Sagetech™
World's Smallest Certified Avionics.

System Description and Installation Manual for MXS

ICD10004-01

May 2018

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Introduction

This document describes the system and provides connection information for the MXS Transponder, part of the Sagetech MX product family.

NOTE: This document is under development. Additional information and/or modifications may be provided with future releases.

1. Sagetech Customer Support

Sagetech Corporation is dedicated to making integration of our MXS a straight-forward and simple exercise. We want your experience with Sagetech to be unparalleled in product quality and customer service. If you have questions, contact us at:

Email: support@sagetech.com

Phone: 1 (509) 493-2185

We also are interested in your feedback on our products, documents and customer service.

2. Equipment Safety

This product uses semiconductors that can be damaged by electrostatic discharge (ESD). When handling, use standard ESD practices to ensure the MXS is not damaged.

Important:

Whenever power is supplied to the MXS, a 50-ohm load must be provided to the SMA connections for the antennas if an antenna is not being used. Use a commercially available 50-ohm load rated for pulses of 500W with a 1% duty cycle in the 1GHz to 2GHz frequency range.

~~1.1~~2.1 FCC Warnings

Exposure Statement

This device meets the FCC requirements for RF exposure in public or uncontrolled environments. A minimum separation of persons to the antenna of 20 cm must be observed.

FCC Warnings

Changes or modifications not approved by Sagetech could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna

• Increase the separation between the equipment and receiver

• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

• Consult the dealer or an experienced radio/TV technician for help.

This device complies with FCC part 15 FCC Rules. Operation is subject to the following two conditions: 1. This device may not cause harmful interference and 2. This device must accept any interference received, including interference that may cause undesired operation

Overview

The MXS transponder performs the following basic functions:

- Transponder:
  - Interacts with air traffic control (ATC) by transmitting and receiving standard secondary surveillance radar pulses per ICAO requirements. The transponder replies to ATCRBS interrogations with a squawk code and pressure altitude data.
  - Provides Mode S replies (includes data such as ICAO address and call sign) and is capable of being selectively interrogated.
- ADS-B In:
  - The MXS receives Automatic Dependent Surveillance-Broadcast (ADS-B) In Extended Squitter messages (ES) that have been transmitted automatically from surrounding planes and the Air Traffic Control (ATC) system.
  - ES messages report Position, Velocity, Identification and Category, Target State and Status, and Aircraft Operational Status. From this data, MXS generates ADS-B, TIS-B and ADS-R reports for delivery to the flight computer which communicates the data to the user.
  - Transponders with ADS-B In are useful for sense and avoid applications by providing the user with surrounding traffic information with a nominal range of 120 nautical miles (NM).
- ADS-B Out:
  - Provides host computer-controlled Automatic Dependent Surveillance-Broadcast (ADS-B) Out capability.
  - Transmits Extended Squitter (ES) and Acquisition Squitter messages at regular intervals, providing Position, Velocity, Identification and Category, Emergency/Priority Status, Target State and Status, Aircraft Operational Status, and other aircraft data.
    - Altitude data for the ES can be based on the MXS's integrated altitude encoder, or one provided external to the MXS.
    - GPS data, also included in the ES, is provided to the MXS from the avionics system integrator.
    - Receives Installation, Flight ID, Operational and GNSS navigation data from Host Computer or directly from sensors.
- Altitude Encoder:
  - Computes own-ship barometric altitude with integral, calibrated pressure sensor and encoder (termed a blind encoder).

The MXS accomplishes these functions by communicating with ATC, surrounding aircraft, the aircraft flight computer, external GPS, and discrete inputs from the aircraft.

Specific aspects of the MXS transponder include the following:

- GPS input is accepted from the following sources: via the host interface command link, or via NMEA or Accord serial formats over dedicated pins on the host connector.
- MXS supports antenna diversity.
- Two Transponder/ADS-B L-Band antennas are used.
- MXS includes an internal pressure altitude sensor, encoder and an altitude encoder port to a static pressure line. The integral altitude encoder is calibrated to 85,000 feet MSL by default. Configurations are available with calibration/defined altitude error up to 100,000 feet MSL.
- Its approximate dimensions are 3.3" x 2.4" x 0.9". (See Figure 0-1~~Figure 4-1~~.)
- Operating temperature is designed to be -40 to +71°C when 2.0°C/Watt of cooling is provided. Storage temperature is expected to be -55 to +85°C.
- Input supply voltage range is 14-28 VDC +/- 4 VDC.

- Flight computer communication is via a proprietary protocol via RS-422, RS-232 or Ethernet.

Installation

Installation of the MXS consists of:

- Mounting MXS with required 2.0°C/Watt heat sink
- Routing power cable and host computer to MXS through the Main Connector
- Connecting to a GPS data source
- Installing antenna(s)
- Routing and connecting the antenna cable
- Connecting the altitude sensor/encoder to system static pressure

Figure 0-1~~Figure 4-1~~ shows a labeled diagram of MXS's features, which may be of use during the installation process.

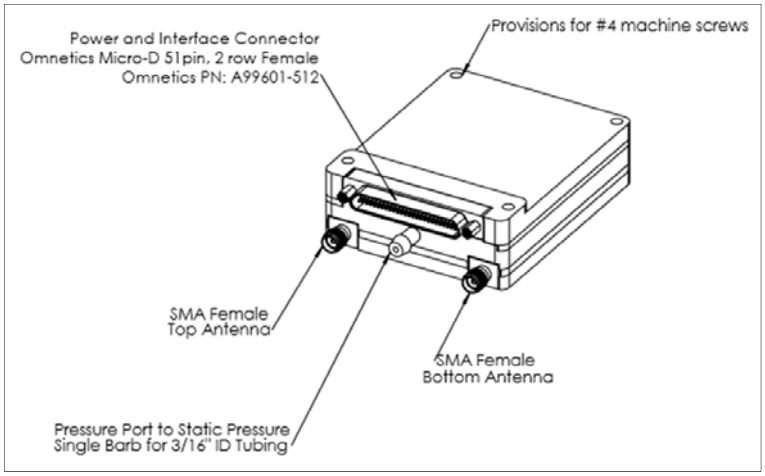

Figure 0-1 MXS Feature Locations

1. Mounting MXS with required 2.0°C/Watt heat sink

2. Ensure Proper Environmental Area

The following environmental characteristics should be in place to install MXS:

Altitude Range

Operation Altitude Range: -1,200 to a maximum of 85,000 feet

Maximum Vibration

Random Vibration 15 to 2000Hz @13.8gRMS (MIL-STD-810E)

Protect from weather

- The MXS needs to be mounted in a location protected from weather.
- Operating temperature is designed to be -40 to +71°C when 2.0°C/Watt of cooling is provided. Storage temperature is expected to be -55 to +85°C.
- MXS should be mounted away from sources of excess heat to better guarantee an operating environment within its designed temperature range.

- The MXS requires a 2.0°C/Watt heat sink at full power above 40°C ambient. Actual heat sink needs are dependent on temperature of operating environment and power load.
- MXS is designed in such a way that its case conducts thermal load to the aircraft frame. It can be firmly mounted directly to the aircraft or to other components within the aircraft.
- MXS should be mounted with the non-labeled side facing the heat sink.
- If inadequate heat sinking is provided, the MXS will not transmit while internal temperature limits are exceeded.

3. Mounting the MXS Unit

- The mounting holes in the MXS are found on the top of the unit. The two holes closer to the Main Connector are 24 mm in depth at the mounting points, while the two further away are 20 mm depth at the mounting points. All four holes are 3.35 mm in diameter and accept 4-40 (or M3 x .05) machine screws.
- The machine screws listed in Table 0-1~~Table 3-1~~ represent an approximate starting point in a search for the correct screw for your custom installation.
- Sagetech recommends applying Loctite 242 Threadlocker to the machine screw threads or using lock washers or nuts.

Table 0-1 Common mounting parts/vendors

Quantity Required	Description	Vendor	Vendor PN
4	1 1/4" Pan Head 4-40 Machine Screw	McMaster-Carr	90279A117
8	Washers	McMaster-Carr	98029A024
4	Lock Nuts	McMaster-Carr	90631A005

3. Route power cables and Host Computer to the MXS

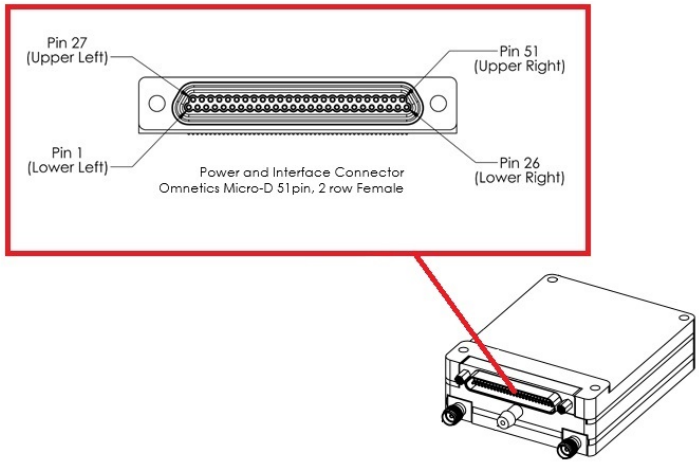

Figure 0-2 51-Pin Micro D-Sub Type Female Main Connector

The Main Connector carries power as well as serial and Ethernet communications to the host computer. MXS's Main Connector is a 51-pin Micro D-Sub type female connector. Figure 0-2~~Figure 3-2~~ shows the Main Connector pin assignment orientation. Table 0-2~~Table 3-2~~ provides the Main Connector manufacturer's part number.

Table 0-2 Main Connector Part Description

Part Description	Manufacturer	Part Number
Female Power and Interface Connector Micro-D 51 pin, 2-row	Omnetics	A99601-512

To connect to the Main Connector:

- Construct a cable to connect the host computer to the Main Connector according to pin-out definitions and instructions described in Section 05.0. The cable should be built according to standard A-A 59569A.
- The MXS can be powered with 14-28 VDC +/- 4 VDC (at the MXS). MXS power consumption is documented in Table 0-3~~Table 3-3~~. If you are supplying voltage to the MXS at the lower end of that range, avoid voltage loss by using short power supply wires and/or larger diameter power supply wires.
- Zener diodes are used on the DC Power pins to protect the MXS against overvoltage and reverse polarity.
- Surge currents can be up to 5A when enabling operating mode or transmitting. The in-rush current at power-on (in operating mode) will also not exceed 5A.

Table 0-3 Maximum Current Consumption

Variant	Supply Voltage	Max Average Current	Note
MXS	14 V	2.1 A	Measured
	28 V	1.0 A	Measured

4. Connect to GPS Interface

GPS data should be provided to the MXS from the aircraft system integrator in one of two ways:

a) GPS serial data stream on the 51-pin Micro-D connector. The data format is either NMEA or a proprietary format from a NexNav Mini GPS (a TSO-C145c compliant solution).
b) Host Computer GPS data is incorporated into the command and control protocol packets on the 51-pin serial interface. (See Section 105.1.)

Note: Sagetech recommends using the external Accord Technology NexNav Mini receiver. It is the smallest TSO-C145c compliant receiver Sagetech has identified.

5. Installing two Antennas

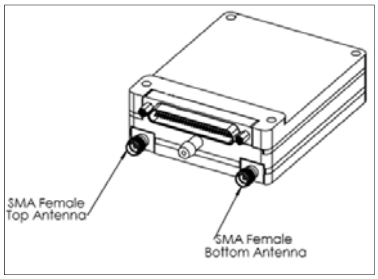

Figure 0-3 Connectors to Top and Bottom Antenna

In the diversity configuration, top and bottom-located antennas should be connected to MXS using the left and right-side female SMA connectors (see Figure 0-3~~Figure 3-3~~). Assuming the orientation shown in Figure 0-3~~Figure 3-3~~, the top

antenna connects to the left connector and the bottom antenna connects to the right connector. Whenever power is supplied to the MXS, a 50-ohm load should be provided to both SMA connections. Ensure that the antenna(s) selected provide a 50-ohm termination for the MXS. If only one antenna is used, replace the top antenna with a 50-ohm termination rated for 5W minimum.

The antennas used by MXS should be mounted on the outside of the aircraft according to the manufacturer's installation instructions, with additional guidance provided below and in Table 0-4~~Table 3-4~~:

- The MXS should have its own antennas. An exception to this rule is use of a high-quality diplexer that enables antenna sharing between a MXS and certain ADS-B equipment. Further guidance on diplexer use can be found in RTCA documents DO-282B and DO-260B, the minimum operational performance standards for UAT and 1090 MHz ADS-B, respectively.
- Minimize the distance between the MXS and its antennas. The antenna cable must have no more than 2dB of signal loss from the MXS to the antenna.
- Take care to locate the antennas away from any objects that may disrupt the ground plane for the antennas, such as doors and landing gear.
- Do not place the antennas close to engine exhaust.
- Try to keep the antennas located at least 36" away from other antennas on the aircraft. The antennas should be located as close to the centerline of the fuselage as space allows, while trying to keep the antennas on a flat surface.
- A ground plane is required for most antennas appropriate for MXS. Failure to provide a good ground plane can result in degradation of antenna performance.
- Use antennas designed to be used with aviation transponders, with the characteristics documented in Table 0-4~~Table 3-4~~.
- Torque mating SMA connectors to: 7-10 lb · in [80-110 N · cm]. Take care not to over-torque the antennas in an attempt to reduce a gap between the antenna and the mounting surface; torque the antenna to the manufacturer's instructions.

Note: If your installation does not meet all of the above requirements, MXS performance (range) may be hindered, and damage to the MXS could result.

Table 0-4 MXS Antenna Requirements

Antenna Requirements	
Frequency	1030 to 1090 MHz
Polarization	Vertical
Nominal Impedance	50 Ω
VSWR	<1.5:1 between 1030 to 1090 MHz
RF Power	500 W Peak
Radiation Pattern	The gain must not be less than the gain of a matched quarter-wave stub minus 3 dB over 90 percent of a coverage volume from 0 to 360 degrees in azimuth and from 5 to 30 degrees above the ground plane when installed at the center of 1.2 m (4 foot) diameter (or larger) flat circular ground plane.
Mounting Location	• One or two antennas may be used.

	• Diversity installations are supported. • Antennas should be mounted as near as possible to the center line of the fuselage. • The bottom antenna should be mounted on the underside of aircraft fuselage, nominally at the wing root. • Antennas should be located to minimize obstruction to their fields in the horizontal plane.

6. Routing and connecting the antenna cable

Attach your antenna cable to the bottom antenna SMA connector shown in Figure 0-3~~Figure 3-3~~.

A suitable antenna cable consists of a male SMA connector, a length of co-axial cable, and a suitable connector for your antenna. For example, if you are using a simple monopole antenna with a BNC female connector, your antenna cable will need a BNC male connector. (See example cable part in Table 0-5~~Table 3-5~~.)

Table 0-5 Antenna Cable Connector Parts

Part Description	Manufacturer	Part Number
SMA Male to BNC Male Right Angle Cable 24”	Sagetech	10-1639

The antenna cable must have no more than 2dB of signal loss from the MXS to the antenna. This includes losses in the connector and cable. Generic and custom-built cables can be obtained from suppliers such as Pasternak, Richardson, and Aircraft Spruce.

Avoid sharp bends in the antenna cable that could lead to additional cable loss.

7. Connecting altitude sensor/encoder to system Static Pressure

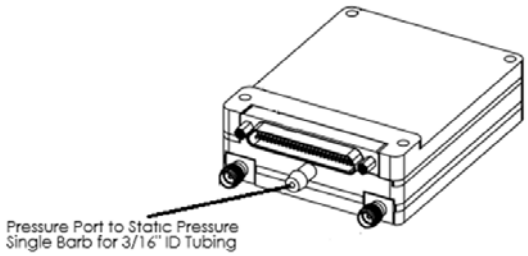

Figure 0-4 Pressure Altitude Encoder Port to Static Pressure

MXS has an altitude encoder port. (See Figure 0-4~~Figure 3-4~~.) Altitude data for the extended squitter can be based on MXS’s integral, calibrated pressure sensor and encoder (termed a *blind encoder*).

Plumb the altitude encoder connection to a static pressure line that shares the same source as the main aircraft altimeter. The pressure barb is sized for 3/16” Internal Diameter (ID) tubing. A typical installation will have a T or Y fitting in the static pressure line with one end running to the MXS. Suitable Y-barbed tube fittings are available from suppliers such as McMaster-Carr.

Mechanical Characteristics

8. Dimension, Weight & Material

MXS's width, height, and length are shown in Figure 0-1~~Figure 4-1~~.

Table 0-1 - Mechanical Attributes

Mechanical Attributes	
Weight:	150g
Color:	Black
Plating:	Electroless Black Nickel

Table 0-1~~Table 4-1~~ lists the weight, color, and material attributes of the MXS.

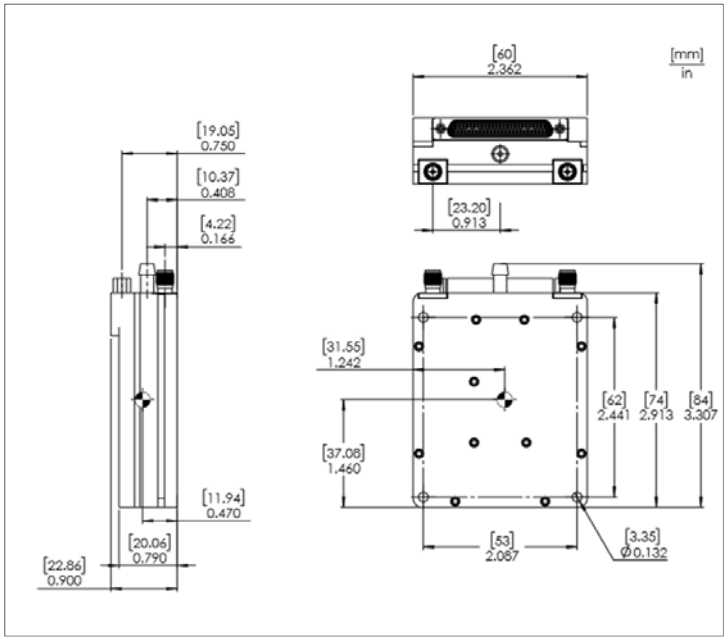

Figure 0-1 – MXS Dimensions

9. Mechanical Connection

The MXS has the following connectors/ports:

- One 51-Pin Micro D-Sub connector, connecting to the host and power.
- Two Transponder/ADS-B L-Band SMA antenna connectors.
- One Pressure Altitude Sensor/Encoder port to static pressure, connected to tubing with a clamped diameter of 0.18".

The locations of these connectors/ports are shown in Figure 0-2~~Figure 4-2~~.

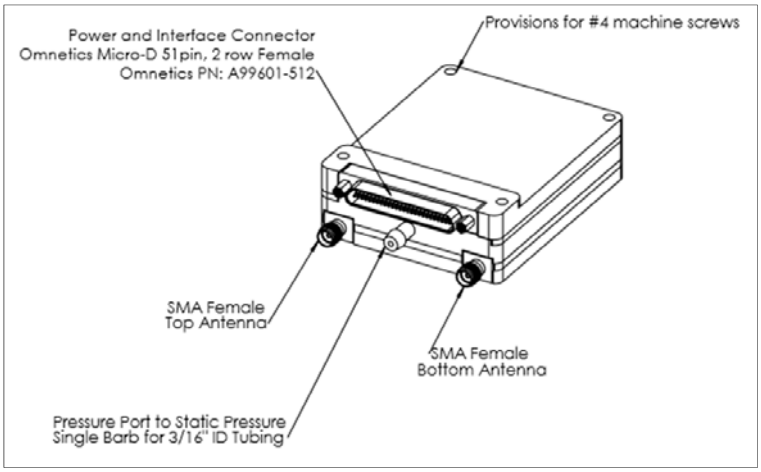

Figure 0-2 – Mechanical Connections

1. MXS Main Connector

The MXS Main Connector is a 51-pin Micro-D type female connector that provides the interface to the host computer's command and control serial and Ethernet buses. The connector also provides an interface to the main power source.

Figure 0-3~~Figure 4-3~~ shows the MXS Main Connector (Omnetics P/N: A99601-512) with pin locations. Figure 0-4~~Figure 4-4~~ presents an image of the female Micro D-Sub Main Connector's front view, with pin number orientation. Table 0-1~~Table 5-1~~ shows the main connector 51-pin assignments.

Connecting the MXS Main Connector to the host requires a shielded cable built according to standard A-A 59569A.

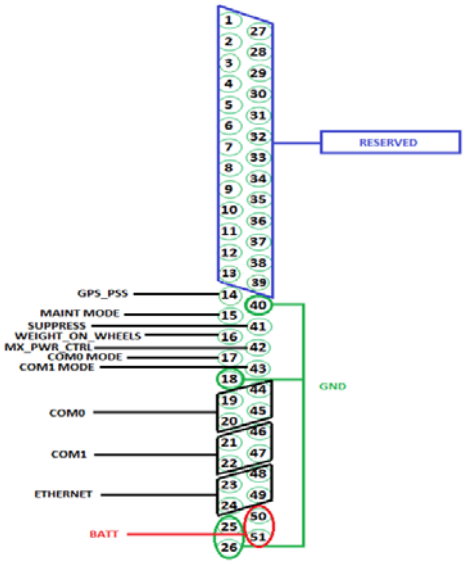

Figure 0-3 MXS Main Connector (Female) Pin Locations

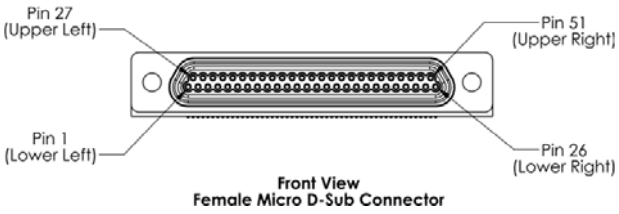

Figure 0-4 Transponder Main Connector - Front View

Electrical Characteristics

10. Main Connector

The electrical interface consists of signals brought to the MXS via the 51-Pin Micro-D main connector. Figure 0-4~~Figure 4-4~~ presents an image of the female Micro D-Sub Main Connector's front view, with pin number orientation. Table 0-1~~Table 5-1~~ shows the pin assignments for the main connector.

By design, all signals on the main connector are protected from damage caused by Indirect Effects of Lightning (DO-160G category K3L3[1]) and Electrostatic Discharge (at 2kV HBM or better).

Additional main connector signal information:

- Power signals are the supply voltage and ground returns provided by the aircraft. Zener diodes are used on the DC Power pins to protect the Transponder against overvoltage and reverse polarity.
- The Maintenance Mode signal is a discrete input that enables or disables Maintenance Mode. To program the transponder, Maintenance Mode must be enabled. To enable Maintenance Mode, connect the Maintenance Mode signal to ground. During normal operation Maintenance Mode should be disabled. To disable Maintenance Mode, leave the Maintenance Mode signal unconnected, i.e. floating.
- MXS Power Control signal is used to shut the Transponder off (near zero power consumption). If the Power Control line is left open, the Transponder will be on. If the power control line is shorted to ground, the Transponder will be off.
- Weight-on-Wheels (WOW) signal is an input that indicates to the Transponder whether the aircraft is on the ground or in the air. Grounding the pin indicates that the aircraft is on the ground. Removing the ground will indicate the aircraft is in the air. If the WOW signal is not used, the pin may be left unconnected.
- The communication ports (Com0 and Com1) can be configured as either a RS-232 or RS-422 serial bus. Selecting the serial communication port bus type and Main Connector pin interface is controlled by the state of Com0-Mode and Com1-Mode. The Com-Mode pins are weakly pulled up to 3.3Vdc and will select RS-422 if left unconnected. A truth table based on the state of Com0-Mode and Com1-Mode is provided in Table 0-2~~Table 5-2~~.
- At least one COM bus or Ethernet must be selected and used for the Host Computer Command and Control interface.
- Mutual Suppress is designed to connect to an aircraft's bidirectional suppression bus. Mutual Suppression bus is used to desensitize L-Band receivers and block L-Band transmitters when another onboard L-Band equipment is transmitting. This prevents interferences from own-ship L-Band transmitters. It is typically used when aircraft equipage includes Transponders, TCAS and/or DME. MXS stops transmitting and receiving when Mutual Suppression line is driven to high (18V-70V) by an external source. The MXS will return to normal operation within 15 microseconds following the suppression pulse. The Mutual Suppression bus follows the design requirements of the ARINC 718 specification.

