadcast messages.

Step 1 Send twelve uplink Comm-A Broadcast messages divided into two groups of six interrogations. The first group will be uplinked with a UF Field = 20 and the second group with UF = 21. Within each group of six interrogations, the 56 bit MA fields will contain a combination of the following bit patterns: all ones, all zeros, alternating ones and zeros and alternating zeros and ones. For each frame, set DI = 1 or 7, IIS = 15, and SD (except IIS) = 0, and provide an indication that the frame is an unlinked Comm-A (LAS = 0).

Step 2 Verify that the data delivered to the A-SSE interface contains the 56 bits of data in the MA field, the 32 bits Mode S frame header information, the II code, the broadcast ID and an indication that the frames are Comm-A broadcast frames."

C.1.2.2.2 MSP Processing

(§B.2.2.6.1.2.3 – MSP Processing)
(§B.2.2.6.2.1 – Short Form MSP Packet)
(§B.2.2.6.2.2 – Long Form MSP Packet)

Objective: This test is designed to validate the uplink MSP processing function of the MSSS, which includes MSP processing and formatting of the short form and long form MSP packets. The tests cover both SLM and ELM capabilities of the Mode S Transponder. The test uplinks several packets on different Mode S MSP channel numbers. The A-SSE is required to reformat Short and Long MSP packets into message and control data for the AE Separate Interface.

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field.

Step 2 Send the following MSP messages to the AAE from the G-SSE interface:

Group	No of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	8	6 bytes	1 segments	48-41
b.	4	13 bytes	2 segments	52-49
c.	4	20 bytes	3 segments	56-53
d.	4	27 bytes	4 segments	60-57
e.	3	29 bytes	see text	63-61

Step 3 Verify that the A-SSE forwards the contents of the UD fields, as well as a means for identifying the packets as MSP data, to the AAE interface.

Step 4 In case e), send to the A-SSE 2 Mode S linked Comm-A frames containing 2 linked Mode S Long Form MSP Packet on the selected MSP channel number. The first packet will have L-bit set to one and contain 26 bytes of user data. The second frame will have L-bit set to zero and contain 3 bytes of user data. Make sure the A-SSE forwards the contents of the UD Field in its entirety and correct order to the AAE.

Step 5 If ELM capability is available, repeat Step e) but this time send a Mode S Short Form MSP packet to the A-SSE containing 29 bytes of data in the UD Field. Verify that the A-SSE forwards the contents of the UD Field as a means for identifying the packet as MSP data, to the AAE.

C.1.2.3 Frame Tests

C.1.2.3.1 Uplink SLM Frames

(§B.2.2.7.1.1 – SLM Frame)
(§B.2.2.7.1.1.1 – SD Field)
(§B.2.2.7.1.1.2 – LAS Coding)
(§B.2.2.7.1.1.3 – Single Segment SLM Frame)
(§B.2.2.7.1.1.4 – Multiple Segment SLM Frame)
(§B.2.2.7.2.5 – Frame Cancellation)

Objective: This test is designed to validate the uplink frame function of the MSSS, which includes processing of the SLM frame, SD field, LAS coding, the frame cancellation function, and the management of single segment and multiple segment SLM frames.

Single Segment SLM Frame

Step 1 From the G-SSE interface, generate 4 unlinked Comm-A frames containing Mode S Short Form MSP Packets having uniquely identifiable data in each of the 6 byte UD fields.
Step 2 Send this data to the A-SSE using MSP Channel Number 48 for the first frame, 47 for the second frames, etc. and use II = 6 for all frames.
Step 3 Verify that the A-SSE accepts control and message data from the transponder interface indicating 4 unlinked Comm-A segments with IIS = 6 and LAS = 0 in each case. Also, Verify also that the A-SSE forwards the content of the UD Field

to the A-SSE interface as well as a means for identifying the packets as MSP data, to the A-SSE interface.

Note: *If this test is to be performed in conjunction with Mode S transponder validation, the message field must be duplicated exactly in the Mode S RF interrogation, and uplink formats 20 and 21 must both be used.*

SD Field
LAS Coding
Frame Cancellation
Multiple Segment SLM Frame

This test requires the transmission of linked Comm-A segments over MSP channels.

In order for the A-SSE to reformat the frames, it is necessary to have segment number one contain the Short Form MSP Packet header.