Table 0-1 MXS Main Connector Pin Assignments

Pin Number	Signal	Direction	Signal Char.	Required
1	Reserved	No Connect	Reserved	N
2	Reserved	No Connect	Reserved	N

[1] Section 22 Waveform 3 Level 3 and Waveform 1 Level 1. A Shielded cable harness built according to Standard A-A 59569A will be required to meet these categories.

Pin Number	Signal	Direction	Signal Char.	Required
3	Reserved	No Connect	Reserved	N
4	Reserved	No Connect	Reserved	N
5	Reserved	No Connect	Reserved	N
6	Reserved	No Connect	Reserved	N
7	Reserved	No Connect	Reserved	N
8	Reserved	No Connect	Reserved	N
9	Reserved	No Connect	Reserved	N
10	Reserved	No Connect	Reserved	N
11	Reserved	No Connect	Reserved	N
12	Reserved	No Connect	Reserved	N
13	Reserved	No Connect	Reserved	N
14	GPS-PPS (See note [2])	Input	TTL PPS	N
15	Maint Mode	Input	GND/Open	N
16	Weight-on-Wheels	Input	GND/Open	N
17	Com0-Mode (See note[3])	Input	GND/Open	N
18	GND[4]	Power	Ground	Y
19	Com0-422-RX+ (See note[3] and note[5]) Com0-232-RX	Input	RS-422 RX+ RS-232 RX	N
20	Com0-422-TX+ (See note[3] and note[5]) Com0-232-TX	Output	RS-422 TX+ RS-232 TX	N
21	Com1-422-RX+ (See note[3] and note[5]) Com1-232-RX	Input	RS-422 RX+ RS-232 RX	N
22	Com1-422-TX+ (See note[3] and note[5])	Output	RS-422 TX+	N

[2] Pins must be driven or terminated to an appropriate TTL logic level. (0.0 – 0.7 V, or 2.0 – 3.3 V)
[3] RS-422 bus will be selected if pins are left unconnected. The pin must be grounded to select RS-232 bus. (See Table 0-2~~Table 5-2~~)
[4] All four GND pins must be grounded.
[5] Transmit and receive are from the MXS perspective. Connect as appropriate.

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Pin Number	Signal	Direction	Signal Char.	Required
	Com1-232-TX		RS-232 TX	
23	Ethernet-TX+ (See note[55])	Output	IEEE 802.3+	N
24	Ethernet-RX+ (See note[55])	Input	IEEE 802.3+	N
25	GND[44]	Power	Ground	Y
26	GND[44]	Power	Ground	Y
27	Reserved	No Connect	Reserved	N
28	Reserved	No Connect	Reserved	N
29	Reserved	No Connect	Reserved	N
30	Reserved	No Connect	Reserved	N
31	Reserved	No Connect	Reserved	N
32	Reserved	No Connect	Reserved	N
33	Reserved	No Connect	Reserved	N
34	Reserved	No Connect	Reserved	N
35	Reserved	No Connect	Reserved	N
36	Reserved	No Connect	Reserved	N
37	Reserved	No Connect	Reserved	N
38	Reserved	No Connect	Reserved	N
39	Reserved	No Connect	Reserved	N
40	GND[44]	Power	Ground	Y
41	Suppress (See note [6])	Bi-Directional	(See note[66])	N
42	MXS Power Control	Input	GND/Open	N
43	Com1-Mode (See note[33] and note[55])	Input	GND/Open	N
44	Com0-422-RX- (See note[33] and note[55])	Input	RS-422 RX-	N
45	Com0-422-TX- (See note[33] and note[55])	Output	RS-422 TX-	N
46	Com1-422-RX- (See note[33] and note[55])	Input	RS-422 RX-	N

[6] Mutual suppression circuit designed to requirements in ARINC 718 - Attachment 6.

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Pin Number	Signal	Direction	Signal Char.	Required
47	Com1-422-TX- (See note[54] and note[55])	Output	RS-422 TX-	N
48	Ethernet-TX- (See note[55])	Output	IEEE 802.3-	N
49	Ethernet-RX- (See note[55])	Input	IEEE 802.3-	N
50	DC Power (See note[7])	Power	14-28VDC	Y
51	DC Power (See note[77])	Power	14-28VDC	Y

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Table 0-2 Communication Port Select Map

Serial Bus Type/ Required Configuration	Main Connector Interface	
	Signal	Pin
RS-422 Com0 **Com0-Mode pin 17 should be left open**	Com0-RX-	44
	Com0-RX+	19
	Com0-TX-	45
	Com0-TX+	20
	Com0-Mode	17
RS-232 Com0 **Com0-Mode pin 17 must be tied to ground**	Com0-232-RX	19
	Com0-232-TX	20
	Com0-Mode	17
RS-422 Com1 **Com0-Mode pin 43 can be left open**	Com1-RX-	46
	Com1-RX+	21
	Com1-TX-	47
	Com1-TX+	22
	Com1-Mode	43
RS-232 Com1 **Com1-Mode pin 43 must be tied to ground**	Com1-232-RX	21
	Com1-232-TX	22
	Com1-Mode	43

[7] Both power pins must be connected to aircraft main power.

Serial Bus Type/ Required Configuration	Main Connector Interface	
Ethernet	Ethernet-TX+	23
	Ethernet-RX+	24
	Ethernet-TX-	48
	Ethernet-RX-	49

Host Interface Characteristics

11. Communications

MXS is controlled by a straightforward messaging system which communicates over a serial or Ethernet interface. Communicating with the MXS involves constructing messages, computing a checksum to ensure data validity, and sending these messages to the MXS.

1. Serial Communication Protocol

MXS's Main Connector provides two RS-422 or RS-232 serial ports that can be used for operational control and command. See Table 0-1~~Table 5-1~~ for pin numbers and connection information for Com0 and Com1. Table 0-1~~Table 6-1~~ provides data rate and format information.

WARNING: If serial communication is being used then only one serial port is used for sending host messages and for ADS-B In reports. The other RS422/RS232 port is reserved for GPS only data (if any). Using the same COM port for both GPS and either host messages or ADS-B In reports will cause unpredictable behavior.

Table 0-1 Serial Communication Protocol Details

COM Port	Data Rate	Data Format
Com0	User adjustable via Installation Message 38.4 KBPS default	"8-N-1", 1 start bit, 8 data bits (Note 8), no parity, 1 stop bit
Com1	User adjustable via Installation Message 38.4 KBPS default	"8-N-1", 1 start bit, 8 data bits (Note 8), no parity, 1 stop bit

2. Ethernet Communication Protocol

Operational control and command messages may also be sent (and replies received) via Ethernet User Datagram Protocol (UDP) packets. Ethernet bandwidth is required to support the requirement for 400 targets in RTCA/DO-260B.

See Table 0-1~~Table 5-1~~ for pin numbers and connection information.

[8] Transmitted least significant bit first.

The IP address and port number are configured in the installation message (Section 01.013.26.3.2).

3. Serial and Ethernet Message Format

The MXS serial and Ethernet interface uses the following message data structure for communication:

Table 0-2 Packet Structure

Message Field	Field Description	Number bytes
Start Byte	Precedes all messages with a fixed value of 0xAA.	1
Message Type	Defines the message type.	1
Message ID	Contains an arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message. (Typically, a sequence number.) Acknowledgement messages include the Message ID of the command message being acknowledged. Sagetech recommends incrementing this field by one with each message sent.	1
Payload Length	Indicates the number of bytes in the Payload Data field.	1
Payload Data	A variable length field with a different length depending upon the specific message. The number of bytes in the Payload Data must match the Payload Length field. The Payload Data contains the information that is used to control and command the MXS. The most significant byte (MSB) of any data field is transmitted first.	0 to 255
Checksum	Contains the regular 8-bit arithmetic summation of the message starting with the Start Byte and ending with the last byte of the Payload Data. The summation is performed assuming all bytes are unsigned, and the result is truncated to the least significant 8 bits.	1

12. Operating Modes

The MXS can operate in the following modes:

OFF – In this mode there is no communication of any kind. The MXS device consumes near zero power. This mode is set using the MXS Power Control pin on the main connector. (See Section 105.1)

STBY (Standby) – In this mode, transmitting is unavailable and receiving is available. In Standby, MXS is in low power mode with minimal components active, including the microprocessor and communication ports. STBY is set using the Operating Message. (See Section 13.46.3.4)

ON –In this mode the transponder is operational but inhibited from transmitting any pressure altitude information. ON is set using the Operating Message. (See Section 13.46.3.4)

ALT – In this mode the MXS is fully operational, including transmitting altitude, if available. ALT is set using the Operating Message. (See Section 13.46.3.4)

13. Messages Sent to the MXS

1. Overview

Table 0-3~~Table 6-3~~ provides an overview of the command messages that can be sent to the MXS.

Table 0-3 Messages Received by the MXS

Command Message Name	Message Type	Payload Length (Bytes)	MXS Response	Frequency	Document Section
Installation	0x01	36	ACK + Message	Once at installation	2~~6.3.2~~
Flight ID	0x02	12	ACK + Message	At least once every five seconds	3~~6.3.3~~
Operating	0x03	12	ACK	Once every second	4~~6.3.4~~
GPS Data	0x04	63	ACK	Once every second	5~~6.3.5~~
Data Request	0x05	4	ACK + Message	As needed	6~~6.3.6~~
Reserved	0x06-0x0A				
Target Request	0x0B	7	ACK + Message(s)	As needed	7~~6.3.7~~
Mode	0x0C	5	ACK + Message	As needed	8~~6.3.8~~
Reserved for future use: Air-Initiated Comm-B Message	0x0D				

2. *Installation Message: Type 0x01*

This message contains information about the aircraft and its capabilities. This information is stored in non-volatile memory and needs to be sent only once at installation time.

Table 0-4~~Table 6-4~~ provides an overview of the payload structure for the Installation Message. Table 0-5~~Table 6-5~~ provides a detailed description of the Installation Message payload. Table 0-6~~Table 6-6~~ provides an example Installation Message with the content of the message in its entirety, including pre- and post-payload bytes.

Table 0-4 Installation Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**ICAO Address**	3
03	**Aircraft Registration**	7
10	**Reserved**	2
12	**COM Port 0**	1
13	**COM Port 1**	1
14	**IP Address**	4
18	**Net Mask**	4
22	**Port Number**	2
24	**GPS Integrity**	1
25	**Emitter Category Set**	1
26	**Emitter Category**	1
27	**Aircraft Size**	1
28	**Max Airspeed**	1
29	**Altitude Encoder Offset**	2
31	**Reserved**	2
33	**Install Configuration**	1
34	**Reserved**	2

Table 0-5 Installation Message Payload Structure Detail

ICAO Address					
Byte Offset	**Byte Name**	**Field Description**			
00	ICA0	**ICA0**	**ICA1**	**ICA2**	**ICAO Address**
01	ICA1	0x1C	0xA6	0xB2	1CA6B2
02	ICA2	Ox2A	0x35	0x6A	2A356A
		Participant Address Bytes: Set 24-bit ICAO Address. Up to 6 hex characters can be entered by the user. This number is issued to the aircraft by the registration authority for the aircraft. If assigned as octal numbers you will need to convert to hexadecimal. If the ICAO Address is set to either all ONES or all ZEROS, the transponder will not send out extended squitters.			

Aircraft Registration									
Byte Offset	**Byte Name**	**Field Description**							
03	AR0	**AR0**	**AR1**	**AR2**	**AR3**	**AR4**	**AR5**	**AR6**	**Aircraft Registration**
04	AR1	0x31	0x32	0x33	0x33	0x30	0x32	0x01	1233021
05	AR2	**Aircraft Registration Bytes** Set 56-bit Aircraft Registration. This can be the tail number or registration number. Up to seven ASCII characters can be entered. Data is sent as unsigned chars and valid ASCII characters are outlined below: **All characters except the following are invalid.** 0x20 (Space) 0x30-0x39 (0-9) 0x41-0x5A (A-Z) The most significant bit is sent first. The ASCII characters are left-justified, and the Aircraft Registration itself may not contain spaces. The Aircraft Registration is padded with space characters on the right. (For reference, see DO-181e section 2.2.19.1.13) If Aircraft Registration is not available, fill this field with space characters (0x20).								
06	AR3								
07	AR4								
08	AR5								
09	AR6								

Reserved		
Byte Offset	**Byte Name**	**Field Description**
10	RE0	This field is reserved for future use. Set to ZERO. All other values are invalid.
11	RE1	

COM Port 0			
Byte Offset	**Byte Name**	**Field Description**	
12	C00	**Byte CO0**	**Com Port 0 Settings**
		0x00	38400 Bits per Second (Default)
		0x01	600 Bits per Second
		0x02	4800 Bits per Second
		0x03	9600 Bits per Second
		0x04	28800 Bits per Second
		0x05	57600 Bits per Second
		0x06	115200 Bits per Second
		0x07	230400 Bits per Second
		0x08-0xFF	Reserved
		If a baud rate change is requested of the same port that the Installation Message was received on, the change will be postponed until the 'acknowledge' has been sent. The baud rate change will be immediate for the port not used to receive the Installation Message.	

COM Port 1			
Byte Offset	**Byte Name**	**Field Description**	
13	C10	**Byte C10**	**Bit value**
		0x00	38400 Bits per Second (Default)
		0x01	600 Bits per Second
		0x02	4800 Bits per Second
		0x03	9600 Bits per Second
		0x04	28800 Bits per Second
		0x05	57600 Bits per Second
		0x06	115200 Bits per Second
		0x07	230400 Bits per Second
		0x08-0xFF	Reserved
		If a baud rate change is requested of the same port that the Installation Message was received on, the change will be postponed until the 'acknowledge' has been sent. The baud rate change will be immediate for the port not used to receive the Installation Message.	

IP Address						
Byte Offset	**Byte Name**	**Field Description**				
14	IP0	**IP0**	**IP1**	**IP2**	**IP3**	**IP Address**
15	IP1	0x01	0xA0	0x0A	0xF0	1.160.10.240
16	IP2	4-byte Internet Protocol address. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255.				
17	IP3					

Net Mask						
Byte Offset	**Byte Name**	**Field Description**				
18	NM0	**NM0**	**NM1**	**NM2**	**NM3**	**Net Mask**
19	NM1	0xFF	0xFF	0xFF	0x00	255.255.255.0
20	NM2	Net Mask is a 32-bit mask used to divide an IP address into subnets and specify the network's available hosts. In a netmask, two bits are always automatically assigned. In the example above, 255.255.225.0, "0" is the assigned network address. In 255.255.255.255, "255" is the assigned broadcast address. The 0 and 255 are always assigned and cannot be used.				
21	NM3					

Port Number		
Byte Offset	**Byte Name**	**Field Description**
22	PRT0	16-bit UDP port number used to communicate with the Transponder. The first byte is the most significant byte.
23	PRT1	

GPS Integrity9			
Byte Offset	Byte Name	Field Description	
24	GI0	Source Integrity Level (SIL) The GPS SIL should be set by a qualified expert. The field is used to declare the probability of the horizontal position exceeding the radius of containment defined by the NIC without alerting. As a guideline, Low integrity should be set for VFR only GPS or an uncertified installation. System Design Assurance (SDA) The GPS SDA should be set by a qualified expert. The field is used to declare the probability of a fault causing false or misleading horizontal position information.	
		GIO (MSN)	GPS Integrity – SIL (per flight hour)
		0x0	Unknown; > 1x10-3 - Default
		0x1	Low; ≤ 1x10-3
		0x2	Medium; ≤ 1x10-5
		0x3	High ≤ 1x10-7
		0x4-0xF	Reserved
		GIO (LSN)	GPS Integrity – SDA (per flight hour)

[9] The supported NexNav Mini GPS receivers are the CCA Part No 11000 and LRU Part No 21000.

GPS Integrity9		
	0x0	Unknown/No safety effect (DAL E); >1x10-3 or Unknown
	0x1	Minor (DAL D); ≤ 1x10-3
	0x2	Major (DAL C); ≤ 1x10-5
	0x3	Hazardous (DAL B); ≤ 1x10-7
	0x4-0xF	Reserved

Emitter Category Set			
Byte Offset	Byte Name	Field Description	
25	ES0	Emitter Category Set Defines the emitter category set of the aircraft.	
		Byte ES0	Category Set
		0x00	Category Set A
		0x01	Category Set B
		0x02	Category Set C
		0x03	Category Set D
		0x04-0xFF	Reserved

Emitter Category			
Byte Offset	Byte Name	Field Description	
26	EC0	Byte EC0	Set A (ES0=0x00) Categories
		0x00	Unknown
		0x01	Light (<15500 lbs.)
		0x02	Small (15500 to 75000 lbs.)
		0x03	Large (75000 to 300000 lbs.)
		0x04	High-Vortex Large (aircraft such as B-757)
		0x05	Heavy (> 300000 lbs.)
		0x06	High Performance (>5g acceleration and >400 knots)
		0x07	Rotorcraft

Emitter Category		
	0x08-0xFF	Reserved
	Byte EC0	Set B (ES0=0x01) Categories
	0x00	Unknown
	0x01	Glider/sailplane
	0x02	Lighter than air
	0x03	Parachutist/Skydiver
	0x04	Ultralight/hang-glider/paraglider
	0x05	Reserved
	0x06	Unmanned Aerial Vehicle (UAV)
	0x07	Space / Trans-atmospheric vehicle
	0x08-0xFF	Reserved
	Byte EC0	Set C (ES0=0x02) Categories
	0x00	Unknown
	0x01	Surface Vehicle – Emergency Vehicle
	0x02	Surface Vehicle – Service Vehicle
	0x03	Point Obstacle
	0x04	Cluster Obstacle
	0x05	Line Obstacle
	0x06-0xFF	Reserved
	Byte EC0	Set D (ES0=0x03) Categories
	0x00	Unknown
	0x01-0xFF	Reserved

Emitter Category				
Byte Offset	Byte Name	Field Description		
27	AS0	AS0 Bit Position	Aircraft Size Length (m)	 Width (m)
		0x00	Unknown-Default	Unknown-Default
		0x01	<= 15	<= 23
		0x02	<= 25	<= 28.5
		0x03	<= 25	<= 34
		0x04	<= 35	<= 33
		0x05	<= 35	<= 38
		0x06	<= 45	<= 39.5
		0x07	<= 45	<= 45
		0x08	<= 55	<= 45
		0x09	<= 55	<= 52
		0x0A	<= 65	<= 59.5
		0x0B	<= 65	<= 67
		0x0C	<= 75	<= 72.5
		0x0D	<= 75	<= 80
		0x0E	<= 85	<= 80
		0x0F	<= 85	<= 90
		0x10-0xFF	Reserved	Reserved

Max Airspeed			
Byte Offset	**Byte Name**	**Field Description**	
28	MA0	**MA0 Bit Position**	**Maximum Airspeed**
		0x00	No airspeed data available- *Default*
		0x01	Up to 75 kt
		0x02	75 kt to 150 kt
		0x03	150 kt to 300 kt
		0x04	300 kt to 600 kt
		0x05	600 kt to 1200 kt
		0x06	Over 1200 kt
		0x07-0xFF	Reserved

Altitude Encoder Offset				
Byte Offset	**Byte Name**	**Field Description**		
29	EO0	**EO0**	**EO1**	**Altitude Encoder Offset**
30	EO1	0x80	0x00	-32,768 ft
		0x00	0x00	0 ft
		0x7F	0xFF	32,767 ft
		Altitude Encoder Offset This field is used to provide an offset to the integrated altitude encoder in order to match the reading of the primary altitude encoder. This is done so that the difference between the primary altimeter and the integrated altitude encoder never exceeds 125 feet. This field should only be set by a qualified maintenance professional. The user should set the fields to ZERO if the offset is unknown.		

Reserved		
Byte Offset	**Byte Name**	**Field Description**
31	RE2	This field is reserved for future use. Set to ZERO. All other values are invalid.
32	RE3	

Install Configuration

Install Configuration			
Byte Offset	**Byte Name**	**Field Description**	
33	IC0	**IC0 Bit Position**	**Install Configuration Setting**
		Bits 0-1	Antenna Install
		0x0	Invalid
		0x1	Bottom Antenna Only
		0x2	(Reserved)
		0x3	Top and Bottom Antennas
		Bit 2	Reserved
		Bit 3	Host Altitude Resolution
		= 0	25 feet
		= 1	100 feet
		Bit 4	Heading Type (HDG)
		= 0	Magnetic
		= 1	True
		Bit 5	Airspeed Type
		= 0	Indicated
		= 1	True
		Bit 6	Pressure Sensor Heater Switch
		= 0	Heater Disabled
		= 1	Heater Enable
		Bit 7	Weight On Wheels (MSbit)
		= 0	WOW Input Not Connected
		= 1	WOW Input Connected

Reserved		
Byte Offset	**Byte Name**	**Field Description**
34	RE4	This field is reserved for future use. Set to ZERO. All other values are invalid.
35	RE5	

Table 0-6 Installation Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x01 Installation Message	[01]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[01]
	Payload Length	36	[24]
PAYLOAD	**ICAO Address**	(Hex) 1CA6B2	[1C A6 B2]
	Aircraft Registration	(ASCII) 1233021	[31 32 33 33 30 32 31]
	Reserved	0x00 00	[00 00]
	COM Port 0	38.4 K Bits per second	[00]
	COM Port 1	38.4 k Bits per second	[00]
	IP Address	10.0.0.1	[0A 00 00 01]
	Net Mask	255.255.255.0	[FF FF FF 00]
	Port Number	10,000	[27 10]
	GPS Integrity	Unknown	[00]
	Emitter Category Set	Set A	[00]
	Emitter Category	Unknown	[00]
	Aircraft Size	Length <= 15 meters Width <= 23 meters	[01]
	Max Airspeed	150 kt to 300 kt	[03]
	Altitude Encoder Offset	0	[00 00]
	Reserved	0x00 00	[00 00]
	Install Configuration	Bottom only antenna installed; Host Altitude Resolution = 25 feet; Heading type is Magnetic; Airspeed Type indicated; Pressure Sensor Heater is OFF; WOW not connected	[01]
	Reserved	0x00 00	[00 00]
	Checksum	8-bit arithmetic sum of message starting from Start Byte to last byte of the Payload Data.	[E4]

3. Flight ID Message: Type 0x02

The Flight ID Message sets the Flight ID and, if used, it should be sent at least once every 5 seconds. If the Flight ID is not received for 10 seconds, the transponder defaults to using the aircraft registration sent in the Installation Message. This message is not commonly sent.

Note: It is not a requirement to use the Flight ID message.

An overview of the Flight ID Message is shown in Table 0-7~~Table 6-7~~. Table 0-8~~Table 6-8~~ provides the detailed message definition. An example of a Flight ID Message is found in Table 0-9~~Table 6-9~~.

Table 0-7 Flight ID Message Payload Structure Overview

Payload Index	Message Field	Number bytes
0	**Flight ID**	8
8	**Reserved**	4

Table 0-8 Flight ID Message Payload Structure Detail

Flight ID										
Byte Offset	**Byte Name**	**Field Description**								
00	FD0	**FD0**	**FD1**	**FD2**	**FD3**	**FD4**	**FD5**	**FD6**	**FD7**	**Flight ID**
01	FD1	0x4E	0x32	0x35	0x36	0x37	0x47	0x41	0x20	N2567GA
02	FD2	**Flight ID Bytes** Set 64-bit Flight ID. If flight identification data is available, this is used in lieu of aircraft registration. Flight ID (aircraft radio call sign) is used in the flight plan. Otherwise the transponder defaults to aircraft registration data as set in the installation message. Up to eight ASCII characters can be entered. Data is sent as unsigned chars and valid ASCII characters are outlined below: **Valid ASCII Hex Values** 0x20 (Space) 0x30-0x39 (0-9) 0x41-0x5A (A-Z) The most significant byte is sent first. The ASCII characters must be left-justified and the Flight ID may not contain spaces. The Flight ID must be padded with space characters on the right. (For reference, see DO-181d section 2.2.19.1.13). If Flight ID is not available, fill this field with space characters (0x20). This will set Flight ID to "Not Available" and Aircraft Registration will be used instead.								
03	FD3									
04	FD4									
05	FD5									
06	FD6									
07	FD7									

Reserved		
Byte Offset	**Byte Name**	**Field Description**
08	RE0	This field is reserved for future use. Set to ZERO. All other values are invalid.
09	RE1	
10	RE2	
11	RE3	

Table 0-9 Flight ID Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x02 Flight ID Message	[02]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[02]
	Payload Length	12	[0C]
PAYLOAD	**Flight ID**	Flight ID = AA1234	[41 41 31 32 33 34 20 20]
	Reserved		[00 00 00 00]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[84]

4. Operating Message: Type 0x03

The operating message:

- Sets squawk code (Mode A/4096 Code), altitude data (if desired), heading, airspeed, MXS mode, and power up state, and activates the IDENT function.
- Must be sent to the MXS periodically (between 1 and 5 hertz).

> Note: The MXS's integrated pressure altitude sensor and encoder provide the MXS with pressure altitude data in the expected format and with the required accuracy. You can elect to use altitude data from an external source. However, Sagetech recommends that you configure the MXS to use the pressure altitude source integrated with the MXS (the default setting).

An overview of the Operating Message is shown in Table 0-10~~Table 6-10~~. Table 0-11~~Table 6-11~~ provides the detailed message definition. An example of the Operating Message is found in Table 6-12.

Table 0-10 Operating Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Squawk Code**	2
02	**Mode/Config**	1
03	**Emergency/Ident**	1
04	**Altitude**	2
06	**Altitude Rate**	2
08	**Heading**	2
10	**Airspeed**	2

Table 0-11 Operating Message Payload Structure Detail

Squawk Code		
Byte Offset	**Byte Name**	**Field Description**
00	SQK0	Mode A "Squawk" Code – A string of 4 3-bit (octal) numbers, padded with 4 leading zeros. For example, Squawk 1234 would be formatted as: 0000 001 010 011 100 (0x02:0x9C)
01	SQK1	

Mode/Config		
Byte Offset	**Byte Name**	**Field Description**
02	MOD0	**Mode** The Mode consists of the following information: **Bit 0-1:** Operation Mode sets the current Transponder Mode. 00 = Standby 01 = On 11 = ALT **Bit 2**: Power Up State. If set to 1, the Mode in this message is stored in non-volatile memory and used on power up; if set to 0, the Transponder powers up in STBY mode. If the MXS is not in Maintenance Mode then this assignment is ignored and not acknowledged. **Bit 3:** ADS-B Out On (1 = Enable output of Extended Squitters) **Bit 4–7:** Reserved

Emergency/Ident Byte		
Byte Offset	**Byte Name**	**Field Description**
03	EMG0	**Emergency** The Emergency Byte consists of the following information:

Bits 0 – 2: Emergency/Priority Status

Binary	Decimal	Emergency/Priority Status
000	0	No Emergency
001	1	General Emergency
010	2	Lifeguard/Medical Emergency
011	3	Minimum Fuel
100	4	No Communications
101	5	Unlawful Interference
110	6	Downed Aircraft
111	7	Reserved

Bit 3: IDENT

IDENT (Indication that the IDENT button has been pressed. The bit will be set in outgoing ADS-B squitters for 18 seconds from the last receipt of an operating message with this bit set)

Altitude		
Byte Offset	**Byte Name**	**Field Description**
04	ALT0	**Altitude**
05	ALT1	Altitude bit field definition is as follows:
		Bits 0-13 Altitude Data The aircraft barometric altitude is measured with reference to a pressure of 29.9213" Hg. The data is an unsigned integer, offset by 1200 feet, in units of 25 or 100 feet (as defined in the Installation Message). Altitude values outside of -1200 to 126,700 feet are invalid. **Altitude Data Examples:**
		0000 -1200 ft, 100 ft scaling 000C 0 ft., 100 ft. scaling 04FF 126,700 ft., 100 ft. scaling 0000 -1200 ft., 25 ft. scaling 0030 0 ft., 25 ft. scaling 13FC 126,700 ft., 25 ft. scaling
		Bit 14 Host altitude allowed = 0 Host altitude unavailable = 1 Host altitude provided
		Bit 15 Internal sensor altitude = 0 Do not use internal sensor altitude = 1 Use internal sensor altitude Internal altitude is fixed at 25' resolution

Altitude Rate				
Byte Offset	**Byte Name**	**Field Description**		
06	ALTR0	**ALTR0**	**ALTR1**	**Altitude Rate**
07	ALTR1	0xFE	0xFF	-16,448 ft/min
		0xFF	0xFF	-64 ft/min
		0x00	0x00	0 ft/min
		0X01	0x01	16,448 ft/min
		0x80	0x00	Altitude Rate not available
		Altitude Data is 2's complement Resolution = 64 ft/min		

Heading			
Byte Offset	**Byte Name**	**Field Description**	
08	HDG0	The Heading field units and resolution are specified as a fraction of a circle. ie. .5 = 180°, .25 = 90°, etc.	
09	HDG1	**Bit 15**	Heading Valid
		Bits 14 - 0	Heading units and resolution Most significant bit = .5, the next .25, the next .125, etc.
		Examples:	
		0x8000	0° valid (.0 * 360)
		0x9000	45° valid (.125 * 360)
		0xA000	90° valid (.25 * 360)
		0xC000	180° valid (.50 * 360)
		0xD000	225° valid (.625 * 360)
		0xF000	315° valid (.875 * 360)

Airspeed			
Byte Offset	**Byte Name**	**Field Description**	
10	TAS0	**Bit 15**	Airspeed Valid
11	TAS1	**Bits 14 - 0**	Airspeed. Unsigned field measured in knots.

Table 0-12 Operating Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x03 Operating Message	[03]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[03]
	Payload Length	12	[0C]
PAYLOAD	**Squawk**	Squawk 1234	[02 9C]
	Mode/Config	Mode/Config: Mode is on, default Power Up state, ADS-B Out is turned off.	[05]
	Emergency/Ident	No Emergency, Ident not pressed	[00]
	Altitude	Using Sagetech integrated altitude encoder	[80 00]
	Altitude Rate	Altitude Rate = +256 ft/min	[00 04]
	Heading	Heading = 315°	[F0 00]
	Airspeed	Airspeed = 100 knots	[80 64]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[B7]

5. GPS Navigation Data Message: Type 0x04

The GPS Data Message:

- Provides the MXS with GPS data, including - latitude, longitude, height, groundspeed, track, and validity, accuracy and integrity measurements.
- If used, should be sent at regular intervals (between one and five times per second), typically at the nominal update rate of the GPS hardware.

> Note: If the Navigation Receiver Valid bit (in the Hemisphere byte) is 0, then all data fields in the message are required to be valid, except for Time of Fix (which can be set to all spaces if it is not valid). If the Navigation Receiver Valid bit is 1, all data fields are considered invalid; sending the message with the Navigation Receiver Valid bit set to 1 has the same effect as not sending the message.

An overview of the GPS Navigation Data Message is shown in Table 0-13~~Table 6-13~~. Table 0-14~~Table 6-14~~ provides the detailed message definition. An example of the GPS Navigation Data Message is found in Table 0-15~~Table 6-15~~.

Table 0-13 GPS Navigation Data Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**GPS Longitude**	11
11	**GPS Latitude**	10
21	**Speed Over Ground**	6
27	**Ground Track**	8
35	**Hemisphere/Data Status**	1
36	**Time of Fix**	10
46	**Height**	4
50	**HPL**	4
54	**HFOM**	4
58	**VFOM**	4
62	**NAC_V**	1

Table 0-14 GPS Navigation Data Message Payload Structure Detail

GPS Longitude													
Byte Offset	**Byte Name**	**Field Description**											
00	LON0	**LON0**	**LON1**	**LON2**	**LON3**	**LON4**	**LON5**	**LON6**	**LON7**	**LON8**	**LON9**	**LON10**	**GPS Longitude**
01	LON1	0x31	0x32	0x32	0x31	0x39	0x2E	0x37	0x35	0x30	0x30	0x32	122 Degrees 19.75002 Minutes
02	LON2	0x30	0x35	0x38	0x33	0x33	0x2E	0x39	0x31	0x34	0x38	0x32	58 Degrees 33.9142 Minutes
03	LON3	0x31	0x32	0x32	0x32	0x30	0x2E	0x39	0x34	0x36	0x30	0x30	122 Degrees 20.946 Minutes
		...	...	...	...	...	0x2E	...	...	...	...	...	...
							...						
04	LON4	**GPS Longitude**											
05	LON5	Current GPS longitude is sent as ASCII characters, formatted as degrees, minutes, and fractions of minutes:											
06	LON6	*dddmm.mmmmm*											
07	LON7	***Note:*** *The Hemisphere Byte contains a bit to declare if the longitude is E or W.*											
08	LON8												
09	LON9												
10	LON10												

GPS Latitude												
Byte Offset	**Byte Name**	**Field Description**										
11	LAT0	**LAT 0**	**LAT 1**	**LAT 2**	**LAT 3**	**LAT 4**	**LAT 5**	**LAT 6**	**LAT 7**	**LAT 8**	**LAT 9**	**GPS Latitude**
12	LAT1	0x34	0x37	0x33	0x37	0x2E	0x32	0x32	0x34	0x30	0x30	47 Degrees 37.224 Minutes
13	LAT2	0x34	0x39	0x31	0x37	0x2E	0x31	0x31	0x32	0x36	0x36	49 Degrees 17.11266 Minutes
14	LAT3	0x32	0x37	0x35	0x39	0x2E	0x32	0x38	0x33	0x33	0x36	27 Degrees 59.28336 Minutes
		...	...	...	...	...	...	...	...	...	...	...
15	LAT4	GPS Latitude										
16	LAT5	Current GPS latitude is sent as ASCII characters, formatted as degrees, minutes, and fractions of minutes:										
17	LAT6	*ddmm.mmmmm*										
18	LAT7											
19	LAT8	***Note:*** *The Hemisphere Byte contains a bit to declare if the Latitude is N or S.*										
20	LAT9											

Speed Over Ground								
Byte Offset	**Byte Name**	**Field Description**						
21	SOG0	**SOG0**	**SOG1**	**SOG2**	**SOG3**	**SOG4**	**SOG5**	**Speed Over Ground**
22	SOG1	0x31	0x31	0x32	0x36	0x2E	0x30	1126.0
23	SOG2	0x31	0x32	0x35	0x2E	0x38	0x30	125.80
24	SOG3	0x30	0x36	0x35	0x2E	0x35	0x30	65.50
		0x30	0x34	0x38	0x2E	0x33	0x32	48.32
25	SOG4	Speed Over Ground						
26	SOG5	Current GPS speed over ground in knots. The data is sent as ASCII characters. Note that two formats are available, in order to support supersonic or subsonic operations: *ssss.s or sss.ss*						
		For example, if the speed over ground is 62.5 kts, the packet structure would look like:						
		[30] [36] [32] [2E] [35] [30]						

Ground Track										
Byte Offset	**Byte Name**	**Field Description**								
27	CRS0	**CRS0**	**CRS1**	**CRS2**	**CRS3**	**CRS4**	**CRS5**	**CRS6**	**CRS7**	**Ground Track**
28	CRS1	0x30	0x37	0x37	0x2E	0x35	0x32	0x30	0x30	77.5200
29	CRS2	0x31	0x38	0x35	0x2E	0x32	0x30	0x30	0x30	185.2000
30	CRS3	0x32	0x37	0x35	0x2E	0x34	0x30	0x30	0x30	275.4000
31	CRS4	...	...	...	...	...	...	...	...	...
32	CRS5	Ground Track Current GPS Ground Track referenced to true north is sent in degrees. The data is sent as ASCII characters. 0 degrees is North, 90 degrees is East, etc. *ccc.cccc (format of data)* For example, if the Ground Track is 165.5 degrees, the packet structure would look like: [31] [36] [35] [2E] [35] [30] [30] [30]								
33	CRS6									
34	CRS7									

Hemisphere/Data Status			
Byte Offset	**Byte Name**	**Field Description**	
35	GHB0	**GHB0**	**Hemisphere and GPS Data Status**
		0x00	S hemisphere, W hemisphere; No SVERROR fault, GPS data is valid
		0x01	N hemisphere, W hemisphere; No SVERROR fault, GPS data is valid
		0x82	S hemisphere, E hemisphere; No SVERROR fault, GPS data is invalid
		0x03	N hemisphere, E hemisphere; No SVERROR fault, GPS data is valid
		0x43	N hemisphere, E hemisphere; SVERROR fault, GPS data is valid
		...	...
		Hemisphere & GPS Data Status Byte **The Hemisphere bits consists of the following information:** **Bit 0:** N / S Hemisphere indicator. Zero indicates that the latitude is South. One indicates that the latitude is North. **Bit 1:** E / W Hemisphere indicator. Zero indicates that the longitude is West. One indicates that the longitude is East. **Bit 2 - 5**: Reserved **GPS Data Status bits provide the following information:** Provides the MXS with GPS data, including - latitude, longitude, height, groundspeed, track, and validity, accuracy and integrity measurements. **Bit 6:** SVERROR State Bit. If set to ONE the GPS receivers Fault Detection and Exclusion (FDE) functions has detected a satellite failure that cannot be excluded within the time-to-alert. If set to ZERO the FDE has not detected any satellite failures or has detected and excluded the failed satellite from the position solution. **Bit 7:** Navigation receiver status bit. If set to ZERO indicates that the GPS data is valid, if set to ONE GPS data is invalid.	

Time of Fix (UTC)												
Byte Offset	**Byte Name**	**Field Description**										
36	TOF0	**TOF 0**	**TOF 1**	**TOF 2**	**TOF 3**	**TOF 4**	**TOF 5**	**TOF 6**	**TOF 7**	**TOF 8**	**TOF 9**	**Time of Fix (UTC)**
37	TOF1	0x32	0x32	0x33	0x33	0x32	0x33	0x2E	0x30	0x30	0x30	22:33:23.000 UTC
38	TOF2	0x31	0x35	0x32	0x34	0x33	0x33	0x2E	0x31	0x31	0x30	15:24:33.110 UTC
39	TOF3	0x30	0x38	0x35	0x36	0x30	0x31	0x2E	0x30	0x31	0x30	08:56:01.010 UTC
40	TOF4	...	...	...	...	...	...	...	...	...	...	...
41	TOF5	Time of Fix										

Time of Fix (UTC)		
42	TOF6	Time of fix in UTC. hhmmss.sss The value is sent as ASCII characters. The hours, minutes, seconds, and fractions of seconds are sent, indicating the time of fix, relative to midnight UTC. For example, if the time of fix was 22 hours, 33 minutes, and 23 seconds, the packet structure would look like: [32] [32] [33] [33] [32] [33] [2E] [30] [30] [30] If Time of Fix is not available, fill this field with Space characters (0x20).
43	TOF7	
44	TOF8	
45	TOF9	

GPS Height (WGS-84)		
Byte Offset	**Byte Name**	**Field Description**
46	HT0	**GPS Height (WGS-84)** All zeros – Altitude not available Else Floating point Height (meters) Above WGS-84 ellipsoid
47	HT1	
48	HT2	
49	HT3	

Horizontal Protection Limit (HPL)		
Byte Offset	**Byte Name**	**Field Description**
50	HP0	**Horizontal Protection Limit (HPL)** All zeros – HPL not available Else Floating point radius (meters) of a circle centered on the true position that contains the computed position with a probability of 10^{-7}/hour.
51	HP1	
52	HP2	
53	HP3	

Horizontal Figure of Merit (HFOM)		
Byte Offset	**Byte Name**	**Field Description**
54	HM0	**Horizontal Figure of Merit (HFOM)** All zeros – HFOM not available Else Floating point radius (meters) of a circle in the horizontal plane and centered at the true position that contains the computed position with an accuracy of 95%
55	HM1	
56	HM2	
57	HM3	

Vertical Figure of Merit (VFOM)		
Byte Offset	**Byte Name**	**Field Description**
58	VM0	**Vertical Figure of Merit (VFOM)** All zeros – VFOM not available Else Floating point distance (meters) that the computed altitude can be above or below the true position with an accuracy of 95%.
59	VM1	
60	VM2	
61	VM3	

Navigation Accuracy for Velocity (NAC_v)			
Byte Offset	**Byte Name**	**Field Description**	
62	NAV0	MSN Bits 7-4 0x0 0x1 0x2 0x3 0x4 0x5-0xF	NAC_V (Most Significant Nibble) The field is used to declare the accuracy of own-vehicle velocity. The value is based on GPS figure of merit for horizontal velocity. Unknown or ≥ 10 m/s < 10 m/s < 3 m/s < 1 m/s < 0.3 m/s Reserved
		LSN Bits 3-0	Least Significant Nibble Reserved

Table 0-15 GPS Navigation Data Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	AA
	Message Type	0x04 GPS Data Message	04
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	12
	Payload Length	63	3F
P	**Longitude**	4543.6632Degrees	[31 32 31 32 39 2E 31 32 34 38 30

			]
	Latitude	12129.1248 Degrees	[34 35 34 33 2E 36 36 33 32 30]
	Speed Over Ground	99.00 knots	[30 39 39 2E 30 30]
	Ground Track	180.0000 Degrees	[31 38 30 2E 30 30 30 30]
	Hemisphere/Data Status	East West Indicator: Longitude is West and latitude is North	[01]
	Time of Fix	12:34:56.789	[31 32 33 34 35 36 2E 37 38 39]
	Height	2000 meters	[00 00 FA 44]
	HPL	100 meters	[00 00 C8 42]
	HFOM	2	[00 00 00 40]
	VFOM	3	[00 00 40 40]
	NAC_V	Unknown or >= 10 m/s	[00]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[F5]

6. Data Request Message: Type 0x05

This message is a request for the MXS to send data in a response message. The type of data being requested is specified in the payload of this message, which consists of a single byte that specifies the response message type. In response to a valid Data Request Message, the MXS sends an Acknowledge Message immediately followed by a response message. The structure of the response message depends on the requested message type. See the sections for the specific "Request Message Type" for details.

An overview of the Data Request Message is shown in Table 0-16~~Table 6-16~~. Table 0-17~~Table 6-17~~ provides the detailed message definition. An example of the GPS Navigation Data Message is found in Table 0-18~~Table 6-18~~.

Table 0-16 Data Request Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Request Message Type**	1
01	**Reserved**	3

Table 0-17 Data Request Message Payload Structure Detail

Request Message Type			
Byte Offset	**Byte Name**	**Field Description**	
00	RMT0	**RMT0**	**Request Message Type**
		0x00-0x80	Reserved
		0x81	Installation Response Message
		0x82	Preflight Data Response Message
		0x83	Status Response Message
		0x84-0x8B	Reserved
		0x8C	Mode Settings Message
		0x8D	Reserved for future use: Air-Initiated Comm-B Message
		0x8E	Version Response Message
		0x8F-0xFF	Reserved
		Requested Message Type contains Message Type being requested.	

Reserved		
Byte Offset	**Byte Name**	**Field Description**
01	RES0	Reserved These bytes are reserved for future use. Set to ZERO. All other values are invalid.
02	RES1	
03	RES2	

Table 0-18 Data Request Message Example Data

	Message Field	Byte Values (original)	Byte Msg (Hex)
	Start Byte	AA	[AA]
	Message Type	0x05 Data Request	[05]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[05]
	Payload Length	4	[04]
PAY-	**Request Message Type**	Installation Response Message	[81]
PAY-	**Reserved**		[00 00 00]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[39]

7. Target Request Message: Type 0x0B

This message is used to request data on ADS-B, TIS-B and ADS-R targets being tracked by the MXS.

An overview of the Target Request Message is shown in ~~Table 6-19~~ Table 0-19. ~~Table 6-20~~ Table 0-20 provides the detailed message definition.

Table 0-19 Target Request Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Request Type**	1
01	**Number of Participants**	2
03	**Participant ID**	3
06	**Requested Reports**	1

Table 0-20 – Target Request Message Payload Structure Detail

Request Type		
Byte Offset	**Byte Name**	**Field Description**
00	RT0	Request Type bits b1, b0 00 = Turn on Auto-Output of specified reports for Number of Targets ~~10~~[10] 01 = Return Summary of # Targets (and turn off Auto-Output) [10] 10 = Return requested reports for Target ID (and turn off Auto-Output) 11 = Turn off all report output. XMIT Port bits b7, b6 00 = Transmit report on port where Target Request was received 01 = Transmit report on COM0 10 = Transmit report on COM1 11 = Transmit report on Ethernet WARNING: If serial communication is being used then only one serial port is used for sending host messages and for ADS-B In reports. The other RS422/RS232 port is reserved for GPS only data (if any). Using the same COM port for both GPS and either host messages or ADS-B In reports will cause unpredictable behavior.

[10] Number of Participants field needs to be completed for Request Types 0 and 1.

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Number of Participants				
Byte Offset	**Byte Name**	**Field Description**		
01	NP0	**NP0**	**NP1**	**# Participants**
02	NP1	0x00	0x20	32
		0x00	0xFF	255
		0x01	0x00	256
		0x01	0x94	404
		Number of Participants (For request types 0 and 1 only) Values 0 to 404 accepted. Allows up to 400 targets and 3 ICAO address duplicates, plus ownship. If the requested number of participants is less than the number detected, only the closest participants are reported (including ownship, if requested, and duplicates). If reporting ownship is selected in the Selected Reports field, in conjunction with turning on auto-report, the ownship is counted among the number of targets. If Number of Targets is 1 and Ownship is selected then a single target is reported: ownship.		

Participant ID					
Byte Offset	**Byte Name**	**Field Description**			
03	ID0	**ID0**	**ID1**	**ID2**	**Participant ID**
04	ID1	0x00	0x01	0x02	000102
05	ID2	0x03	0xFE	0x14	03FE14
		Participant ID ICAO Address for Request Type 2			

Requested Reports		
Byte Offset	**Byte Name**	**Field Description**
06	RR0	**Report Transmit Requested** (Bit value of 1 = Transmit)

Bit	Requested Reports
0	State Vector or Coarse Position Reports
1	Mode Status
2	Target State
3	Air Referenced Velocity
4	TIS-B & ADS-R Management Reports
5	Enable/Disable Tracking of Military Aircraft
6	Comm-A
7	Include Own Aircraft

Table 0-21 Target Request Message Example Data

Message Field	Byte Values (original)	Byte Message Content (Hex)
Start Byte	AA	[AA]
Message Type	0x0B Target Request Message	[0B]
Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[0B]
Payload Length	0	[07]
Request Type	Turn on Auto-Output of specified reports for targets (count is provided in “Number of Participants” field).	[00]
Number of Participants	32 participants	[00 20]
Participant ID	03FE14	[03 FE 14]
Requested Reports	Mode Status and Target State reports	[06]
Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[E2]

8. *Mode Message: Type 0x0C*

The Mode Message is sent to the transponder to enable/disable modes or set mode data values. The current settings of the mode enable/disable flags and the mode data values can be obtained by using the Data Request Message to send the Mode Settings Message.