Linked Comm-A messages can be canceled either whole or in part if the segments are not correctly received as determined by the LAS Field.

Step 1 Generate the following table of uplink frame data. Uniquely identify the data in the MA fields of each segment by using recognizable sequences of bit and/or byte patterns. All segments should be delivered by the same sensor II code, that is sensor 1, except frames 13 and 15 which should be delivered by sensor number 2.

Step 2 Send the following sequence of frames to the A-SSE:

LAS CODING

Frame	1	2	3	4	5	6	Notes
1.	1	0	0	0	1	0	Initial and Final Segments
2.	0	1	1	1	0	0	Two intermediate and one final segment; no initial segment
3.	1	1	0	0	0	1	Initial intermediate and final segments
4.	1	1	1	0	0	0	Initial and intermediate segments; no final segment
5.	1	0	0	0	0	1	Initial, third/final segments, no second segment
6.	1	1	1	0	0	0	Initial and intermediates; no final segment
7.	0	0	0	0	0	0	Delay Tc Plus one second
8.	0	0	0	1	0	0	Final segment for frame 6
9.	1	1	1	0	0	0	Initial and intermediate segments
10.	0	0	1	1	0	0	Duplicate and final segment for frame 9
11.	1	1	1	1	0	0	All 4 segments complete
12.	1	0	0	0	0	0	Initial segment IIS=1
13.	1	0	0	0	0	0	Initial segment IIS=2
14.	0	0	0	0	1	0	Final segment IIS=1
15.	0	0	0	0	1	0	Final segment IIS=2
16.	1	0	0	0	0	1	First and final segment
17.	0	1	0	0	0	0	Second segment

Step 3 Send each frame at 10-second intervals, except frame 7. After sending frame 6, wait at least Tc plus one seconds before sending frame 8. Thereafter, continue with 10-second intervals.

Step 4 Verify that frames 1, 3, 11, 12/14, 13/15, and 16/17 are sent to the A-SSE interface. Verify the 0.25 second reformatting time requirement and the data content for completeness and proper order.

Step 5 Frames 9 and 10 should comprise a complete linked Comm-A. However, segment 3 is duplicated in frame 10 and should be discarded. Verify that frames 9 and 10 are sent to the A-SSE interface. Verify from the length and content that the duplicate segment has been discarded.

Step 6 Frames 2, 4, 5, 6 and 8 should all be discarded; no message data should result. Each of these frames meets one of the conditions of paragraph 2.2.5.1.1.4 for uplink frame cancellation.

Link Frame Cancellation Timer Tc

Step 1 Generate two Short Form MSP packets with a 27 byte UD Field to fit into a four segment linked Comm-A message. The content of the UD Field will be a 1 in the first byte, 2 in the second byte, etc. Set II = 1 for all segments.

Step 2 Send only the first three Comm-A segments of the first frame to the A-SSE. Impose a delay of Tc minus two seconds, then send the final segment.

Step 3 Verify that the A-SSE forwards to the AAE interface a MSP message with a 27-byte UD Field in correct order and content.

Step 4 Repeat the process just described and transmit the first three Comm-A segments of the second frame. However, this time impose a delay of Tc plus two seconds between the transmission of the third and the final Comm-A segments. Verify that there is no output to the AAE.

C.1.2.3.2 Uplink ELM Frames

(B.2.2.7.1.2 – Uplink ELM Frame)

Objective: This test is designed to validate the uplink frame function of the MSSS, and is intended to demonstrate that the A-SSE can receive segments of an ELM. ELM protocol is strictly a transponder issue; the A-SSE has no part in the message handling until the transponder sends a complete ELM.

The data content of each of the segments of the ELM will be identical to the transponder MC Fields after the receipt of an ELM. The bit pattern contained in the MC Field should permit each segment's data to be uniquely identified. Note that the first four bits of each uplink ELM MC Field contains the II code of the sensor. Therefore, there are 76 bits of User Data in each uplink ELM segment. All segments should be delivered by the same sensor 1, code.

Step 1 Send the following table of ELM frames (UF = 24) containing the Short Form of MSP packets, to the A-SSE at the transponder interface:

Group	No of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	1	18 bytes	2 segments	2
b.	1	27 bytes	3 segments	3
c.	1	37 bytes	4 segments	4
d.	1	46 bytes	5 segments	5
e.	1	56 bytes	6 segments	6
f.	1	65 bytes	7 segments	7
g.	1	75 bytes	8 segments	8
h.	1	84 bytes	9 segments	9
i.	1	94 bytes	10 segments	10
j.	1	103 bytes	11 segments	11
k.	1	113 bytes	12 segments	12
1.	1	122 bytes	13 segments	13
m.	1	132 bytes	14 segments	14
n.	1	141 bytes	15 segments'	15
o.	1	151 bytes	16 segments	16

Step 2 Verify also that the A-SSE forwards the contents of the UD fields of the MSP packets and a means for identifying the packet as MSP data, to the AAE interface.

Negative Uplink ELM Frame Test

The A-SSE must discard the entire uplink ELM if all of the segments do not contain the same II code.

Step 1 Repeat the previous test with data from group a of the test but send the last segment with an II code different from the II code contained in the first segment.

Step 2 Verify that no output is generated to the A-SSE.

C.1.2.3.3 Downlink SLM Frames

(§B.2.2.7.2.1 – Downlink SLM Frame)
(§B.2.2.7.2.1.1 – LBS Coding)
(§B.2.2.7.2.1.2 – Linking Protocol)
(§B.2.2.7.2.1.3 – Directing SLM Frames)
(§B.2.2.7.2.3 – Delivery Status)

Objective: This test is designed to validate the downlink frame function of the MSSS, which includes processing of the SLM frame, LBS coding, linking protocol, directing and delivery status of SLM frames. This test requires the transmission single and linked Comm-B segments over MSP channels.

SLM Capable

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field. Set II = 1 for all packets in this section.

Step 2 Send the following MSP messages to the A-SSE from the AAE interface:

Group	No. of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	8	5 bytes	1 segments	48-41
b.	4	12 bytes	2 segments	52-49
c.	4	19 bytes	3 segments	56-53
d.	4	26 bytes	4 segments	60-57
e.	3	29 bytes	see text	63-61

Step 3 - Extract each Comm-B segments from the A-SSE and send Comm-D close-outs, as necessary. Verify the A-SSE sends an indication of the downlink delivery status to the AAE. Verify the correct association of LBS value with the number of segments delivered and that the M/CH field decrements correctly.

Note: Since the transponder is not downlink ELM capable, the packets from group e will be sent via Comm-B segments with MSP L-bit procedures.

Step 4 Verify that the first Comm-B message from group e consists of 4 segments and contains 26 bytes of data in the MB Field(s) and that the second Comm-B message contains one segment with three bytes of data in the MB Field.

C.1.2.3.4 Downlink ELM Frame

(§B.2.2.7.2.2 – Downlink ELM Frame)
(§B.2.2.7.2.2.1 – Directing ELM Frame)

Objective: This test is designed to validate the downlink frame function of the MSSS, which includes processing of the ELM frames This test requires the transmission of ELM segments over MSP channels.

ELM Capable

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field.

Step 2 Send the following MSP messages to the A-SSE from the AAE interface:

Group	No of Packets	UD Field Length	Packet Size	MSP Channel Nubers
a.	1	9 bytes	1 segment	1
b.	1	19 bytes	2 segments	2
c.	1	29 bytes	3 segments	3
d.	1	39 bytes	4 segments	4
e.	1	49 bytes	5 segments	5
f.	1	59 bytes	6 segments	6
g.	1	69 bytes	7 segments	7
h.	1	79 bytes	8 segments	8
i.	1	89 bytes	9 segments	9
j.	1	99 bytes	10 segments	10
k.	1	109 bytes	11 segments	11
1.	1	119 bytes	12 segments	12
m.	1	129 bytes	13 segments	13
n.	1	139 bytes	14 segments	14
o.	1	149 bytes	15 segments	15
p.	1	159 bytes	16 segments	16

Step 3 Extract the Comm-D segments from the A-SSE and send Comm-D close-outs, as necessary. Verify the A-SSE sends an indication of the downlink delivery status to the AAE interface. At the GAE interface, verify the correct association of the ND value with the number of segments delivered and that the M/CH field increments correctly for each packet.

C.1.2.4 MSP Operations

(These additional MSP operations tests may be considered, I need to look at these to find a home (requirements section), and to validate them. Requires further attention.