An overview of the Mode Message is shown in Table 0-22~~Table 6-22~~. Table 0-23~~Table 6-23~~ provides the detailed message definition and Table 0-24~~Table 6-24~~ provides a detailed example of message data.

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Table 0-22 Mode Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Mode Settings**	5

Table 0-23 Mode Message Payload Structure Detail

Mode Settings				
Byte Offset	**Byte Name**	**Field Description**		
00	MDE 0	**Byte Name**	**Bits**	**Mode Field Description**
01	MDE 1	**MDE0**	**0 - 7**	Reply Rate Limit: Maximum reply rate limit measured in replies per 100 milliseconds. Allowable values are between 50 and 120 replies per 100 milliseconds (500 to 1,200/second).
02	MDE 2			
03	MDE 3	**MDE1**	**0**	Acquisition Squitter Inhibit (ADS-B In) – Enabled in Operating Message, Bit 3 of the Mode/Config Byte.
04	MDE 4		**1**	Reserved
			2	Reserved
			3	*Reserved for Future use: Cancel Air-Initiated Comm-B*
			4	Reserved
			5	Reboot MXS - Reboot the system (with the same effect as a power-on restart)
			6 - 7	Reserved
		MDE2	**0 - 7**	Reserved
		MDE3	**0 - 7**	Reserved
		MDE4	**0 - 7**	Reserved

Table 0-24 Mode Message Example Data

Message Field	Byte Values (original)	Byte Message Content (Hex)
Start Byte	AA	[AA]
Message Type	0x0B Target Request Message	[0B]
Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[0C]
Payload Length	7	[07]
MDE0	Reply Rate Limit	[00]
MDE1	0	[20]
MDE2	0	[00]
MDE3	0	[00]
MDE4	0	[00]
Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[40]

14. Messages Sent From the MXS

1. Overview

Table 0-25~~Table 6-27~~ lists the message types the MXS can send.

Table 0-25~~27~~ Messages Sent from the MXS

Message Name	Message Type	Payload Length (Bytes)	Document Section
Acknowledge	0x80	6	2~~6.4.2~~
Installation Response	0x81	36	3~~6.4.3~~
Flight ID Response	0x82	12	4~~6.4.4~~
Status Response	0x83	6	5~~6.4.5~~
Reserved	0x84		
Comm-A Report	0x85	Maximum 253	6~~6.4.6~~
Mode Settings Message	0x8C	5	7~~6.4.7~~
Reserved for future use: *Air-Initiated Comm-B (AICB) Status*	0x8D		
Version Response Message	0x8E	6	8~~6.4.9~~
Target Summary Report	0x90	Varies	1.1.1.1~~6.4.10.1~~
ADS-B State Vector Report	0x91	24-48	1.1.1.2~~6.4.10.2~~
ADS-B Mode Status Report	0x92	16-36	1.1.1.3~~6.4.10.3~~
TIS-B State Vector Report	0x93	24-48	1.1.1.6~~6.4.11.1~~
TIS-B Mode Status Report	0x94	16-36	1.1.1.7~~6.4.11.2~~
TIS-B Coarse Position Report	0x95	18	1.1.1.9~~6.4.11.4~~
TIS-B/ADS-R Management Report	0x96	11	1.1.1.10~~6.4.11.5~~
ADS-B Target State Report	0x97	23	1.1.1.4~~6.4.10.4~~
ADS-B Air Referenced Velocity Report	0x98	14	1.1.1.5~~6.4.10.5~~

2. Acknowledge Message: Type 0x80

The Acknowledge Message (ACK) is sent by the MXS to indicate that a message was received in the correct format and with valid data. The MXS performs range checking on all incoming data. If any data is invalid the message is ignored and the MXS does not ACK. This message:

- Is sent after every receipt of a valid message.
- Contains MXS status information.
- Contains the current altitude being used by the MXS[11].

Note: When a data reply is required, the ACK is sent first followed by the data reply.

An overview of the Acknowledge Message is shown in Table 0-26~~Table 6-28~~. Table 0-27~~Table 6-29~~ provides the detailed message definition. An example of the Acknowledge Message is found in Table 0-28~~Table 6-30~~.

Table 0-26~~28~~ Acknowledge Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**ACK'd Message Type**	1
01	**ACK'd Message ID**	1
02	**System State Byte**	1
03	**Pressure Altitude**	3

Table 0-27~~29~~ Acknowledge Message Payload Structure Overview

ACK'd Message Type			
Byte Offset	**Byte Name**	**Field Description**	
00	AMT0	**AMT0**	**ACK'd Message Type**
		0x01	Installation Message
		0x02	Flight ID Message
		0x03	Operating Message
		0x04	GPS Navigation Data Message
		0x05	Data Request Message
		0x06-0A	Reserved
		0x0B	Target Request Message
		0x0C	Mode Message
		0x0D	*Reserved for future use: Air-Initiated Comm-B Message*

[11] The MXS can be configured to either (a) use the integrated altitude encoder or (b) use an external altitude source at the user's discretion (Sagetech recommends use of the integrated altitude encoder). The MXS always provides the data from the current altitude source as part of the ACK message.

ACK'd Message Type		
	0x0E-0xC1	Reserved
	ACK'd Message Type Contains the Message Type of the message being acknowledged.	

ACK'd Message ID			
Byte Offset	**Byte Name**	**Field Description**	
01	AMTI	**AMTI**	**ACK'd Message ID**
		0x00 0x01 …	[0000 0000] [0000 0001] ...
		ACK'd Message ID Contains the Message ID of the message being acknowledged.	

System State Byte			
Byte Offset	**Byte Name**	**Field Description**	
02	SSB0	**SSB0**	**System State Byte indicates current Transponder State Information**
		Bit 0	**Transponder Fail Flag** 1 = an error within the Transponder. The Status message can be queried to determine the cause of the Transponder error.
		Bit 1	**System Fail Flag** 1 = an error detected by the transponder in which a required input from the system is not available. The Status message can be queried to determine the cause of the system failure.
		Bit 2	**Reserved**
		Bit 3	**Weight on Wheels** 1 = Transponder has detected that the WoW discrete input is valid in the Installation message and the discrete is true indicating that the aircraft weight is on the wheels.
		Bit 4	**Maintenance Mode** 1= ON
		Bit 5	**Altitude Source** 0 = Integral 1 = From host
		Bits 6 - 7	**Transponder Operational Mode** 00 = STBY 01 = ON 11 = ALT

Pressure Altitude					
Byte Offset	**Byte Name**	**Field Description**			
03	ALT0	**ALT0**	**ALT1**	**ALT2**	**Pressure Altitude**
04	ALT1	0xFF	0xFB	0x50	-1200 ft
05	ALT2	0x00	0x00	0x00	0 ft
		0x01	0xEE	0xEC	126,700 ft
		Pressure Altitude The Transponder always provides the current altitude from the current altitude source here. The data is barometric altitude in feet with reference to a pressure of 29.9213" Hg (101325 Pascals) for zero feet indication. The MSB is sent first. The data is a 24-bit signed 2's complement integer, in units of feet. The value 0x800000 is used to indicate invalid altitude; all other values reported in this message are valid altitudes.			

Table 0-2830 Acknowledge Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x80 Acknowledge Message	[80]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[00]
	Payload Length	6	[06]
PAYLOAD	**ACK'd Message Type**	Operating Message Type	[03]
PAYLOAD	**ACK'd Message ID**	0	[00]
PAYLOAD	**System State Byte**	System Fail Flag and Weight on Wheels are set.	[0A]
PAYLOAD	**Pressure Altitude**	8,000 feet	[00 1F 40]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[9C]

3. *Installation Response Message: Type 0x81*

The Installation Response Message is sent in response to an Installation Message (0x01) or to a Data Request Message (0x05) that specifies a Requested Message Type of Installation Message (0x81). This message contains the data stored in non-volatile memory from the last valid Installation Data Message.

Table 0-2931 Installation Response Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**ICAO Address**	3
03	**Aircraft Registration**	7
10	**Reserved**	2
12	**COM Port 0**	1
13	**COM Port 1**	1
14	**IP Address**	4
18	**Net Mask**	4
22	**Port Number**	2
24	**GPS Integrity**	1
25	**Emitter Category Set**	1
26	**Emitter Category**	1
27	**Aircraft Size**	1
28	**Max Airspeed**	1
29	**Altitude Encoder Offset**	2
31	**Reserved**	2
33	**Install Configuration**	1
34	**Reserved**	2

Since the data elements of the Installation Response Message are defined exactly as in the Installation Message. Table 0-4Table 6-4 and Table 0-5Table 6-5 provide the definitions for these data elements. Table 0-30Table 6-32 shows an example of a valid and complete Installation Response Message with the same data as the Installation Data Message example from Table 0-6Table 6-6 (only the Message Type and Checksum differ).

Table 0-3032 Installation Response Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]

	Message Type	0x81 Installation Message Response	[81]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[01]
	Payload Length	36	[24]
PAYLOAD	**ICAO Address**	(Hex) 1CA6B2	[1C A6 B2]
	Aircraft Registration	(ASCII) 1233021	[31 32 33 33 30 32 31]
	Reserved	0x00 00	[00 00]
	COM Port 0	38.4 K Bits per second	[00]
	COM Port 1	38.4 k Bits per second	[00]
	IP Address	10.0.0.1	[0A 00 00 01]
	Net Mask	255.255.255.0	[FF FF FF 00]
	Port Number	10,000	[27 10]
	GPS Integrity	Unknown	[00]
	Emitter Category Set	Set A	[00]
	Emitter Category	Unknown	[00]
	Aircraft Size	Length <= 15 meters Width <= 23 meters	[01]
	Max Airspeed	150 kt to 300 kt	[03]
	Altitude Encoder Offset	0	[00 00]
	Reserved	0x00 00	[00 00]
	Install Configuration	Bottom only antenna installed; Host Altitude Resolution = 25 feet; Heading type is Magnetic; Airspeed Type indicated; Pressure Sensor Heater is OFF; WOW not connected	[01]
	Reserved	0x00 00	[00 00]
	Checksum	8-bit arithmetic sum of message starting from Start Byte to last byte of the Payload Data.	[64]

4. Flight ID Response Message: Type 0x82

The Flight ID Response Message is sent in response to a Flight ID Message (0x02) or to a Data Request Message (0x05) that specifies a Requested Message Type of 0x82. This message contains the Flight ID, stored in volatile memory from the last valid Flight ID Message; if a Flight ID Message has not been received for 10 seconds, then all fields in this message are set to all ZEROs (0x00).

NOTE: The format of the payload of the Flight ID Response Message is exactly the same as that of the Flight ID Message.

Table 0-3133 Flight ID Response Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Flight ID**	8
08	**Reserved**	4

The data elements of the Flight ID Response Message, found in Table 0-31Table 6-33, are defined exactly as in the Flight ID Message. Table 0-7Table 6-7 and Table 0-8Table 6-8 provide the definitions for these data elements. Table 0-32Table 6-34 shows an example of a valid and complete Flight ID Response Message with the same data as the Flight ID Message example from Table 0-9Table 6-9. (Only the Message Type and Checksum differ).

Table 0-3234 Flight ID Response Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x82 Flight ID Response Message	[82]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[02]
	Payload Length	12	[0C]
PAYLOAD	**Flight ID**	Flight ID = N 2 5 6 7 G A	[4E 32 35 36 37 47 41 20]
	Reserved		[00 00 00 00]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[04]

5. *Status Response Message: Type 0x83*

The Status Response Message is sent in response to a Data Request Message that specifies a Requested Message Type of 0x83. This message contains the software and complex hardware (i.e., firmware) versions of the MXS, the checksum of the SW image and the results of the Built-In Tests (BITs).

The Power-On BIT is executed once when the MXS is powered on and power is stable. After the Power-On BIT is executed, the Host should send the Data Request Message to request the Status Response Message and review the results of all BITs. While in operation the MXS will perform a Continuous BIT in background execution. Each BIT has a one-bit field is used to indicate all the BIT tests pass. A bit value of "1" signifies all tests pass and a value of "0" indicates at least one test has failed.

An overview of the Status Response Message is shown in Table 0-33~~Table 6-35~~. Table 0-34~~Table 6-36~~ provides the detailed message definition. An example of the Status Response Message is found in Table 0-35~~Table 6-37~~.

Table 0-33~~35~~ Status Response Message Payload Structure Overview

Payload Index	Message Field	Number bytes
0	**SW Version**	1
1	**FW Version**	1
2	**SW Image Checksum (CRC)**	4
6	**Built-In-Test (BIT)**	4

Table 0-34~~36~~ Status Response Message Payload Structure Detail

Software Version			
Byte Offset	**Byte Name**	**Field Description**	
00	SWV0	**SWV0**	**SW Version**
		0x01 0x02 …	SW version 1 SW version 2 …
		SW Version Contains the software version of the Transponder.	

Firmware Version			
Byte Offset	Byte Name	Field Description	
01	FWV0	FWV0	FW Version

Firmware Version		
	0x01 0x02 …	FW version 1 FW version 2 …
	FW Version Contains the firmware version of the Transponder.	

SW Image Checksum (CRC)		
Byte Offset	Byte Name	Field Description
02	CRC0	SW Image Checksum: 32-bit checksum of the SW Image.
03	CRC1	
04	CRC2	
05	CRC3	

Built-In Test				
Byte Offset	Byte Name	Field Description		
06	BIT0	Byte	Bit	Built In Test (BIT)
07	BIT1	BIT0	7 (msb)	Power On Tests Pass
08	BIT2		6	Continuous Tests Pass
09	BIT3		5	Reserved
			4	Processor Test Passed
			3	Flash Image CRC Valid
			2	Memory Test Passed
			1	Calibrated
			0	Power On RF Loopback Test Passed
			7 (msb)	RF Loopback Test Pass
			6	53V Power Valid
			5	ADC Ready

Built-In Test			
	BIT1	4	Pressure Transducer Ready
		3	FPGA Ready
		2	Rx Oscillator Locked
		1	Tx Oscillator Locked
		0	Mutual Suppression Valid
	BIT2	7 (msb)	Temperature In Range
		6	Squitter Rate Valid
		5	Transmit Rate In Range
		4	System Latency In Range
		3	Reserved
		2	Reserved
		1	Reserved
		0	Reserved
	BIT3	7 (msb)	Input Power In Range
		6	ICAO Address Valid
		5	GPS Position Valid
		4	GPS PPS Valid
		3	Reserved
		2	Reserved
		1	Reserved
		0	Reserved

Table 0-3537 Status Response Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x83 Status Response Message	[83]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[05]

	Payload Length	10	[0A]
PAYLOAD	Software Version	17	[11]
	Firmware Version	4	[04]
	SW Image Checksum	0x1C 8C F1 54	[1C 8C F1 54]
	Built-In Test (BIT)	All tests have passed	[DF FF F0 F0]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[FC]

6. *Comm-A Report Message: Type 0x85*

The Comm-A Report Message is sent when Comm-A messages are received, provided this report was previously enabled through the Target Request Message Comm-A report setting. The MXS buffers up to 23 interrogations in a response message. Each Comm-A packet occupies 11 bytes in the message. The total payload message length will be 11 times the number of Comm-A packets included.

An overview of the Comm-A Report Message is shown in Table 0-36~~Table 6-38~~. Table 0-37~~Table 6-39~~ provides the detailed message definition.

Table 0-36~~38~~ Comm-A Report Message Payload Structure Overview

Payload Index	Packet Number (p) where $0 > p \leq 23$	Field Position (f) where $0 \leq f \leq 11$	Byte Name	Number bytes
00	PACKET 1	0	CA10	1
01		1	CA11	1
…		…	…	…
10		10	CA110	1
11	PACKET 2	0	CA20	1
12		1	CA21	1
…		…	…	…
21		10	CA210	1
…	PACKET *p*	…	…	…
*(p * 11) + f*		*f*	CA*pf*	1
…		…	…	…

Table 0-3739 Comm-A Report Message Payload Structure Detail

Comm-A Report Packets			
Byte Offset	**Field Position**	**Byte Name**	**Field Description**
			The MXS can buffer up to 23 interrogations in a Comm-A Report message. Each Comm-A packet occupies 11 bytes in the message. The total payload message length will be 11 times the number of Comm-A packets included.
00	0	CA10	
01	1	CA11	
02	2	CA12	
…	…	…	
10	10	CB16	
Byte Offset	**Field Position**	**Byte Name**	
11	0	CB20	
12	1	CB21	
…	…	…	
21	10	CB26	
…			
Byte Offset	**Field Position** **(f) where** ***0 ≤f ≤ 11***	**Byte Name**	
(p * 7) +f	***(p * 11) + f***	CA***pf***	

7. Mode Settings Message: Type 0x8C

The Mode Settings Message provides data from the most recent Mode Message. This message is sent in response to a Mode Message (0x0C) or through the Data Request Message (0x05).

The overview structure of the Mode Settings Message is provided in Table 0-38~~Table 6-40~~. The overview and details of this message is identical to that of the Mode Message Payload structure overview and details, shown in Table 0-22~~Table 6-22~~ and Table 0-23~~Table 6-23~~.

Table 0-38~~40~~ Mode Settings Message Structure Overview

Payload Index	Message Field	Number bytes
00	**Mode Settings**	5

The actual content of a Mode Setting Message is the same data as the data from the Mode Message, except that the Message Type and Checksum change.

8. *Version Response Message: Type 0x8E*

The Version Response Message is sent in response to a Data Request Message that specifies a Requested Message Type of 0x8E. This message contains the software and complex hardware (i.e., firmware) versions of the MXS along with the latest SVN revisions of software and firmware code repositories.

An overview of the Version Response Message is shown in Table 0-39~~Table 6-43~~. Table 0-41~~Table 6-45~~ provides the detailed message definition.

Table 0-39~~43~~ Version Response Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Software Version**	1
01	**Firmware Version**	1
02	**Software SVN Revision**	2
04	**Firmware SVN Revision**	2

Table 0-40~~44~~ Version Response Message Detailed Field Description

Software Version			
Byte Offset	**Byte Name**	**Field Description**	
00	SWV0	**SWV0**	**SW Version**
		0x01	SW version 1
		0x02	SW version 2
		…	…
		SW Version Contains the software version of the MXS.	

Firmware Version			
Byte Offset	**Byte Name**	**Field Description**	
01	FWV0	**FWV0**	**FW Version**
		0x01	FW version 1
		0x02	FW version 2
		…	…
		SW Version Contains the firmware version of the MXS.	

Software SVN Revision		
Byte Offset	**Byte Name**	**Field Description**
02	SWR0	16-bit integer of the Software SVN Revision.
03	SWR1	

Firmware SVN Revision		
Byte Offset	**Byte Name**	**Field Description**
04	FWR0	16-bit integer of the Firmware SVN Revision.
05	FWR1	

Table 0-4145 Version Response Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x8E Version Response Message	[8E]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[05]
	Payload Length	6	[06]
PA	**Software Version**	9	[09]

	Firmware Version	9	[09]
	Software SVN Revision	12367	[30 4F]
	Firmware SVN Revision	12313	[30 19]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[1D]

9. *ADS-B In Report Message Overview*

Extended Squitters messages received by the MXS report Position, Velocity, Identification and Category, Target State and Status, and Aircraft Operational Status. From this data, MXS generates ADS-B, TIS-B and ADS-R reports for delivery to the flight computer which communicates the data to the user.

ADS-B In Reports are sent when target position data becomes available and thereafter as participant data changes. If the data for a given ADS-B In participant [12] has not been updated for a specified amount of time ADS-B In reports are no longer sent for that participant.

If enabled in the Target Request Message, the MXS sends out ADS-B In Report Messages for the host aircraft's position. The Host controls the number of targets reported on and the types of reports sent for those targets and requests a report for a particular target using the Target Request Message.

Table 0-42~~Table 6-46~~ lists ADS-B Reports and associated Message Types, lengths and document sections.

Table 0-42~~46~~ ADS-B Report Messages

Message Name	Message Type	Payload Length (Bytes)	Document Section
Target Summary Report	0x90	Varies	1.1.1.1~~6.4.10.1~~
ADS-B State Vector Report	0x91	24-48	1.1.1.2~~6.4.10.2~~
ADS-B Mode Status Report	0x92	16-36	1.1.1.3~~6.4.10.3~~
ADS-B Target State Report	0x97	23	1.1.1.4~~6.4.10.4~~
ADS-B Air Referenced Velocity Report	0x98	14	1.1.1.5~~6.4.10.5~~

[12] In this context, a participant is a vehicle/aircraft sending ADS-B signals within the range of the MXS.

1. Target Summary Report Message: Type 0x90

When a Target Request Message (Type 0x0B) Type 1 (Request Target Summary) is received, a Target Summary Report described in Table 0-44~~Table 6-48~~ is transmitted. The report lists the nearest N targets (with N specified in the Target Request Message) in range order.

An overview of the Target Summary Report Message is shown in Table 0-43~~Table 6-47~~. Table 0-44~~Table 6-48~~ provides the detailed message definition.

Table 0-43~~47~~ Target Summary Report Message Payload Structure Overview

Payload Index	Target Range	Byte Name	Number bytes
00	**NEAREST TARGET ID**	IDA0	3
		IDA1	
		IDA2	
03	**NEXT NEAREST TARGET ID**	IDB0	3
		IDB1	
		IDB2	
…			
t*3	**FURTHEST TARGET ID *t***	IDx0	3
		IDx1	
		IDx2	

Table 0-44~~48~~ Target Summary Report Message Payload Structure Detail

Nearest Target ID					
Byte Offset	**Byte Name**	**Field Description**			
00	IDA0	**IDA0**	**IDA1**	**IDA2**	**Nearest Target ID**
01	IDA1	0x00 0x03	0x01 0xFE	0x02 0x14	000102 03FE14
02	IDA2	Nearest Target ID ICAO Address for Target closest to aircraft			

Next Nearest Target ID					
Byte Offset	**Byte Offset**	**Field Description**			
03	IDB0	**IDB0**	**IDB1**	**IDB2**	**Next Nearest Target ID**

Next Nearest Target ID					
04	IDB1	0x00 0x03	0x01 0xFE	0x02 0x14	000102 03FE14
05	IDB2	Next Nearest Target ID ICAO Address for the next closest Target			
…					

Furthest Target ID X					
Byte Offset	**Byte Name**	**Field Description**			
X * 3	IDBX0	**IDX0**	**IDX1**	**IDX2**	**Furthest Target ID**
(X * 3) + 1	IDBX1	0x00 0x03	0x01 0xFE	0x02 0x14	000102 03FE14
(X * 3) + 2	IDBX2	Furthest Target ID ICAO Address for the Target furthest from aircraft			

2. ADS-B State Vector Report Message: Type 0x91

The ADS-B State Vector Report Message is one of several message types sent by the MXS to report data on a particular ADS-B In participant. The ADS-B State Vector Report Message contains information about a specific ADS-B participant.

- This message is sent for aircraft/vehicles that are transmitting ADS-B information, within range as specified in the Target Request Message (type 0x0B).
- It provides position, velocity, and other information about an ADS-B participant.
- The length of the ADS-B State Vector Report Message depends on the amount of information the MXS has received from an ADS-B participant.
- Since each report can contain at most, 85 targets, multiple reports may be transmitted for a single request.