Step 1 Send 4 bytes of CONTROL MESSAGE data from the AAE interface on channel 1. Verify at the G-SSE interface that the A-SSE has sent a Mode S short form MSP packet on channel 1.

Step 2 Send 42 bytes of CONTROL MESSAGE DATA from the AAE interface on channel 1. At the G-SSE, verify that two Mode S MSP packets (long form) are received from the A-SSE on channel 1.The first frame will have L-bit set to one and contain 26 bytes of user data. The second frame will have L-bit set to zero and contain 16 bytes of user data.

Step 3 Send a Mode S frame containing a Mode S MSP (short form) Packet to the A-SSE on channel 2. Fill the UD Field with five bytes of the bit pattern 01010101. At the A-SSE interface, verify the reception of a CONTROL MESSAGE DATA on channel 2.

Step 4 Generate 42 bytes of Control Message Data from the G-SSE interface on MSP channel 1 in a total of 2 MSP packets (Long Form). The first MSP packet will have L-bit set to 1 and contain 26 bytes of User Data. The second MSP packet will have L-bit set to 0 and contain 16 bytes of User Data. At the A-SSE interface, verify that an MSP packet (Long Form) is received from the A-SSE on channel 1.

C.1.2.5 L-bit Linking

(§B.2.2.6.3.)
(§B.2.2.8.)

Objective: This test is designed to validate the L-bit linking function of the MSSS for long form MSP channels, and the use of the Tm timer for L-bit linking.

The Long Form MSP Packet test procedures are designed to test the A-SSE's ability to link Mode S Long Form MSP Packets when the packet size is greater than 28 bytes and the transponder has no downlink ELM capability.

Step 1 Use a selected MSP number, fill the Used Data Field with 32 bytes of the bit pattern 01010101. At the G-SSE interface, verify that two mode S long form MSP packets are received on the selected MSP channel from the A-SSE. The first frame will have L-bit set to one and contain 26 bytes of user data. The second frame will have L-bit set to zero and contain 6 bytes of user data.

Step 2 Send two Mode S Comm-A frames containing a linked Mode S Long Form MSP Packet to the A-SSE on a MSP channel number. Fill the UD Field with 26 bytes and 6 bytes respectively with the bit pattern 10101010. At the A-SSE interface, verify that a Mode S long form MSP packet is received from the AAE. Verify the UD Field for content and order.

L-bit Delivery Timer (Tm)

Step 1 From the GAE, create 2 long form MSP packets for delivery to the AAE. The first packet will have 26 bytes of user control data and L-bit set to 1. The seconds packet will have 16 bytes of user control data and L-bit set to 0 for a complete sequence.

Step 2 After sending the first packet, send the second packet within the Tm time period. At the AAE interface, verify the receipt of this constructed packet containing 42 bytes of user control data in correct order and content.

Step 3 Repeat the process to generate the long form MSP packets again to the A-SSE, except this time, send the second packet after Tm time period. This allows the A-SSE to discard the complete sequence since the expiration of the Tm timer for L-bit sequencing.

Verify that there's no related output for this transaction at the AAE interface.

C.1.2.6 Link Frame Cancellation Timer (Tc)

(§B.2.2.7.2.5)
(§B.2.2.8.)

Objective: This test is designed to validate the Tc frame cancellation timer of the frame processing function.

Step 1 Generate two Short Form MSP packets with a 27 byte UD Field to fit into a four segment linked Comm-A message. The content of the UD Field will be a 1 in the first byte, 2 in the second byte, etc. Set II = 1 for all segments.

Step 2 Send only the first three Comm-A segments of the first frame to the A-SSE. Impose a delay of Tc minus two seconds, then send the final segment.

Step 3 Verify that the A-SSE receives a MSP message with a 27-byte UD Field in correct order and content.

Step 4 Repeat the process just described and transmit the first three Comm-A segments of the second frame. However, this time impose a delay of Tc plus two seconds between the transmission of the third and the final Comm-A segments. Verify that there is no output to the AAE.

C.1.2.7 Interrogator Link Timer (Tz)

(§B.2.2.6.1.1.5)
(§B.2.2.8.)

Objective: This test is designed to validate the Tz interrogator link timer of the MSSS.

Step 1 <Include Tz tests here. Tz timer tests will be available for the next version of Appendix C test procedures.