An overview of the ADS-B State Vector Report Message is shown in Table 0-45~~Table 6-49~~[13].

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Table 0-46

~~Table 6-50~~ provides the detailed message definition. An example of the ADS-B State Vector Report Message is found in Table 0-47~~Table 6-51~~.

Table 0-45~~49~~ ADS-B State Vector Report Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Report Type and Structure ID**	3

[13] This figure shows all possible fields of the State Vector report. The MXS does not transmit Estimated Velocity. The presence of other fields depends on whether the participant is airborne or on the surface. The presence of fields in the message is controlled by the "Report Type and Structure ID" field.

Payload Index	Message Field	Number bytes
03	Validity Flags	2
05	Participant Address	3
08	Address Qualifier	1
09	Report Times of Applicability	6
15	Latitude	3
18	Longitude	3
21	Geometric Altitude	3
24	N/S Velocity	2
26	E/W Velocity	2
28	Ground Speed While on Surface	1
29	Heading While on Surface	1
30	Barometric Altitude	3
33	Vertical Rate	2
35	NIC	1
36	Estimated Latitude	3
39	Estimated Longitude	3
42	Estimated N/S Velocity[1313]	2
44	Estimated E/W Velocity[1313]	2
46	Surveillance Status	1
47	Report Mode	1

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Table 0-~~4650~~ ADS-B State Vector Report Message Payload Structure Detail

Report Type and Structure ID						
Byte Offset	**Byte Name**	**Field Description**				
00	RS0	**RS0 (MSN)**	**RS0 (LSN)**	**RS1**	**RS2**	**Report Type and Structure ID**
01	RS1	0x1	0xF	0xCF	0x98	State Vector Report for Airborne Target Omitting GS and HDG on surface, and estimated velocity.
02	RS2	0x1	0x7	0x32	0x18	State Vector Report for Surface Target Omitting the Estimated Position Time Of Applicability, Geometric Altitude, N/S and E/W Velocity, Barometric Altitude,

Report Type and Structure ID

						Vertical Rate, and Estimated Lat/Long and Velocity.

Report Type and Structure ID

The Most Significant Nibble (MSN) of the byte RS0 contains the Report Type. For the State Vector Report, this field will always contain a value of 0x1. This identifies the report as a State Vector Report.

The remaining data constitutes the Structure ID, which indicates the fields that are being reported in the current message. If the bit for the field is set to "ONE", then the data field is available and included in the current report. If the bit is set to "ZERO", this indicates that the field is not reported for the current message and the State Vector message will not include that field. The State Vector Message will concatenate the next field to be included into the report, following the previous reported field. This will be performed for each data field that is reported.

The below table outlines the Structure ID layout:

Byte Name	Bit	State Vector Data Parameter(s) to be Reported
RSO (LSN)	3	Time of Applicability for Estimated Position
	2	Position Time of Applicability
	1	Velocity Time of Applicability
	0	Latitude (WGS-84) & Longitude (WGS-84)
RS1	7	Altitude, Geometric (WGS-84)
	6	North/South Velocity & East/West Velocity
	5	Ground Speed while on the Surface
	4	Heading While on the Surface
	3	Altimeter, Barometric
	2	Vertical Rate Geometric/Baro.
	1	Navigation Integrity Category
	0	Estimated Latitude
RS2	7	Estimated Longitude
	6	Estimated North/South Velocity
	5	Estimated East/West Velocity
	4	Surveillance Status/Discretes
	3	Report Mode
	0-2	Reserved for future expansion

Validity Flags

Byte Offset	Byte Name	Field Description		
03	VF0	Byte	Bit	Data Field(s)
04	VF1	VF0	7	Latitude and Longitude
			6	Altitude, Geometric
			5	N/S and E/W Velocity
			4	Ground Speed while on Surface
			3	Heading while on the Surface
			2	Altitude, Barometric
			1	Vertical Rate, Geometric
			0	Vertical Rate, Barometric
		VF1	7	Estimated Latitude and Longitude
			6	Estimated N/S and E/W Velocity
			0-5	Reserved
		Validity Flags These flags indicate whether or not the data contained in the specified field is valid or not. If the bit is set to “ONE” then the data field contains valid information. If the bit is set to “ZERO” then the data field contains invalid information.		

Participant Address

Byte Offset	Byte Name	PA0	PA1	PA2	Participant Address
05	PA0				
06	PA1	0x1C	0xA6	0xB2	1CA6B2
		0x2A	0x35	0x6A	2A356A
07	PA2	Participant Address Bytes Contains the address of the transmitting installation. These fields contain up to six (6) hex characters. This can be the ICAO address or some other type of address.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
08	AQ0	**AQ0**	**Example Address Qualifier Descriptions**
		0x00	ICAO Address; Unknown Emitter Category
		0x01	Non-ICAO Address; Unknown Emitter Category
		0x02	ICAO Address; Aircraft
		0x03	Non-ICAO Address; Aircraft
		0x04	ICAO Address; Surface Vehicle, Fixed Ground or Tethered Obstruction
		0x05	Non-ICAO Address; Surface Vehicle, Fixed Ground or Tethered Obstruction
		0x20	Duplicate Target (having same ICAO Address as another tracked target)
		0x81	ADS-R Target
		Address Qualifier Byte Indicates the type of participant address being reported and what the emitter category is set to for the given participant.	

Report Times of Applicability								
Byte Offset	**Byte Name**	**Field Description**						
09	RA0	**RA0**	**RA1**	**RA2**	**RA3**	**RA4**	**RA5**	**Reported Time of Applicability**
10	RA1	00x00	0x58	00x00	0x70	0x00	0x80	Estimated Position and Velocity: 0.6875 seconds
11	RA2							Position: 0.875 seconds Velocity: 1.000 seconds
12	RA3	0x28	0x30	0x28	0x52	0x28	0x60	Estimated Position and Velocity: 80.375 seconds
13	RA4							Position: 80.641 seconds Velocity: 80.750 seconds
14	RA5	Report Times of Applicability						

Report Times of Applicability	
	The Report Times of Applicability field contains time stamps created when an ADS-B message is received by the message processor or when the message processor updates the SV report. The time stamp is based on the Transponder's established receiver unit time. Each TOA is formatted in units of 1/128 second. The first two bytes of this message (RA0 and RA1) contain the time of applicability for the estimated position field. The value is the time stamp created when the SV report was updated with current estimated position data. The next two bytes of this message (RA2 and RA3) contain the position time of applicability. The value is the time stamp created when the Airborne or Surface Position Message was received. The last two bytes of this message (RA4 and RA5) contain the velocity time of applicability. The value is the time stamp created when the Airborne Velocity Message or Surface Position Message was received.

Latitude					
Byte Offset	**Byte Name**	**Field Description**			
15	EL0	EL0	EL1	EL2	Latitude
16	EL1	0x28	0x00	0x80	56.252747 Degrees
17	EL2	0x19	0x28	0x60	35.378036 Degrees
		0xCB	0x54	0xE9	-74.064825 Degrees
		Latitude The data is sent as a 24-bit 2's complement number: *SMdddddd ddddddd ddddddL* The S bit indicates whether the data is positive (North) or negative (South). If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The resolution of the M bit is 90 degrees. The resolution of the L bit is $180/2^{23}$ (~0.0000215) degrees.			

Longitude

Byte Offset	Byte Name	Field Description			
18	EG0	EG0	EG1	EG2	Longitude
19	EG1	0xA0	0x00	0x80	-134.997253 Degrees
20	EG2	0x80	0x28	0x60	-179.778214 Degrees
		0x04	0x25	0x09	5.828440 Degrees

Longitude

The data is sent in the following format:

SMdddddd ddddddd ddddddd

The S bit indicates whether the data is positive (East) or negative (West). If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The resolution of the M bit is 90 degrees. The resolution of the L bit is $180/2^{23}$ (~0.0000215) degrees.

Geometric Altitude

Byte Offset	Byte Name	Field Description			
21	GA0	GA0	GA1	GA2	Geometric Altitude
22	GA1	0x20	0x00	0x80	32,770 Feet
23	GA2	0x01	0x28	0x30	1,184.75 Feet
		0xFF	0xC7	0xC0	-225 Feet

Geometric Altitude

The data is sent in the following format:

Sddddddd ddddddd ddddddd

The S bit indicates whether the data is positive or negative. If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The geometric altitude is sent in feet with a resolution of 0.015625 feet.

Note: Geometric Altitude is in 2's complement.

Note: : Geometric Altitude is the WGS-84 GNSS Height Above the Ellipsoid.

N/S Velocity

Byte Offset	Byte Name	Field Description		
24	NS0	**NS0**	**NS1**	**North/South Velocity**
25	NS1	0x00	0xA7	20.87 Knots
		0x08	0x25	260.63 Knots
		0xFD	0xEF	-66.13 Knots
		North/South Velocity Format the N/S Velocity in the target's State Vector into a 16-bit 2's complement number (SMddddddddddddL, where S=0 for north and 1 for south, M = 2048 knots, and L = 0.125 knots), and store the result in the N/S Velocity field of the State Vector report.		

East/West Velocity

Byte Offset	Byte Name	Field Description		
26	EW0	**EW0**	**EW1**	**East/West Velocity**
27	EW1	0x00	0xD9	27.13 Knots
		0x07	0x15	226.63 Knots
		0xFF	0x00	-32.00 Knots
		East/West Velocity Format the E/W Velocity in the target's State Vector into a 16-bit 2's complement number (SMddddddddddddL, where S=0 for east and 1 for west, M = 2048 knots, and L = 0.125 knots), and store the result in the E/W Velocity field of the State Vector report.		

Ground Speed While on Surface				
Byte Offset	**Byte Name**	**Field Description**		
28	GS0	**GS0**	**Ground Speed While on Surface**	**Quantization**
		0x00	No Movement Information Available	
		0x01	Aircraft Stopped (Ground Speed=0 knots)	
		0x02	0 knots < Ground Speed ≤ 0.125 kt	
		0x03-0x08	0.125 kt < Ground Speed ≤ 1 kt	0.146 kt steps
		0x09-0x0C	1 kt < Ground Speed ≤ 2 kt	0.25 kt steps
		0x0D-0x26	2 kt < Ground Speed ≤ 15 kt	0.50 kt steps
		0x27-0x5D	15 kt < Ground Speed ≤ 70 kt	1.00 kt steps
		0x5E-0x6C	70 kt < Ground Speed ≤ 100 kt	2.00 kt steps
		0x6D-0x7B	100 kt < Ground Speed ≤ 175 kt	5.00 kt steps
		0x7C	175 kt < Ground Speed	
		0x7D	Reserved for Aircraft Decelerating	
		0x7E	Reserved for Aircraft Accelerating	
		0x7F	Reserved for Aircraft Backing-Up	
		Ground Speed while on Surface The data specifies the status of the “Movement” of the ADS-B transmitting subsystem (aircraft or surface vehicle) while on the surface.		

Heading While on Surface

Byte Offset	Byte Name	Field Description	
29	HS0	**HS0**	**Heading While on Surface**
		0x28	56.25 Degrees
		0x86	-171.5625 Degrees
		0x96	-149.0625 Degrees

Heading while on Surface

The data is sent in the following format: *Sddddddd*

The S bit indicates whether the data is positive or negative. If the S bit is set to “ONE” then the data is negative, if set to “ZERO” then the data is positive. The heading is sent in degrees with a resolution of 1.40625 degrees.

Note: Heading while on Surface is in 2's complement format.

Note: The “Track/Heading and HRD” data in the Mode Status report specifies whether this represents a ground track or heading, and for heading, whether it is relative to true or magnetic north.

Barometric Altitude

Byte Offset	Byte Name	Field Description			
30	BA0	BA0	BA1	BA2	Barometric Altitude
31	BA1	0x20	0x00	0x80	32,770 Feet
32	BA2	0x01	0x28	0x30	1,184.75 Feet
		0xFF	0xC7	0xC0	-225 Feet

Barometric Altitude

The data is sent in the following format: *Sddddddd ddddddddd ddddddddd*

The S bit indicates whether the data is positive or negative. If the S bit is set to “ONE” then the data is negative, if set to “ZERO” then the data is positive. The Barometric altitude is sent in feet with a resolution of 0.015625 feet.

Note: Barometric Altitude is in 2's complement format.

Note: Barometric Altitude is relative to a standard pressure of 1013.25 millibars (29.92 in Hg).

Vertical Rate

Byte Offset	Byte Name	Field Description		
33	VR0	**VR0**	**VR1**	**Vertical Rate**
34	VR1	0x01	0xF4	500 ft/min going up
		0x01	0x90	400 ft/min going up
		0xFE	0xA2	-350 ft/min going down

Vertical Rate

This the altitude rate of change of the reported ADS-B participant. This is either the rate of change for the barometric or the geometric altitude; whichever one is in the State Vector Message. The data is sent in the following format: *Sdddddd ddddddd*

The S bit indicates whether the data is positive or negative. If the S bit is set to "ONE" then the data is negative and the direction is down, if set to "ZERO" then the data is positive and the direction is up). The Vertical Rate is sent in feet per minute with a resolution of 1.0 feet per minute.

Note: Vertical Rate is in 2's complement format.

NIC			
Byte Offset	**Byte Name**	**Field Description**	
35	NI0	**NI0**	**NIC**
		0x00	Rc unknown
		0x01	Rc< 20 NM
		0x02	Rc< 8 NM
		0x03	Rc< 4 NM
		0x04	Rc< 2 NM
		0x05	Rc< 1 NM
		0x06	Rc< 0.6 NM
		0x07	Rc< 0.2 NM
		0x08	Rc< 0.1 NM
		0x09	Rc< 75m
		0x0A	Rc< 25m
		0x0B	Rc< 7.5m
		0x0C-0x15	Reserved
		0x16	Rc<0.3
		0x17-0xFF	Reserved
		The Navigation Integrity Category (NIC) field specifies radius of containment for the ADS-B participant.	

Estimated Latitude

Byte Offset	Byte Name	Field Description			
36	LE0	LE0	LE1	LE2	Estimated Latitude
37	LE1	0x0F	0x1C	0x71	21.249983 Degrees
38	LE2	0xF9	0x99	0x99	-9.000013 Degrees
		0xDF	0x77	0x77	-45.750010 Degrees

Estimated Latitude

Latitude position is estimated when an Airborne Velocity message is received.

The data is sent in the following format: *SMdddddd dddddddd dddddddd*

The S bit indicates whether the data is positive or negative. If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The M bit should be set to ZERO for Latitude. The resolution of the Latitude field is 0.0000215 Degrees.

Estimated Longitude

Byte Offset	Byte Name	Field Description			
39	GE0	GE0	GE1	GE2	Estimated Longitude
40	GE1	0x2B	0xC6	0x79	61.558993 Degrees
41	GE2	0xA9	0x9C	0x7B	-121.484177 Degrees
		0x4C	0x90	0x8B	107.668998 Degrees

Estimated Longitude

Longitude position is estimated when an Airborne Velocity message is received.

The data is sent in the following format: *SMdddddd dddddddd dddddddd*

The S bit indicates whether the data is positive or negative. If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The M bit indicates a longitude of 180 degrees if set to "ONE" and all remaining bits will be set to "ZERO". The resolution of the Longitude field is 0.0000215 Degrees.

Estimated North/South Velocity

Byte Offset	Byte Name	Field Description
42	EN0	The MXS does not transmit Estimated Velocity .
43	EN1	

Estimated East/West Velocity		
Byte Offset	**Byte Name**	**Field Description**
44	EE0	The MXS does not transmit Estimated Velocity.
45	EE1	

Surveillance Status			
Byte Offset	**Byte Name**	**Field Description**	
46	SS0	**SS0 (MSN)**	**Surveillance Status**
		0x0	No Condition Information Available
		0x2	Permanent Alert Condition (Emergency)
		0x4	Temporary Alert Condition (Change in Mode Identity Code other than emergency condition)
		0x6	Special Position Identification (SPI) Condition
		0x7-0xF	Reserved
		SSO (LSN)	**Intent Change Flag**
		0x0	No Change in Intent
		0x1	Reserved
		0x2	Intent Change
		0x3-0xF	Reserved
		Surveillance Status This field reports two sets of data. The most significant nibbles (MSN) reports the surveillance status of the ADS-B participant. The least significant nibble (LSN) reports the Intent Change Flag of the ADS-B participant.	

Report Mode			
Byte Offset	**Byte Name**	**Field Description**	
47	RM0	**RM0**	**Report Mode**
		0x00	No Report Generation Capability
		0x01	Acquisition Mode
		0x02	Track Mode
		0x03-0xFF	Reserved
		Report Mode This field is used to indicate the current state of report for the ADS-B participant being reported.	

Table 0-4751 ADS-B State Vector Report Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x91 ADS-B State Vector Report Message	[91]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[D4]
	Payload Length	42 (variable: missing fields IDd in Structure ID bytes)	[2A]
PAYLOAD	Report Type and Structure ID	No: Ground Speed While on Surface, Heading While on Surface, N/S Velocity, E/W Velocity	[1F CF 98]
	Validity Flags	Invalid: Ground Speed While on Surface, Heading While on Surface, Vert Rate Geom, Est. Lat/Long.	[E5 80]
	Participant Address	Address: C001ED	[C0 01 ED]
	Address Qualifier	Non-ICAO Address; Unknown Emitter Category	[01]
	Report Times of Applicability	Est Position TOA: 383.391, Position TOA: 383.391, Velocity TOA: 380.352	[BF B2 BF B2 BE 2D]
	Lat	45.588 degrees N	[20 6B 1F]
	Long	121.685 degrees W	[A9 77 FA]
	Geometric Altitude	44625 feet	[2B 94 40]
	N/S Velocity	330 knots S	[F5 B0]
	E/W Velocity	76 knots E	[02 60]
	Barometric Altitude	45000 feet	[2B F2 00]
	Vertical Rate	+192 feet/minute	[00 C0]
	NIC	Navigation Integrity Category = 9	[09]
	Estimated Latitude	45.588 degrees N	[20 6B 1F]
	Estimated Longitude	121.685 degrees W	[A9 77 FA]
	Surveillance Status	No alert, No intent change	[00]
	Report Mode	Tracked	[02]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of Payload Data.	[16]

3. ADS-B Mode Status Report Message: Type 0x92

The ADS-B Mode Status Report Message is one of several message types sent by the MXS to report data on a particular ADS-B In participant. The ADS-B Mode Status Report Message:

- Is sent for aircraft/vehicles being monitored by the MXS as specified in the Target Request Message (type 0x0B).
- Provides aircraft/vehicle information about the ADS-B participant (such as call sign and emitter category).

An overview of the ADS-B Mode Status Report Message is shown in Table 0-48~~Table 6-52~~. Table 0-49~~Table 6-53~~ provides the detailed message definition. An example ADS-B Mode Status Report Message is found in Table 0-50~~Table 6-54~~.

Table 0-~~48~~52 ADS-B Mode Status Report Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Report Type and Structure ID**	3
03	**Validity Flags**	1
04	**Participant Address**	3
07	**Address Qualifier**	1
08	**Report Times of Applicability**	2
10	**ADS-B Version**	1
11	**Call Sign**	8
19	**Emitter Category**	1
20	**A/V Length & Width Code**	1
21	**Emergency/Priority Status**	1
22	**Capability Class Codes**	3
25	**Operational Mode**	2
27	**SV Quality - NACp**	1
28	**SV Quality - NACv**	1
29	**SV Quality – SIL** **SV Quality – SIL Supplement** **SV Quality – System Design Assurance**	1
30	**SV Quality - GVA**	1
31	**SV Quality – NIC baro**	1
32	**Track/Heading and Horizontal Reference Direction**	1
33	**Vertical Rate Type**	1
34	**Reserved**	2

Table 0-~~49~~53 ADS-B Mode Status Report Message Payload Structure Detail

Report Type and Structure ID						
Byte Offset	**Byte Name**	**Field Description**				
00	RS0	**RS0 (MSN)**	**RS0 (LSN)**	**RS1**	**RS2**	**Report Type and Structure ID**
01	RS1	0x2	0xF	0x6E	0x60	Version 0 TargetVersion 1 Airborne Target
02	RS2	0x2	0xF	0x7E	0xE0	Version 1 Surface Target
		0x2	0xF	0xFE	0xE0	Version 2 Airborne Target
		0x2	0xF	0x7F	0xE0	Version 2 Surface Target
		0x2	0xF	0xFF	0xE0	

Report Type and Structure ID

The Most Significant Nibble (MSN) of the byte RS0 contains the Report Type. For the Mode Status Report, this field will always contain a value of 0x2. This identifies the report as a Mode Status Report.

The remaining data constitutes the Structure ID, which indicates the fields that are being reported in the current message. If the bit for the field is set to "ONE", then the data field is available and included in the current report. If the bit is set to "ZERO", this indicates that the field is not reported for the current message and the Mode Status message will not include that field. The Mode Status Message will concatenate the next field to be included into the report, following the previous reported field. This is performed for each data field reported.

The below table from D0-260B outlines the Structure ID layout:

Byte Name	Bit #	Mode Status Data Parameter to be Reported
RS0 (LSN)	3	Time of Applicability
	2	ADS-B Version
	1	Call Sign
	0	Emitter Category
RS1	7	A/V Length and Width Code
	6	Emergency/Priority Status
	5	Capability Codes
	4	Operational Mode
	3	SV Quality – NAC_P
	2	SV Quality – NAC_V
	1	SV Quality – SIL, SIL Supplement, SDA
	0	SQ Quality – Geometric Vertical Accuracy (GVA)
RS2	7	SV Quality – NIC_{BARO}

Report Type and Structure ID			
		6	True/Magnetic Heading (HRD)
		5	Vertical Rate Type
		4	(Reserved for) Flight Mode Specific Data
		3	Other (Reserved)
		0-2	Reserved

Validity Flags			
Byte Offset	**Byte Name**	**Field Description**	
03	VF0	**Bit**	**Data Field(s)**
		7	Capability Codes
		6	Operational Mode
		5	SV Quality - NACp
		4	SV Quality - NACv
		3	SV Quality - SIL
		2	Emergency/Priority Status
		0-1	Reserved
		Validity Flags These flags indicate whether or not the data contained in the specified field is valid or not. If the bit is set to "ONE" then the data field contains valid information. If the bit is set to "ZERO" then the data field contains invalid information.	

Participant Address					
Byte Offset	**Byte Name**	**Field Description**			
04	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
05	PA1	0x1C	0xA6	0xB2	1CA6B2
06	PA2	0x2A	0x35	0x6A	2A356A
		Participant Address Bytes Contains the address of the transmitting installation. These fields contain up to 6 hex characters. This can be the ICAO address or some other type of address.			

Address Qualifier

Byte Offset	Byte Name	Field Description
07	AQ0	**AQ0** **Example Address Qualifier Description**
		Address Qualifier Byte Indicates the type of participant address being reported and what the emitter category is set to for the given participant. See State Vector Report (section 0) for examples.

Report Time of Applicability

Byte Offset	Byte Name	Field Description		
08	RA0	**RA1**	**RA0**	**Report Times of Applicability**
09	RA1	0x00	0x80	Time of Applicability: 1.0 seconds
		0x28	0x60	Time of Applicability: 80.75 seconds
		Report Time of Applicability This two-byte field (RA0 and RA1) contains the Report Times of Applicability with a resolution of 1/128 seconds. For example, a value of 0x0058 would have a value of 0.6875 seconds.		

ADS-B Version

Byte Offset	Byte Name	Field Description	
10	AV0	**AV0**	**ADS-B Version**
		0x00	Conformant to DO-260/ED-102 and DO-242
		0x01	Conformant to DO-260A and DO-242A
		0x02	Conformant to DO-260B/ED-102A and DO-242B
		0x03-0xFF	Reserved
		ADS-B Version Indicates the formats and protocol used on the ADS-B participant.	

Call Sign

Byte Offset	Byte Name	Field Description								
11	CS0	**CS0**	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**Call Sign**
12	CS1	0x4E	0x32	0x35	0x36	0x37	0x47	0x41	0x20	N2567GA
13	CS2	Call Sign The Call Sign field indicates the aircraft identification used by the ADS-B participant. Data is sent as unsigned char ASCII characters. Valid ASCII characters are outlined below: **Valid ASCII Hex Values** 0x20 (Space) 0x30-0x39 (0-9) 0x41-0x5A (A-Z) The most significant bit is sent first. The Call Sign is padded with space characters on the right.								
14	CS3									
15	CS4									
16	CS5									
17	CS6									
18	CS7									

Emitter Category			
Byte Offset	**Byte Name**	**Field Description**	
19	EC0	**EC0**	**Emitter Category**
		0x00	No Emitter Category Information Available
		0x01	Light (<15500 lbs.)
		0x02	Reserved
		0x03	Small (15500 to 75000 lbs.)
		0x04	Reserved
		0x05	Large (75000 to 300000 lbs.)
		0x06	High-Vortex Large (aircraft such as B-757)
		0x07	Heavy (>300000 lbs)
		0x08	High Performance (>5 g acceleration and >400 knots)
		0x09	Reserved
		0x0A	Rotorcraft
		0x0B	Glider/Sailplane
		0x0C	Lighter-than-Air
		0x0D	Unmanned Aerial Vehicle
		0x0E	Space/Trans-atmospheric Vehicle
		0x0F	Ultralight / hang-glider / paraglider
		0x10	Parachutist / Skydiver
		0x11-0x13	Reserved
		0x14	Surface Vehicle – Emergency Vehicle
		0x15	Surface Vehicle – Service Vehicle
		0x16	Point Obstacle (includes Tethered Balloons)
		0x17	Cluster Obstacle
		0x18	Line Obstacle
		0x19-0xFF	Reserved
		Emitter Category Indicates the type of vehicle or aircraft ADS-B participant.	

A/V Length and Width Code

Byte Offset	Byte Name	Field Description		
20	LW0	**LW0**	**Aircraft Size**	
			Length (m)	**Width (m)**
		0x00	Unknown	Unknown
		0x01	<= 15	<= 23
		0x02	<= 25	<= 28.5
		0x03	<= 25	<= 34
		0x04	<= 35	<= 33
		0x05	<= 35	<= 38
		0x06	<= 45	<= 39.5
		0x07	<= 45	<= 45
		0x08	<= 55	<= 45
		0x09	<= 55	<= 52
		0x0A	<= 65	<= 59.5
		0x0B	<= 65	<= 67
		0x0C	<= 75	<= 72.5
		0x0D	<= 75	<= 80
		0x0E	<= 85	<= 80
		0x0F	<= 85	<= 90
		0x10-0xFF	Reserved	Reserved
		A/V Length and Width Code Indicates the length and width of the vehicle or aircraft ADS-B participant. Aircraft and vehicles that exceed a width of 90 meters and a length of 85 meters shall use code of 0x0F.		

Emergency/Priority Status			
Byte Offset	**Byte Name**	**Field Description**	
21	EP0	**EP0**	**Emergency/Priority Status**
		0x00	No Emergency
		0x01	General Emergency
		0x02	Lifeguard/medical Emergency
		0x03	Minimum Fuel
		0x04	No Communications
		0x05	Unlawful Interference
		0x06	Downed Aircraft
		0x07-0xFF	Reserved

Capability Class Codes

Byte Offset	Byte Name	Field Description		
22	CC0	**Byte**	**Bit**	**Capability Class Codes**
23	CC1	CC0	**4-7**	Reserved
24	CC2		**3**	B2 Low – Indicates that the surface vehicle transmits with less than 70 watts of power
			0-2	Reserved
		CC1	**7**	TCAS Operational – TCAS is operational or not
			6	1090ES In – ADS-B 1090ES receive capability
			5	ARV – Capability to send messages to support Air-Referenced Velocity Reports
			4	TS Report – Capability to send messages to support Target State Reports
			3	TC Report – See table below
			2	TC Report – See table below
			1	UAT In – ADS-B UAT receive capability
			0	Reserved
		CC2	**0-7**	Reserved

Capability Class Codes

These flags indicate the capabilities of the ADS-B participant. If a bit is set to “ONE”, then it indicates that the service is supported. All reserved bits should be “ZERO”.

The *TC Report* field in byte CC1 is encoded as follows:

Bit3	Bit2	TC Report
0	0	No capability to send messages that support Trajectory Change Reports
0	1	Capability to send messages to support TC+0 Report only
1	0	Capability to send messages to support multiple TC Reports
1	1	Reserved

Operational Mode				
Byte Offset	**Byte Name**	**Field Description**		
25	OM0	**Byte**	**Bit**	**Operational Mode**
26	OM1	OM0	**7**	OM Format – Set to "ZERO" to indicate the formatting below.
			6	OM Format – Set to "ZERO" to indicate the formatting below.
			5	TCAS RA Active – TCAS II or ACAS Resolution Advisory is in effect
			4	IDENT Switch – IDENT is active
			3	Reserved
			2	Single Antenna Flag – ADS-B Transmitting subsystem is operating with a single antenna
			1	Reserved
			0	Reserved
		OM1	**7**	Lateral Axis GPS Antenna Offset
			6	Lateral Axis GPS Antenna Offset
			5	Lateral Axis GPS Antenna Offset
			4	Longitudinal Axis GPS Antenna Offset
			3	Longitudinal Axis GPS Antenna Offset
			2	Longitudinal Axis GPS Antenna Offset
			1	Longitudinal Axis GPS Antenna Offset
			0	Longitudinal Axis GPS Antenna Offset

Operational Mode

These flags indicate the operational mode of the ADS-B participant. All reserved bits should be "ZERO".

The *Lateral Axis GPS Antenna Offset* field in byte OM1 is encoded as follows:

Bit 7	**Bit 6**	**Bit 5**	**Upper Bound of GPS Antenna Offset Along Lateral Axis Left or Right Longitudinal Axis**
0	0	0	No Data
0	0	1	Left – 2 meters
0	1	0	Left – 4 meters
0	1	1	Left – 6 meters
1	0	0	Right – 0 meters
1	0	1	Right – 2 meters
1	1	0	Right – 4 meters
1	1	1	Right – 6 meters

Operational Mode

The *Longitudinal Axis GPS Antenna Offset* field in byte OM1 is encoded as follows:

Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Upper Bound of GPS Antenna Offset Along Longitudinal Axis Aft From Aircraft Noise
0	0	0	0	0	No Data
0	0	0	0	1	Position Offset Supplied by Sensor
0	0	0	1	0	2 meters
0	0	0	1	1	4 meters
0	0	1	0	0	6 meters
*	*	*	*	*	***
*	*	*	*	*	***
1	1	1	1	1	60 meters

SV Quality - NACp

Byte Offset	Byte Name	Field Description	
27	NP0	**NP0**	**95% Horizontal Accuracy Bounds (EPU)**
		0x00	EPU ≥ 18.52 km (10 NM)
		0x01	EPU < 18.52 km (10 NM)
		0x02	EPU < 7.408 km (4 NM)
		0x03	EPU < 3.704 km (2 NM)
		0x04	EPU < 1852 m (1 NM)
		0x05	EPU < 926 m (0.5 NM)
		0x06	EPU < 555.6 m (0.3 NM)
		0x07	EPU < 185.2 m (0.1 NM)
		0x08	EPU < 92.6 m (0.05 NM)
		0x09	EPU < 30 m
		0x0A	EPU < 10 m
		0x0B	EPU < 3 m
		0x0C-0xFF	Reserved
		SV Quality – NACp The NACp field reports the level of accuracy of the geometric position being reported. EPU is defined as the radius of a circle that is centered on the ADS-B participant and indicates the probability of being inside the circle is 95%.	

SV Quality - NACv			
Byte Offset	**Byte Name**	**Field Description**	
28	NV0	**NV0**	**Horizontal Velocity Error**
		0x00	Unknown or ≥10 m/s
		0x01	< 10 m/s
		0x02	< 3 m/s
		0x03	< 1 m/s
		0x04	< 0.3 m/s
		0x05-0xFF	Reserved
		SV Quality – NACv. The NACv field reports the horizontal velocity error with 95% certainty.	

SV Quality – SIL

SV Quality – SIL Supplement

SV Quality – System Design Assurance

Byte Offset	Byte Name	Field Description		
29	SL0	**Byte**	**Bit**	**SV Quality - SIL**
		SL0	5-7	Reserved
			4	System Design Assurance
			3	System Design Assurance
			2	SIL Supplement
			1	SIL
			0	SIL

SV Quality – System Design Assurance The System Design Assurance field defines the failure condition that the position transmission chain is able to support. See the table below for SDA format:

Bit 4	Bit 3	Supported Failure Condition	Probability of undetected fault causing transmission of false information
0	0	Unknown/No safety effect	$>1x10^{-3}$ per flight hour or unknown
0	1	Minor	$\leq 1x10^{-3}$ per flight hour
1	0	Major	$\leq 1x10^{-5}$ per flight hour
1	1	Hazardous	$\leq 1x10^{-7}$ per flight hour

SV Quality – SIL Supplement

The Source Integrity Level Supplement provides whether the SIL probability is based upon a per sample or per hour probability of exceeding the radius of containment. If bit 2 is set to "ONE" then the probability of exceeding the radius of containment is based upon "per sample". If bit 2 is set to "ZERO" then the probability of exceeding the radius of containment is based upon "per hour".

SV Quality – SIL The Source Integrity Level provides the probability of the ADS-B participant exceeding the radius of containment specified by the NIC field.

Bit 1	Bit 0	Probability of Exceeding the NIC Containment Radius (Rc)
0	0	Unknown or $> 1x10^{-3}$ per flight hour or per sample
0	1	$\leq 1x10^{-3}$ per flight hour or per sample
1	0	$\leq 1x10^{-5}$ per flight hour or per sample
1	1	$\leq 1x10^{-7}$ per flight hour or per sample

SV Quality - GVA			
Byte Offset	**Byte Name**	**Field Description**	
30	SG0	**SGO**	**Geometric Vertical Accuracy**
		0x00	Unknown or > 150 meters
		0x01	≤ 150 meters
		0x02	≤ 45 meters
		0x03-0xFF	Reserved

SV Quality - NICbaro			
Byte Offset	**Byte Name**	**Field Description**	
31	NB0	**NBO**	**Barometric Altitude Integrity Code**
		0x00	Barometric Altitude based upon Gilham coded input that has not been cross-checked against another source of pressure altitude.
		0x01	Barometric Altitude based upon Gilham coded input that has been cross-checked against another source of pressure altitude or is based on a non-Gilham coded source.
		0x02-0xFF	Reserved

Track/Heading and HRD			
Byte Offset	**Byte Name**	**Field Description**	
32	TH0	**TH0**	**Track/Heading and Horizontal Reference Direction (HRD)**
		0x00	Ground track relative to true north being reported
		0x01	Ground track relative to magnetic north reported
		0x02	Heading relative to true north being reported
		0x03	Heading relative to magnetic north being reported
		0x04-0xFF	Reserved
		Track Heading and HRD This data indicates the nature of the horizontal direction information being reported in the “Heading while on Surface” field in the State Vector report.	

Vertical Rate Type			
Byte Offset	**Byte Name**	**Field Description**	
33	VT0	**VT0**	**Vertical Rate Type**
		0x00	Vertical Rate in State Vector Report is the rate of change of barometric pressure altitude
		0x01	Vertical Rate in State Vector Report is the rate of change of geometric altitude
		0x02-0xFF	Reserved

Reserved		
Byte Offset	**Byte Name**	**Field Description**
34	RE0	These bytes are reserved for future use and are not output by the MXS.
35	RE1	

Table 0-5054 ADS-B Mode Status Report Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x92 ADS-B Mode Status Report Message	[92]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[00]
	Payload Length	33	[21]
	Report Type & Structure ID	Structure ID indicates all data is reported except Length/Width code.	[2F 7F E0]
	Validity Flags	All validity flags are valid	[FC]
PAYLOAD	**Participant Address**	ICAO Address: AC82EC	[AC 82 EC]
	Address Qualifier	ADS-B Target	[01]
	Report Times of Applicability	381.336 Seconds	[BE AB]
	ADS-B Version	Conformant to DO-260B	[02]
	Call Sign	Call Sign: N978CP	[4E 39 37 38 43 50 20 20]
	Emitter Category	Emitter Category: Light (<15500 lbs.)	[01]
	A/V Length and Width Code	Not reported for this target (target is airborne).	N/A
	Emergency/Priority Status	No emergency	[00]
	Capability Class Codes	TCAS operational, ARV, TS Report capable	[00 B0 00]
	Operational Mode	Dual Antenna, GPS Antenna Offset: 7	[07 00]

SV Quality - NACp	NACP: EPU < 10 m	[0A]
SV Quality - NACv	NACV: Horizontal Velocity Error < 3 m/s	[02]
SV Quality – System Design Assurance. **SV Quality - SIL**	SDA supported failure condition: Hazardous, SIL: ≤ 1x10^–7 per flight hour	[1B]
GVA	GVA: ≤ 45 m	[02]
NIC Baro.	Barometric altitude reported is either based on a cross-checked Gilham code input or is based on a non-Gilham coded source	[01]
HRD	Heading referenced to True North	[00]
Vertical Rate Type	Vertical Rate Type: Barometric Altitude	[01]
Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[CE]

4. ADS-B Target State Report Message: Type 0x97

The ADS-B Target State Report is one of several message types sent by the MXS to report data on a particular ADS-B In participant. The ADS-B Target State Report Message:

- Is sent for aircraft/vehicles being monitored by the MXS as specified in the Target Request Message (type 0x0B).
- Provides aircraft/vehicle information about the ADS-B participant (such as selected altitude and autopilot settings).

An overview of the ADS-B Target State Report Message is shown in Table 0-51~~Table 6-55~~. Table 0-52~~Table 6-56~~ provides the detailed message definition.

Table 0-5155 ADS-B Target State Report Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Report Type and Structure ID**	2
02	**Validity Flags**	2
04	**Participant Address**	3
07	**Address Qualifier**	1
08	**Report Times of Applicability**	2
10	**Selected Altitude Type**	1
11	**Selected Altitude**	2
13	**Baro Setting**	2
15	**Selected Heading**	2
17	**Autopilot Engaged**	1
18	**VNAV Mode Engaged**	1
19	**Altitude Hold Mode**	1
20	**Approach Mode**	1
21	**LNAV Mode Engaged**	1
22	**Reserved**	1

Table 0-~~5256~~ ADS-B Target State Report Message Payload Structure Detail

Report Type and Structure ID					
Byte Offset	**Byte Name**	**Field Description**			
00	RS0	**RS0 (MSN)**	**RS0 (LSN)**	**RS1**	**Report Type and Structure ID**
01	RS1	0x5	0xF	0xF8	Target State Report; All data fields are supported

Report Type and Structure ID

The Most Significant Nibble (MSN) of the byte RS0 contains the Report Type. For the Target State Report, this field will always contain a value of 0x5. This identifies the report as a Target State Report.

The remaining data constitutes the Structure ID, which indicates the fields that are being reported in the current message. If the bit for the field is set to "ONE", then the data field is available and included in the current report. If the bit is set to "ZERO", this indicates that the field is not reported for the current message and the Mode Status message will not include that field. The Mode Status Message will concatenate the next field to be included into the report, following the previous reported field. This is performed for each data field that is reported.

The below table from D0-260B outlines the Structure ID layout:

	Bit #	**Target State Data Parameter to be Reported**
RS0 (LSN)	3	Selected Altitude :Selected Altitude Type
	2	Selected Altitude: MCP/FCU Selected Altitude or FMS Selected Altitude
	1	Barometric Pressure Setting (Minus 800 millibars)
	0	Selected Heading
RS1	7	Mode Indicators: Autopilot Engaged
	6	Mode Indicators: VNAV Mode Engaged
	5	Mode Indicators: Altitude Hold Mode
	4	Mode Indicators: Approach Mode
	3	Mode Indicators: LNAV Mode Engaged
	0-2	Reserved

Validity Flags

Byte Offset	Byte Name	Field Description		
02	VF0	Byte	Bit	Data Field(s)
03	VF1	VF0	0 - 7	Reserved
		VF1	7	Selected Altitude
			6	Barometric Pressure Setting
			5	Selected Heading
			4	MCP/FCU Mode
			0-3	Reserved
		Validity Flags These flags indicate whether or not the data contained in the specified field is valid or not. If the bit is set to “ONE” then the data field contains valid information. If the bit is set to “ZERO” then the data field contains invalid information.		

Participant Address

Byte Offset	Byte Name	Field Description			
04	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
05	PA1	0x1C	0xA6	0xB2	1CA6B2
06	PA2	0x2A	0x35	0x6A	2A356A
		Participant Address Bytes Contains the address of the transmitting installation. These fields contain up to 6 hex characters. This can be the ICAO address or some other type of address.			

Address Qualifier Description

Byte Offset	Byte Name	Field Description	
07	AQ0	**QA0**	**Address Qualifier Description**
		Address Qualifier Byte Indicates the type of participant address being reported and what the emitter category is set to for the given participant. See State Vector Report (section 0) for examples.	

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
08	RA0	**RA1**	**RA0**	**Report Times of Applicability**
09	RA1	0x00	0x80	Time of Applicability: 1.0 seconds
		0x28	0x60	Time of Applicability: 80.75 seconds
		Report Times of Applicability The two bytes of this message (RA0 and RA1) contain the Report Times of Applicability. The data is formatted such that subfield is in seconds with a resolution of 1/128 seconds. For example, a value of 0x0058 would have a value of 0.6875 seconds.		

Selected Altitude Type			
Byte Offset	**Byte Name**	**Field Description**	
10	AT0	**AT0**	**Selected Altitude Type**
		0x00	Selected altitude derived from Control Panel
		0x01	Selected altitude derived from Flight Management System (FMS)
		0x02-0xFF	Reserved
		Selected Altitude Type Indicates the source of the Selected Altitude data.	

Selected Altitude				
Byte Offset	**Byte Name**	**Field Description**		
11	SA0	SA0	SA1	Selected Altitude
12	SA1	0x00	0x01	0 feet
		0x00	0x02	32 feet
		0x00	0x03	64 feet
		0x07	0xFF	65472 feet
		Selected Altitude Selected altitude is sent in the following format: *ddd dddd dddd* with the most significant 5 bits unused. Selected altitude is sent in units of feet with a resolution of 32 feet. A value of zero is used to indicate no data or invalid. Therefore, 32 feet must be subtracted from the value in the field.		

Baro Setting				
Byte Offset	**Byte Name**	**Field Description**		
13	BS0	**BS0**	**BS1**	**Baro Setting**
14	BS1	0x00	0x01	800.0 millibars
		0x00	0x02	800.8 millibars
		0x00	0x03	801.6 millibars
		0x01	0xFF	1208.0 millibars
		Barometric Setting Barometric setting is sent in the following format: *d dddd dddd* with the most significant 7 bits unused. Barometric setting is sent in units of millibars with a resolution of 0.8 millibars and an offset of 800 millibars. A value of zero is used to indicate no data or invalid. Therefore, 800 millibars must be added to the value in the field and 0.8 millibars must be subtracted.		

Selected Heading				
Byte Offset	**Byte Name**	**Field Description**		
15	SH0	**SH0**	**SH1**	**Selected Heading**
16	SH1	0x00	0x00	0 degrees
		0x00	0x01	0.703125 degrees
		0x01	0xFF	359.296875 degrees
		Selected Heading Selected heading is sent in the following format: *d dddd dddd* with the most significant 7 bits unused. Selected heading is sent in units of degrees with a resolution of 0.703125 degree.		

A/P Engaged			
Byte Offset	**Byte Name**	**Field Description**	
17	AP0	**AP0**	**Autopilot Engaged**
		0x00	Autopilot is not engaged or unknown
		0x01	Autopilot is engaged (actively coupled and flying the aircraft)
		0x02-0xFF	Reserved
		Autopilot Engaged Indicates whether or not the autopilot is engaged.	

VNAV Engaged			
Byte Offset	**Byte Name**	**Field Description**	
18	VN0	**VN0**	**VNAV Engaged**
		0x00	VNAV Mode is not active or unknown
		0x01	VNAV Mode is active
		0x02-0xFF	Reserved
		VNAV Engaged Indicates whether or not vertical navigation mode is active.	

Alt Hold			
Byte Offset	**Byte Name**	**Field Description**	
19	AH0	**AH0**	**Altitude Hold**
		0x00	Altitude Hold Mode is not engaged or unknown
		0x01	Altitude Hold Mode is engaged
		0x02-0xFF	Reserved
		Altitude Hold Engaged Indicates whether or not altitude hold mode is active.	

Appr Mode Engaged			
Byte Offset	**Byte Name**	**Field Description**	
20	AM0	**AM0**	**Approach Mode Engaged**
		0x00	Approach Mode is not active or unknown
		0x01	Approach Mode is active
		0x02-0xFF	Reserved
		Approach Mode Engaged Indicates whether or not approach mode is active.	

LNAV Mode Engaged			
Byte Offset	**Byte Name**	**Field Description**	
21	LN0	**LN0**	**LNAV Mode Engaged**
		0x00	LNAV Mode is not active or unknown
		0x01	LNAV Mode is active
		0x02-0xFF	Reserved
		LNAV Engaged Indicates whether or not lateral navigation mode is active.	

Reserved		
Byte Offset	**Byte Name**	**Field Description**
22	RE0	These bytes are reserved for future use and are not output by the MXS.

5. ADS-B Air Referenced Velocity Report Message: Type 0x98

The ADS-B Air Referenced Velocity Report Message is one of several message types sent by the MXS to report data on a particular ADS-B In participant. The ADS-B Air Referenced Velocity Report Message:

- Is sent for aircraft/vehicles being monitored by the MXS as specified in the Target Request Message (type 0x0B).
- Provides aircraft airspeed and heading information for the ADS-B participant.

An overview of the ADS-B Air Referenced Velocity Report Message is shown in Table 0-53~~Table 6-57~~.

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Table 0-54

~~Table 6-58~~ provides the detailed message definition.

Table 0-53~~57~~ ADS-B Air Referenced Velocity Report Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Report Type and Structure ID**	2
02	**Validity Flags**	1
03	**Participant Address**	3
06	**Address Qualifier**	1
07	**Time of Applicability**	2
09	**Airspeed**	2
11	**Airspeed Type**	1
12	**Heading**	2

Table 0-~~5458~~ ADS-B Air Referenced Velocity Report Message Payload Structure Detail

Report Type and Structure ID					
Byte Offset	**Byte Name**	**Field Description**			
00	RS0	**RS0 (MSN)**	**RS0 (LSN)**	**RS1**	**Report Type and Structure ID**
01	RS1	0x4	0x0	0x07	Air Referenced Velocity Report; All data fields are supported

Report Type and Structure ID

The Most Significant Nibble (MSN) of the byte RS0 contains the Report Type. For the Air Referenced Velocity Report, this field will always contain a value of 0x4. This identifies the report as an Air Referenced Velocity Report.

The remaining data constitutes the Structure ID, which indicates the fields that are being reported in the current message. If the bit for the field is set to "ONE", then the data field is available and included in the current report. If the bit is set to "ZERO", this indicates that the field is not reported for the current message and the Mode Status message will not include that field. The Mode Status Message will concatenate the next field to be included into the report, following the previous reported field. This is performed for each data field that is reported.

The below table from D0-260B outlines the Structure ID layout:

Byte Name	**Bit #**	**Air Referenced Velocity Data Parameter to be Reported**
RS0 (LSN)	0-3	Reserved
RS1	3-7	Reserved
	2	Airspeed
	1	Airspeed Type and Validity
	0	Heading While Airborne

Validity Flags				
Byte Offset	**Byte Name**	**Field Description**		
02	VF0	**Byte**	**Bit**	**Data Field(s)**
		VF0	2-7	Reserved
			1	Airspeed
			0	Heading

Validity Flags: These flags indicate whether or not the data contained in the specified field is valid or not. If the bit is set to "ONE" then the data field contains valid information. If the bit is set to "ZERO" then the data field contains invalid information.

Participant Address					
Byte Offset	**Byte Name**	**Field Description**			
03	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
04	PA1	0x1C	0xA6	0xB2	1CA6B2
05	PA2	0x2A	0x35	0x6A	2A356A
		Participant Address Bytes Contains the address of the transmitting installation. These fields contain up to 6 hex characters. This can be the ICAO address or some other type of address.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
06	AQ0	**AQ0**	**Address Qualifier Description**
		Address Qualifier Byte Indicates the type of participant address being reported and what the emitter category is set to for the given participant. See State Vector Report (section 0) for examples.	

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
07	RA0	**RA1**	**RA0**	**Report Times of Applicability**
08	RA1	0x00	0x80	Time of Applicability: 1.0 seconds
		0x28	0x60	Time of Applicability: 80.75 seconds
		Report Times of Applicability The two bytes of this message (RA0 and RA1) contain the Report Times of Applicability. The data is formatted such that subfield is in seconds with a resolution of 1/128 seconds. For example, a value of 0x0058 would have a value of 0.6875 seconds.		

Airspeed

Byte Offset	Byte Name	Field Description		
09	AS0	**AS0**	**AS1**	**Airspeed**
10	AS1	0x00	0x00	0 knots
		0x00	0xCE	206 knots
		0x01	0x0D	269 knots
		Airspeed. Airspeed is sent in units of knots with a resolution of 1 knot.		

Airspeed Type

Byte Offset	Byte Name	Field Description	
11	AT0	**AT0**	**Airspeed Type**
		0x00	Invalid
		0x01	True
		0x02	Indicated
		0x3-0xFF	Reserved
		Airspeed Type Indicates the type of airspeed.	

Heading

Byte Offset	Byte Name	Field Description		
12	HD0	**HD0**	**HD1**	**Heading**
13	HD1	0x00	0x01	0.3515625 degree
		0x01	0x02	90.703125 degrees
		0x02	0x00	180.00000 degrees
		0x03	0xFF	359.6484375 degrees
		Heading Heading is sent in the following format: *dd dddd dddd* with the most significant 6 bits unused. Heading is sent as a 10 bit fraction of 360 degrees. The MSB is 180 degrees. The LSB is 0.3515625 degrees ((1 / 1024) * 360).		

10. TIS-B Report Message Overview

Like ADS-B In Reports, TIS-B In Reports are sent when position data becomes available for a TIS-B participant and thereafter as participant data changes. If the position data for a TIS-B participant has not been updated in 120 seconds, TIS-B In Reports are no longer sent for that participant.

Two types of targets are defined for TIS-B: Fine Targets and Coarse Targets.

The data available for Fine targets is similar to the data for ADS-B targets and is reported in TIS-B State Vector, Mode Status and Air Referenced Velocity (ARV) Reports. These messages are based on their ADS-B equivalents but with a few modifications to support TIS-B-specific data.

The data for coarse targets is combined into a single Coarse Position Report, containing all the data available for the Coarse TIS-B participant.

Table 0-55~~Table 6-59~~ lists TIS-B Reports and associated Message Types, lengths and document sections.

Table 0-55~~59~~ TIS-B Report Messages

Message Name	Message Type	Payload Length (Bytes)	Document Section
TIS-B State Vector Report	0x93	24-48	6~~6.4.11.1~~
TIS-B Mode Status Report	0x94	16-36	7~~6.4.11.2~~
TIS-B Coarse Position Report	0x95	18	9~~6.4.11.4~~
TIS-B/ADS-R Management Report	0x96	11	10~~6.4.11.5~~
TIS-B Air Referenced Velocity Report	0x98	14	8~~6.4.11.3~~

6. TIS-B State Vector Report Message: Type 0x93

The TIS-B State Vector Report Message is sent for TIS-B participants transmitting fine format TIS-B messages. The TIS-B State Vector Report is identical to the ADS-B State Vector Report with the following exceptions:

- The content of the Address Qualifier field is modified
- A single Vertical Rate valid bit is defined (instead of Baro and Geometric)
- The NIC field contains only the Position Message Type Code and Supplement A (No Supplement B or C)
- Bit b2 of the Surveillance Status field changes from “Intent Change” to “Reserved”
- The Processing States are renamed “Incomplete” and “Complete”

7. TIS-B Mode Status Report Message: Type 0x94

The TIS-B Mode Status Report Message is sent for TIS-B participants transmitting fine format TIS-B messages.

For commonality with the ADS-B Mode Status Report structure, the same Report Type and Structure Identification field is included in the TIS-B Mode Status Report. In the TIS-B Mode Status Report, this field is always set to 0x0BCE40, indicative of the payload structure defined in Table 0-56~~Table 6-60~~. Table 6-74 provides the detailed message definition.

Table 0-56~~60~~ TIS-B Mode Status Report Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Report Type and Structure ID**	3
03	**Validity Flags**	1
04	**Participant Address**	3
07	**Address Qualifier**	1
08	**Time of Applicability**	2
10	**Call Sign**	8
18	**Emitter Category**	1
19	**Message Reserved1**	1
20	**Message Reserved2**	1
21	**SV Quality - NACp**	1
22	**SV Quality - NACv**	1
23	**SV Quality – SIL**	1
24	**Message Reserved3**	1
25	**Message Reserved4**	1
26	**Track/Heading and Horizontal Reference Direction**	1

Table 0-5761 TIS-B Mode Status Report Message Payload Structure Detail

Report Type and Structure ID						
Byte Offset	**Byte Name**	**Field Description**				
00	RS0	**RS0 (MSN)**	**RS0 (LSN)**	**RS1**	**RS2**	**Report Type and Structure ID** For commonality with the ADS-B Mode Status Report structure, the Report Type and Structure Identification field is included in the TIS-B Mode Status Report. In the TIS-B Mode Status Report, this field is always set to 0x0BCE40.
01	RS1	0x0	0xB	0xCE	0x40	
02	RS2					

Report Type

The Most Significant Nibble (MSN) of the byte RS0 contains the Report Type.

Structure ID

The remaining data constitutes the Structure ID, which indicates the fields that are being reported in the current message. If the bit for the field is set to "ONE", then the data field is available and included in the current report. If the bit is set to "ZERO", this indicates that the field is not reported for the current message and the Mode Status message will not include that field. The Mode Status Message will concatenate the next field to be included into the report, following the previous reported field. This is performed for each data field that is reported.

The table below outlines the Structure ID layout:

Byte Name	**Bit**	**Mode Status Data Parameter to be Reported**	**Number of Bytes**
RSO (LSN)	3	Time of Applicability	2
	2	ADS-B Version	1
	1	Call Sign	8
	0	Emitter Category	1
RS1	7	Message Reserved1	1
	6	Message Reserved2	1
	5	Capability Codes	2
	4	Operational Mode	2
	3	SV Quality – NACp	1
	2	SV Quality – NACv	1
	1	SV Quality – SIL	1
	0	Message Reserved 3	1

Report Type and Structure ID				
	RS2	7	Message Reserved4	1
		6	True/Magnetic Heading (HRD)	1
		5	Vertical Rate Type	1
		4	(Reserved for) Flight Mode Specific Data	1
		3	Reserved	1
		0-2		

Validity Flags				
Byte Offset	**Byte Name**	**Field Description**		
03	VF0	**Byte**	**Bit**	**Data Field(s)**
		VF0	**6-7**	Reserved
			5	SV Quality - NACp
			4	SV Quality - NACv
			3	SV Quality - SIL
			2	Message Reserved2
			0-1	Reserved
		Validity Flags These flags indicate whether or not the data contained in the specified field is valid or not. If the bit is set to “ONE” then the data field contains valid information. If the bit is set to “ZERO” then the data field contains invalid information.		

Participant Address					
Byte Offset	**Byte Name**	**Field Description**			
04	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
05	PA1	0x1C	0xA6	0xB2	1CA6B2
		0x2A	0x35	0x6A	2A356A
06	PA2	Participant Address Bytes Contains the address of the transmitting installation. These fields contain up to six (6) hex characters. This can be the ICAO address or some other type of address.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
07	AQ0	**AQ0**	**Address Qualifier Description**
		0x00-0x01	Reserved
		0x02	ICAO Address; Aircraft
		0x03	Non-ICAO Address; Aircraft

Address Qualifier		
	0x04-0xFF	Reserved

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
08	RA0	**RA0**	**RA1**	**Reported Times of Applicability**
09	RA1	0x00	0x80	Time of Applicability: 1.0 seconds
		0x28	0x60	Time of Applicability: 80.75 seconds
		Report Times of Applicability The two bytes of this message (RA0 and RA1) contain the Report Times of Applicability. The data is formatted such that subfield is in seconds with a resolution of 1/128 seconds. For example, a value of 0x0058 would have a value of 0.6875 seconds.		

Call Sign										
Byte Offset	**Byte Name**	**Field Description**								
10	CS0	**CS0**	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**Call Sign**
11	CS1	0x4E	0x32	0x35	0x36	0x37	0x47	0x41	0x20	N2567GA
12	CS2	Call Sign The Call Sign field indicates the aircraft identification used by the TIS-B participant. Data is sent as unsigned char ASCII characters. Valid ASCII characters are outlined below: **Valid ASCII Hex Values** 0x20 (Space) 0x30-0x39 (0-9) 0x41-0x5A (A-Z) The most significant bit is sent first. The Call Sign is padded with space characters on the right. (For reference, see RTCA DO-181d section 2.2.19.1.13).								
13	CS3									
14	CS4									
15	CS5									
16	CS6									
17	CS7									

Emitter Category		
Byte Offset	**Byte Name**	**Field Description**

Emitter Category			
18	EC0	EC0	Emitter Category
		0x00	No Emitter Category Information Available
		0x01	Light (<15500 lbs.)
		0x02	Reserved
		0x03	Small (15500 to 75000 lbs.)
		0x04	Reserved
		0x05	Large (75000 to 300000 lbs.)
		0x06	High-Vortex Large (aircraft such as B-757)
		0x07	Heavy (>300000 lbs)
		0x08	High Performance (>5 g acceleration and >400 knots)
		0x09	Reserved
		0x0A	Rotorcraft
		0x0B	Glider/Sailplane
		0x0C	Lighter-than-Air
		0x0D	Unmanned Aerial Vehicle
		0x0E	Space/Trans-atmospheric Vehicle
		0x0F	Ultralight / hang-glider / paraglider
		0x10	Parachutist / Skydiver
		0x11-0x13	Reserved
		0x14	Surface Vehicle – Emergency Vehicle
		0x15	Surface Vehicle – Service Vehicle
		0x16	Point Obstacle (includes Tethered Balloons)
		0x17	Cluster Obstacle
		0x18	Line Obstacle
		0x19-0xFF	Reserved
	Emitter Category Indicates the type of vehicle or aircraft TIS-B participant.		

Message Reserved1

Message Reserved1		
Byte Offset	**Byte Name**	**Field Description**
19	R10	Message Reserved1 This field contains the “Reserved” bits, “ME” bits 53-56 from the Velocity Message subtypes 1 and 2 for GEO=0.

Message Reserved2		
Byte Offset	**Byte Name**	**Field Description**
20	R20	Message Reserved2 This field contains the “Reserved” bit, “ME” bit 48 from the Velocity Message subtypes 1 and 2 for GEO=1.

SV Quality - NACp			
Byte Offset	**Byte Name**	**Field Description**	
21	NP0	**NP0**	**95% Horizontal Accuracy Bounds (EPU)**
		0x00	EPU ≥ 18.52 km (10 NM)
		0x01	EPU < 18.52 km (10 NM)
		0x02	EPU < 7.408 km (4 NM)
		0x03	EPU < 3.704 km (2 NM)
		0x04	EPU < 1852 m (1 NM)
		0x05	EPU < 926 m (0.5 NM)
		0x06	EPU < 555.6 m (0.3 NM)
		0x07	EPU < 185.2 m (0.1 NM)
		0x08	EPU < 92.6 m (0.05 NM)
		0x09	EPU < 30 m
		0x0A	EPU < 10 m
		0x0B	EPU < 3 m
		0x0C-0xFF	Reserved

SV Quality - NACp	
	SV Quality - NACp The NACp field reports the level of accuracy of the geometric position being reported. EPU is defined as the radius of a circle that is centered on the TIS-B participant and indicates the probability of being inside the circle is 95%.

SV Quality - NACv			
Byte Offset	**Byte Name**	**Field Description**	
22	NV0	**NV0**	**Horizontal Velocity Error**
		0x00	Unknown or ≥10 m/s
		0x01	< 10 m/s
		0x02	< 3 m/s
		0x03	< 1 m/s
		0x04	< 0.3 m/s
		0x05-0xFF	Reserved
		SV Quality - NACv The NACv field reports the horizontal velocity error with 95% certainty.	

SV Quality – SIL				
Byte Offset	**Byte Name**	**Field Description**		
23	SL0	**SV Quality - SIL**		
		The Source Integrity Level provides the probability of the TIS-B participant exceeding the radius of containment specified by the NIC field.		
		Bit 1	**Bit 0**	**Probability of Exceeding the NIC Containment Radius (Rc)**
		0	0	Unknown or > $1x10^{-3}$ per flight hour or per sample
		0	1	≤ $1x10^{-3}$ per flight hour or per sample
		1	0	≤ $1x10^{-5}$ per flight hour or per sample
		1	1	≤ $1x10^{-7}$ per flight hour or per sample

Message Reserved3

Message Reserved3		
Byte Offset	**Byte Name**	**Field Description**
24	R30	Message Reserved3 Reserved Velocity (subtype 3,4 and GEO=0) ME 53-56

Message Reserved4		
Byte Offset	**Byte Name**	**Field Description**
25	R40	Message Reserved4 Reserved Velocity (subtype 3,4 and GEO=1) ME 48

Track/Heading and Horizontal Reference Direction (HRD)			
Byte Offset	**Byte Name**	**Field Description**	
26	TH0	**TH0**	**Track/Heading and Horizontal Reference Direction (HRD)**
		0x00	Ground track relative to true north being reported
		0x01	Ground track relative to magnetic north reported
		0x02	Heading relative to true north being reported
		0x03	Heading relative to magnetic north being reported
		0x04-0xFF	Reserved

8. TIS-B Air Referenced Velocity Report Message: Type 0x98

The TIS-B Air Referenced Velocity Report Message is sent for TIS-B participants transmitting fine format TIS-B messages. It uses the same Message Type as the ADS-B Air Referenced Velocity Report (0x98) and is identical to that report with the following exception:

- For ADS-B targets: Airspeed is zeroed in the report if either Airspeed or NAC_V are all zeros.
- For TIS-B targets: Airspeed is zeroed in the report if airspeed is all zeros, or the GEO flag is equal to 0 and NAC_V is all zeros.

9. TIS-B Coarse Report Message: Type 0x95

The TIS-B Coarse Report Message is sent for TIS-B participants transmitting the TIS-B Coarse Position and Velocity Message. This message:

- Is sent for every aircraft/vehicle that is transmitting TIS-B Coarse Position and Velocity messages, within range.
- Provides coarse position, coarse velocity and other information about a TIS-B participant.

An overview of the TIS-B Coarse Report Message is shown in Table 0-58~~Table 6-62~~. Table 0-59~~Table 6-63~~ provides the detailed message definition. An example of the TIS-B Coarse Report Message is found in Table 0-60~~Table 6-64~~**.**

Table 0-58~~62~~ TIS-B Coarse Report Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Participant Address**	3
03	**Address Qualifier**	1
04	**Surveillance Status**	1
05	**Service Volume ID**	1
06	**Pressure Altitude**	2
08	**Ground Track Status & Angle**	1
09	**Ground Speed**	1
10	**Report Times of Applicability**	2
12	**Latitude**	3
15	**Longitude**	3

Table 0-5963 TIS-B Coarse Report Message Payload Structure Detail

Participant Address					
Byte Offset	**Byte Name**	**Field Description**			
00	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
01	PA1	0x1C	0xA6	0xB2	1CA6B2
02	PA2	0x2A	0x35	0x6A	2A356A
		Participant Address Bytes Contains the address of the transmitting installation. These fields contain up to six (6) hex characters. This can be the ICAO address or some other type of address.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
03	AQ0	**AQ0 (MSN)**	**Address Qualifier**
		0x00-0x01	Reserved
		0x02	ICAO Address, Aircraft
		0x03	Non-ICAO Address, Aircraft
		0x04-0xFF	Reserved
		Address Qualifier This field reports the TIS-B participant's address type.	

Surveillance Status			
Byte Offset	**Byte Name**	**Field Description**	
04	SS0	**SS0 (MSN)**	**Surveillance Status**
		0x00	No Condition Information Available
		0x01	Permanent Alert Condition (Emergency)
		0x02	Temporary Alert Condition (Change in Mode Identity Code other than emergency condition) Special Position Identification (SPI) Condition
		0x03	Reserved
		0x04-0xFF	
		Surveillance Status This field reports the surveillance status of the TIS-B participant.	

Service Volume ID		
Byte Offset	**Byte Name**	**Field Description**
05	SV0	Service Volume ID Contains a number that identifies the TIS-B site that delivered the surveillance data.

Pressure Altitude				
Byte Offset	**Byte Name**	**Field Description**		
06	PA0	**PA0**	**PA1**	**Pressure Altitude**
07	PA1	0x01	0x40	8000 Feet
		0x02	0xEC	18,525 Feet
		0xFF	0xF7	-225 Feet
		0x80	0x00	Data is invalid
		Pressure Altitude The data is sent in the following format: *Sddddddd ddddddd* The S bit indicates whether the data is positive or negative. If the S bit is set to “ONE” then the data is negative, if set to “ZERO” then the data is positive. The Pressure altitude is sent in feet with a resolution of 25 feet. A value of 0x8000 (-32768 decimal) indicates Pressure Altitude is invalid. Note: Pressure Altitude is in 2's complement format. Note: Pressure Altitude is relative to a standard pressure of 1013.25 millibars (29.92 in Hg).		

Ground Track and Angle			
Byte Offset	**Byte Name**	**Field Description**	
08	GT0	**GT0**	**Ground Track Status & Angle**
		0x21	11.25 Degrees, data valid
		0x3C	315.0 Degrees, data valid
		0x3F	348.75 Degrees, data valid
		0x00	0 degrees, data invalid
		Ground Track Status & Angle This byte consists of the following information:	
		Bit	**Definition**
		0-4	Ground Track Angle
		5	Ground Track Status
		6-7	Reserved
		Ground Track Angle is encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/32 degrees, with ZERO (0) indicating true north. Ground Track Status specifies the validity of the Ground Track Angle and Ground Speed values. Coding for this field is as follows: 0=not valid and 1= valid.	

Ground Speed			
Byte Offset	**Byte Name**	**Field Description**	
09	GS0	**GS0**	**Ground Speed**
		0x00	No Ground Speed information available
		0x01	Ground Speed < 16 knots
		0x02	16 knots ≤ GS < 48 knots
		0x03	48 knots ≤ GS < 80 knots
		***	***
		0x3E	1936 knots ≤ GS < 1968 knots
		0x3F	GS ≥ 1968 knots
		Ground Speed This byte encodes ground speed as specified above.	

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
10	RA0	**RA1**	**RA0**	**Report Times of Applicability**
11	RA1	0x00	0x80	Time of Applicability: 1.0 seconds
		0x28	0x60	Time of Applicability: 80.75 seconds
		Report Times of Applicability The two bytes of this message (RA0 and RA1) contain the Report Times of Applicability. The data is formatted such that subfield is in seconds with a resolution of 1/128 seconds. For example, a value of 0x0058 would have a value of 0.6875 seconds.		

Latitude					
Byte Offset	**Byte Name**	**Field Description**			
12	EL0	**EL0**	**EL1**	**EL2**	**Latitude**
13	EL1	0x28	0x00	0x80	56.252747 Degrees
14	EL2	0x19	0x28	0x60	35.378036 Degrees
		0xCB	0x54	0xE9	-74.064825 Degrees
		Latitude The data is sent as a 24-bit 2's complement number: *SMdddddd ddddddd ddddddL* The S bit indicates whether the data is positive (North) or negative (South). If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The resolution of the M bit is 90 degrees. The resolution of the L bit is $180/2^{23}$ (~0.0000215) degrees.			

Longitude					
Byte Offset	**Byte Name**	**Field Description**			
15	EG0	**EG0**	**EG1**	**EG2**	**Longitude**
16	EG1	0xA0	0x00	0x80	-134.997253 Degrees
17	EG2	0x80	0x28	0x60	-179.778214 Degrees
		0x04	0x25	0x09	5.828440 Degrees
		Longitude The data is sent as a 24-bit 2's complement number: *SMdddddd ddddddd ddddddL* The S bit indicates whether the data is positive (East) or negative (West). If the S bit is set to "ONE" then the data is negative, if set to "ZERO" then the data is positive. The resolution of the M bit is 90 degrees. The resolution of the L bit is $180/2^{23}$ (~0.0000215) degrees.			

Table 0-~~60~~64 TIS-B Coarse Report Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x95 TIS-B Coarse Report Message	[95]

	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[00]
	Payload Length	18	[12]
PAYLOAD	**Participant Address**	ICAO Address: 3C29EF	[3C 29 EF]
	Address Qualifier	Address Qualifier: 2	[02]
	Surveillance Status	Surveillance Status: SPI condition	[03]
	Service Volume ID	Service Volume ID: 7	[07]
	Pressure Altitude	Pressure Altitude: 4575 feet	[00 B7]
	Ground Track Status & Angle	Ground Track Angle: 292.5 degrees	[3A]
	Ground Speed	Ground Speed: 80 ≤ GS < 112 knots	[04]
	Report Times of Applicability	Report Times of Applicability: 15.625 milliseconds	[00 02]
	Latitude	Latitude: 45.727308 Degrees	[20 84 67]
	Longitude	Longitude: -121.484177 Degrees	[A9 9C 7B]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[73]

10. TIS-B ADS-R Management Report Message: Type 0x96

The TIS-B/ADS-R Management Report Message is sent for TIS-B or ADS-R Management Messages received by the MXS. Transmission of Management Messages is enabled or disabled through a discrete flag in the Target Request Message (see Section 13.7~~6~~.3.7~~)~~).

The TIS-B and ADS-R Management Messages do not relate to an aircraft but rather relate to the coverage and availability of the TIS-B or ADS-R service that is being provided by the local ground infrastructure.

The payload data of the TIS-B/ADS-R Management Report Message is the complete 88-bit content of the DF, CF, AA and ME fields from the Extended Squitter Message.

Table 0-61~~Table 6-65~~ provides an example of a TIS-B/ADS-R Management Report Message.

Table 0-61~~65~~ TIS-B/ADS-R Management Report Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x96 TIS-B ADS-R Management Report	[96]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[0D]
	Payload Length	13	[0D]

PAYLOAD	**DF/CF**	Fields have fixed values of DF=18 and CF=4 for TIS-B or ADS-R Management Messages.	[94]
	Data	Not defined by the MOPS and are shown as all 0x00.	[00 00 00 00 00 00 00 00 00 00 00 00]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[EE]

15. Use Case Scenarios

Users interfacing with the MXS can follow these Use Cases to perform common operations.

1. Power On

Upon power-up, the power-on Built-in-Test is executed and the Status Response message is sent. The Host Computer uses the status message to assess the state of the MXS to determine the next operational state. The following steps outline a typical Power-On process and command sequence.

1. The Wake-up Built-in-Test (BIT) is executed once when the MXS is powered on and power is stable.
2. After the power-on BIT is executed, the Host should send the Data Request Message to request the Status Response Message. The Host should then review the results of the BITs provided in the Status Response Message to confirm that the MXS is Operational.
3. *If MXS is Operational, jump to the Operational Use Case (Section 3~~6.5.3~~).*
4. *If the Status Message indicates an ICAO Address failure but is otherwise functional, jump to the Installation Use Case (Section 2~~6.5.2~~).*
5. *If the Status Message indicates a failure, Host Computer should log the failure and take appropriate remedial action.*

Step	Message	Msg Direction	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
1	Construct and send a Data Request Message requesting MXS Status to determine health of MXS.					
	Data Request	Sent from Host	Start Byte	[AA]		13.6~~6.3.6~~
			Message Type	[05]		
			Message ID	[00]		
			Packet Length	[04]		
			Request Message Type	[83]	Message Type = Status Response Message. The ACK Message will be returned first followed by the Status Response Message.	
			Reserved	[00 00 00]		
			Checksum	[36]		
2	Receive and decode Acknowledge Message (ACK)					
	Acknowledge	Received by Host	Start Byte	[AA]		14.2~~6.4.2~~
			Mess Type	[80]		
			Mess ID	[00]		
			Packet Len	[05]		
			Ack'd Mess Type	[05]	Acknowledgement of Data Request Message	
			System State	[28]	MXS is in STBY mode, has detected a system failure due to lack of GPS data, ICAO address is all zeros or all ones, and Extended Squitters are not being generated. GPS Data and Extended Squitter failures are to be expected until MXS is initialized with Operating and GPS Data Messages. Likely cause of the ICAO address failure is lack of	

Step	Message	Msg Direction	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
					Installation data. Verify by running the Installation Use Case.	
			Pressure Altitude	[00 02 77]	Pressure altitude is 631 feet	
			Checksum	[D5]		
3	Receive and decode Status Response Message					
	Status Response	Received by Host	Start Byte	[AA]		14.5~~6.4.5~~
			Mess Type	[83]		
			Mess ID	[00]		
			Packet Len	[06]		
			SW Version	[02]	This message can be used to verify the correct version of software/hardware is installed.	
			HW Version	[01]		
			Built-In Test	[9F FF F0 80]	The Built-In Tests have passed except for ICAO address and GPS position. This is another indication that the Installation Data is missing.	
			Checksum	[44]		

2. Installation

Installation Use Case is executed to load and verify Installation Data. Installation Data is written into MXS's nonvolatile memory and only needs to be loaded once per installation. Installation Data can be read at any time to determine if the data has been corrupted.

The process and command sequences for the Installation Use Case is outlined in the following steps and in Table 0-62~~Table 6-66~~.

1. Construct and send a Data Request Message requesting Installation Response Message
2. Receive and decode Acknowledge Message (ACK)
3. Receive and decode Installation Response Message.
   Note: The Installation Message communication fields vary depending on whether Serial or Ethernet communications are to be used:
   6. Serial Communications:
      Enter values for one of the two COM Port fields.
   - Ethernet communications:
     Enter values in both the Ethernet IP Address field and one of the two COM Port fields. The COM port field is used to send the Installation Message via Serial communications. The Ethernet with the provided IP Address, is used thereafter.
4. If the Installation Response Message indicates a new installation, construct and send Installation Message [14]
5. Receive and decode Acknowledge Message (ACK)
6. Repeat steps 1 – 3 to verify installation data is stored properly

Table 0-62~~Table 6-66~~ is an Installation Use Case example that assumes the MXS does not contain installation data (New Installation), the power on operational mode is STBY, and the aircraft is on the ground.

Table 0-62~~66~~ Installation Use Case Example Data

Step	Message	Msg Direction	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
1	Construct and send a Data Request Message requesting Installation Response Message to determine if installation data exists and is valid. The ACK message will be returned first followed by the Installation Response Message.					
	Data Request	Sent from Host	Start Byte	[AA]		13.6~~6.3.6~~
			Mess Type	[05]		
			Mess ID	[03]		
			Packet Len	[04]		
			Request Message Type	[81]	Request for Installation Response message.	

[14] Installation Message data is stored in non-volatile memory and needs to be sent only once.

Step	Message	Msg Direction	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
			Reserved	[00 00 00]		
			Checksum	[37]		
2	Receive and decode Acknowledge Message (ACK). ACK message is returned to indicate that MXS received the Data Request Message.					
	ACK	Received by Host	Start Byte	[AA]		14.2~~6.4.2~~
			Mess Type	[80]		
			Mess ID	[03]		
			Packet Len	[05]		
			Ack'd Mess Type	[05]	Acknowledging the Data Request message	
			System State	[28]	The System State byte indicates the MXS is in STBY. It has detected a system failure due to lack of GPS data, ICAO address is all zeros or all ones, and Extended Squitters are not being generated. Mostly likely cause of the ICAO address failure is lack of Installation data.	
			Pressure Altitude	[00 02 77]	Pressure altitude is 631 feet	
			Checksum	[D8]		
3	Receive and decode Installation Response Message					
	Installation Response	Received by Host	Start Byte	[AA]		14.3~~6.4.3~~
			Mess Type	[81]		
			Mess ID	[00]		
			Packet Len	[24]		
			ICAO Address	[00 00 00]	Data fields contain the default value of zero indicating the Installation Data is not yet loaded into MXS nonvolatile memory.	
			Aircraft Registration:	[00 00 00 00 00 00 00 00]		
			Reserved	[00 00]		
			Com Port 0	[00]		
			Com Port 1	[00]		
			IP Address	[0 00 00 00]		
			Net Mask	[00 00 00 00]		
			Port Number	[00 00]		
			GPS Integrity	[00]		
			Emitter Category Set	[00]		
			Emitter Category	[00]		
			Aircraft Size	[00]		
			Max Airspeed	[00]		
			Altitude Encoder Offset	[00 00]		
			Reserved	[00 00]		

Step	Message	Msg Direction	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
			Install Configuration	[00]		
			Reserved	[00 00]		
			Checksum	[4F]		
4	If the Installation Response Message indicates a new installation, construct and send Installation Message [15]					
	Installation	Sent from Host	Start Byte	[AA]		13.26.3.2
			Mess Type	[01]		
			Mess ID	[04]		
			Packet Len	[24]		
			ICAO Address	[1C A6 B2]	1CA6B2	
			Aircraft Registration:	[31 32 33 33 30 32 31]	1233021	
			Reserved	[00 00]		
			COM Port 0	[00]	Set to default 38.4k Baud	
			COM Port 1	[00]	Set to default 38.4k Baud	
			IP Address	[0A 00 00 00]	Set IP address to 10.0.0.1	
			Net Mask	[FF FF FF 00]	Set Net Mask to 255.255.255.0	
			Port Number	[27 10]	Set Port Number to 10,000	
			GPS Integrity	[00]	GPS Integrity is unknown	
			Emitter Category Set	[00]	Emitter Set A	
			Emitter Category	[00]	Unknown	
			Aircraft Size	[01]	Length <= 15 meters, Width <= 23 meters	
			Max Airspeed	[02]	150 to 300 kt	
			Altitude Encoder Offset	[00 00]	Zero offset	
			Reserved	[00 00]		
			Install Configuration	[01]	Bottom only antenna installed; Host Altitude Resolution = 25 feet; Heading type is Magnetic; Airspeed Type indicated; Pressure Sensor Heater OFF; WOW not connected	
			Reserved	[00 00]		
			Checksum	[E9]		
5	Receive and decode Acknowledge Message (ACK)					
	ACK	Received by Host	Start Byte	[AA]		14.26.4.2
			Mess Type	[80]		
			Mess ID	[04]		
			Packet Len	[05]		
			Ack'd Mess Type	[01]	MXS received the Installation Message.	

[15] Installation Message data is stored in non-volatile memory and needs to be sent only once.

Step	Message	Msg Direction	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
			System State	[28]	Transponder on, no system fail, TSO valid, Weight on Wheels on, Standby Mode	
			Pressure Altitude	[00 02 77]	Pressure altitude is 631 feet	
			Checksum	[D5]		
6	Receive and decode Installation Response Message					
	Installation Response	Received by Host	Start Byte	[AA]		14.3~~6.4.3~~
			Mess Type	[81]	Read installation data and verify load was successful	
			Mess ID	[04]		
			Packet Len	[24]		
			ICAO Address	[1C A6 B2]		
			Aircraft Registration:	[31 32 33 33 30 32 31]	1233021	
			Reserved	[00 00]		
			COM Port 0	[00]	Set to default 38.4k Baud	
			COM Port 1	[00]	Set to default 38.4k Baud	
			IP	[0A 00 00 01]	Set IP address	
			Net Mask	[FF FF FF 00]	Set Net Mask	
			PRT	[27 10]	Set Port Number	
			GPS Integrity	[00]	GPS Integrity is unknown	
			Emitter Category Set	[00]	Emitter Set A	
			Emitter Category	[00]	Unknown	
			Aircraft Size	[01]	Length <= 15 meters, Width <= 23 meters	
			Max Airspeed	[02]	150 to 300 kt	
			Altitude Encoder Offset	[00 00]	Zero offset	
			Reserved	[00 00]		
			Install Configuration	[01]	Install Config - Bottom only antenna installed; Host Altitude Resolution = 25 feet; Heading type is Magnetic; Airspeed Type indicated; Pressure Sensor Heater is OFF; WOW not connected	
			Reserved	[00 00]		
			Checksum	[66]		

3. Operational

The Operational Use Case describes a process that will initiate MXS functionality following power on and assumes the Installation Data was previously loaded.

The process and command sequences for the Operational Use Case is outlined in the following steps.

1. Load Flight ID construct and send Flight ID Message.
2. Receive and decode Acknowledge Message (ACK)
3. Receive and decode Flight ID Response Message
4. Construct and send Operating Message (Continue to construct and send Operating Message at 1-5 Hz [16])
5. Receive and decode Acknowledge Message (ACK)
6. If specified by the installation message, construct and send GPS Navigation Data Message (Continue to construct and send GPS Data Message at 1-5 Hz [17])
7. Receive and decode Acknowledge Message (ACK)
8. Send Target Request Message
9. Receive and decode Acknowledge Message (ACK)
10. Receive and decode ADS-B In Report Messages

[16] The Host Computer should continue to update the Operating Message at the specified rate throughout the duration of the flight
[17] Typically, at the nominal update rate provided by the GPS hardware. Message updates should be continued throughout the duration of the flight

Table 0-63~~Table 6-67~~ is an Operational Use Case example that assumes the operator has a new Flight ID to load, the current operational mode is STBY, the Installation data from the previous Installation Use Case example, and the aircraft is on the ground.

Table 0-63~~67~~ Operational Use Case Example Data

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
1	Load Flight ID construct and send Flight ID Message.					
	Flight ID	Sent from host	Start Byte	[AA]		13.3~~6.3.3~~
			Mess Type	[02]		
			Mess ID	[05]		
			Packet Len	[0C]		
			Flight ID	[41 41 31 32 33 34 20 20]	Load Flight ID. Flight ID is stored in MXS volatile memory and must be loaded whenever power is removed.	
					Flight ID = AA1234	
			Reserved	[00 00 00 00]		
			Checksum	[87]		
2	Receive and decode Acknowledge Message (ACK)					
	ACK	Received by host	Start Byte	[AA]		14.2~~6.4.2~~
			Mess Type	[80]		
			Mess ID	[05]		
			Packet Len	[05]		
			Ack'd Mess Type	[02]	ACK message is returned to indicate that MXS received the Flight ID Message.	

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
			System State	[08]	The System State byte will continue to show GPS Data, and Extended Squitter errors until the Host Computer provides Operating and GPS Data Messages	
			Pressure Altitude	[00 02 77]	Pressure altitude is 631 feet	
			Checksum	[B7]		
3	Receive and decode Flight ID Response Message					
	Flight ID Response	Received by host	Start Byte	[AA]		14.4~~6.4.4~~
			Mess Type	[82]		
			Mess ID	[05]		
			Packet Len	[0C]		
			Flight ID	[4E 32 35 36 37 47 41 20]	Flight ID was stored correctly. Flight ID = N2567GA	
			Reserved	[00 00 00 00]		
			Checksum	[07]		
4	Construct and send Operating Message (Continue to construct and send Operating Message at 1-5 Hz)					
	Operating	Sent from host	Start Byte	[AA]		13.4~~6.3.4~~
			Mess Type	[03]	Establishes MXS Operating Mode. This message must be sent periodically (between 1 to 5 Hz) to maintain Operating mode	
			Mess ID	[06]		
			Packet Len	[0C]		

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
			Squawk	[02 9C]	Squawk Code = 1234	
			Mode/Config	[0B]	Turn MXS to ALT, and ADS-B Out to ON.	
			Emergency/Ident	[00]	Set Emergency = none and Ident off	
			Altitude	[80 00]	Use MXS internal pressure encoder.	
			Altitude Rate	[00 04]	Set Altitude Rate = +256 ft/min.	
			Heading	[F0 00]	Set Heading to 315°	
			Air Speed	[80 64]	Set Air Speed to 100 knots	
			Checksum	[C0]		
5	Receive and decode Acknowledge Message (ACK)					
	ACK	Received by host	Start Byte	[AA]		14.2~~6.4.2~~
			Mess Type	[80]		
			Mess ID	[06]		
			Packet Len	[05]		
			Ack'd Mess Type	[03]	ACK message is returned to indicate that MXS received the Operating Message.	
					ACK is sent prior to System State byte update to clear Extended Squitter fail flag.	
					GPS Data fail will be set until user sends GPS position data.	
			System State	[28]	Transponder on, no system fail, TSO valid, Weight on Wheels on, Standby Mode	

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
			Pressure Altitude	[00 02 77]	Pressure altitude is 631 feet	
			Checksum	[D9]		
6	If specified by the installation message, construct and send GPS Navigation Data Message (Continue to construct and send GPS Data Message at 1-5 Hz)					
	GPS Data	Sent from host	Start Byte	[AA]		13.5~~6.3.5~~
			Mess Type	[04]	Send GPS navigation data. This message must be sent periodically (between 1 to 5 Hz) to maintain valid GPS data.	
			Mess ID	[07]		
			Packet Len	[3F]		
			GPS Longitude:	[31 32 32 31 39 2E 37 35 30 30 32]	122.329167 Degrees West	
			GPS Latitude:	[34 37 33 37 2E 32 32 34 30 30]	47.620400 Degrees North	
			Speed Over Ground:	[31 32 35 2E 38 30]	125.80 knots	
			Ground Track:	[30 37 37 2E 35 32 30 30]	77.5200 Degrees	
			Hemisphere	[01]	North and West Valid	
			Time of Fix:	[31 32 33 37 32 32 2E 34 30 30]	37:22.4	
			Height	[00 00 00 00]	Not available	
			HPL	[00 00 00 00]	Valid	
			HFOM	[00 00 00 00]	Not available	
			VFOM	[00 00 00 00]	Not available	

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
			NAC_v	[00]	Unknown or >= 10 m/s	
			Checksum	[C4]		
7	Receive and decode Acknowledge Message (ACK)					
	ACK	Received by host	Start Byte	[AA]		14.2~~6.4.2~~
			Mess Type	[80]		
			Mess ID	[07]		
			Packet Len	[05]		
			Ack'd Mess Type	[04]	ACK message is returned to indicate that MXS received the GPS Data Message.	
					ACK is sent prior to System State byte update to clear GPS Data fail flag.	
			System State	[00]	Extended Squitter fail flag is cleared assuming ADS-B Out Messages are transmitting at required rates	
			Pressure Altitude	[00 02 77]		
			Checksum	[AC]		
8	Send Target Request Message					
			Start Byte	[AA]		13.7~~6.3.7~~
			Message Type	[0B]		
			Message ID	[0B]		
			Packet Len	[07]		

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
			Request Type	[00]	Turn on Auto-Output of specified reports for targets	
			Number of Participants	[00 20]	32 participants	
			Participant ID	[AC 82 EC]	ICAO Address: AC82EC	
			Requested Reports	[06]	Mode Status and Target State reports	
			Checksum	[C1]		
9	Receive and decode Acknowledge Message (ACK)					
	ACK	Received by host	Start Byte	[AA]		13.7~~6~~.3.7
			Mess Type	[80]		
			Mess ID	[0B]		
			Packet Len	[05]		
			Ack'd Mess Type	[0B]	ACK message is returned to indicate that MXS received the Target Request Message.	
			System State	[00]	Extended Squitter fail flag is cleared assuming ADS-B Out Messages are transmitting at required rates	
			Pressure Altitude	[00 02 77]		
			Checksum	[BE]		
10	Receive and decode ADS-B In Report Message. MXS will send ADS-B In reports as ADS-B messages are processed. Processing began when Operating message was received. ADS-B Reports will continue as long as this Operating Mode is maintained.					
	ADS-B	Received	Start Byte	[AA]		2~~6.4.10.2~~

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
	State Vector Report	by host	Message Type	[91]	ADS-B State Vector Report Message	
			Message ID	[0C]	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	
			Payload Length	[27]	39 (variable: missing fields ID'd in Structure ID)	
			Report Type and Structure ID	[1F 4F 98]	Missing Alt/Geom, surface ground speed and heading, Est N/S E/W velocity	
			Validity Flags	[A5 C0]	Invalid: Altitude, Geometric, Ground Surface Speed/Heading, Baro/Geom Vertical Rate	
			Participant Address	[AC 82 EC]	ICAO Address: AC82EC	
			Address Qualifier	[00]	Unknown Emitter Category	
			Report Times of Applicability	[00 58 00 70 00 80]	Reporting Barometric only altitude of 13,000 ft.	
			Latitude	[28 00 80]	Latitude: 56.252747 Degrees	
			Longitude	[A0 00 80]	Longitude: -134.997253 Degrees	
			Geometric Altitude	[20 00]	32,770 feet	
			N/S Velocity	[08 25]	North/South Velocity: 260.625 kt North	
			E/W Velocity	[FF 00]	East/West Velocity: 32 kt West	
			Ground Speed While on Surface	[03 08]	0.125 kt	
			Heading While on Surface	[86]	-171.5625 degrees	
			Barometric Altitude	[0C B2 00]		

Step	Message	Msg Direction	Field Name[18]	Data Values (Hex)	Data/Functional Description	SDIM
			Vertical Rate	[00 64]	Vertical Rate: +100 ft./min	
			NIC	[00]	NIC: Unknown	
			Estimated Latitude	[28 00 81]	Estimated Latitude: 56.252768	
			Estimated Longitude	[A0 00 80]	Estimated Longitude: -134.997253 Degrees	
			Estimated N/S Velocity	[08 25]	Estimated North/South Velocity: 260.625 kt North	
			Estimated E/W Velocity	[FF 00]	Estimated East/West Velocity: 32 kt West	
			Surveillance Status	[00]	No alert condition	
			Report Mode	[02]	Track Mode	
			Checksum	[F9]	8-bit arithmetic sum of message Start to last byte of Payload Data.	

Revision History

Rev	Summary of Changes	Effective Date	Approval
01	Initial Release	January 2017	CR00027

Referenced Documents

Document Number	Description
RTCA/DO-181E	Minimum Operational Performance Standard for Air Traffic Control Radar Beacon System / Mode Select (ATCRBS/Mode S) Airborne Equipment, March 17, 2011
SAE Aerospace Standard AS 8003	Minimum Performance Standard for Automatic Pressure Altitude Reporting Code Generating Equipment, Feb 2008
RTCA/DO-260B	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services Broadcast (TIS-B), December 2, 2009
ASTM A-A-59569A	American Society for Testing and Materials (ASTM), Standard A-A 59569A, Commercial Item Description; BRAID, WIRE (Copper, Tin-Coated, Silver-Coated, or Nickel Coated, Tubular or Flat), October 31, 2002.

Appendix A: Glossary

ACK: Each time the MXS receives a message, it responds with an acknowledgement message indicating that the information was received and set correctly. The acknowledgement message also contains MXS status information. This message is called the Acknowledge Message or ACK for short.

ADS-B: Automatic Dependent Surveillance-Broadcast (ADS-B) is an emerging system for cooperative air traffic control. The MXS broadcast GPS and other aircraft-related data to the ATC system and nearby aircraft.

ADS-B MOPS: Automatic Dependent Surveillance-Broadcast (see ADS-B) minimum operational performance standards (MOPS). The MXS is compliant with RTCA/DO-260B.

ADS-R: ADS-B Rebroadcast. The Messages of the ADS-B Rebroadcast Service are not transmitted by aircraft, but by ADS-B ground stations.

ATC: The Air Traffic Control (ATC) system uses ground-based hardware and air traffic controllers to direct aircraft traffic.

ATCRBS: Air Traffic Control Radar Beacon System.

GPRMC: Recommended minimum data. NMEA 0183 sentence that contains all basic GPS requirements for an MXS. See NMEA 0183 below.

GPS: A space-based global positioning system that provides reliable location and time information. Note that other systems that provide equivalent data may be used (GLONASS, Galileo, etc.). It is not the intent of this document to limit the user to only the GPS.

Heading: The direction an aircraft is pointing.

ICAO address: A 24-bit address used to identify aircraft. ICAO stands for International Civil Aviation Organization.

IDENT: IDENT is short for identify. When air traffic control requests that the aircraft "identify," the pilot uses the IDENT function to send a message to ATC that enhances or exaggerates the blip on the air traffic controller's radar screen. The IDENT function should only be activated at the request of ATC.

IIC: Interrogator Identifier Subfield. The 4-bit IIS within the SD field, contains the self-identification code of the interrogator.

IP Address: Internet Protocol address. A numerical label assigned to a device participating in a computer network that uses the Internet Protocol for communication.

LSB: Least significant bit.

LSN: Least significant nibble (4 bits).

MOPS: Minimum Operational Performance Specification.

MSB: Most significant bit.

MSN: Most significant nibble (4 bits).

Net Mask: A net mask is a 32-bit mask used to divide an IP address into subnets and specify the network's available hosts. In a netmask, two bits are always automatically assigned.

NMEA 0183 message (using GPRMC): The National Marine Electronics Association (NMEA) defines a messaging protocol called 0183. GPRMC is a specific message type within that protocol.

Non-volatile memory: Data stored in non-volatile memory is not lost when power to the device is removed or interrupted.

SOG: Speed over ground. The speed of a vessel relative to the surface of the earth.

Squawk code: The ATC system for a given geographic area assigns a unique four-digit number to each MXS equipped aircraft in that area. This number is called a squawk code, and it is transmitted by the MXS only when interrogated by ATC to aid in aircraft identification.

TAS: True air speed. The speed of the aircraft relative to the airmass in which it is flying.

TIS-B: Traffic Information Services – Broadcast. TIS-B complements the operation of ADS-B by providing ground-to-air broadcast of radar-derived aircraft surveillance data, including from aircraft not equipped for 1090 MHz ADS-B.

UTC: Universal Time Coordinated. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM). UTC was formerly known as Greenwich Mean Time (GMT).

