Host Interface Control Document for MXS

ICD02373

February 2022

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1.0 Introduction

This document defines the Interface protocol specification that is used to communicate with the MXS Transponder.

1.1 Sagetech Customer Support

Sagetech Avionics 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 Sagetech Avionics customer support at:

Phone Number: (928) 300-1462

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

2.0 Host Interface Communication Protocol

MXS is accessed by a straightforward messaging system communicating over a serial or Ethernet interface. The Host Interface involves constructing messages and computing a checksum to ensure data validity.

2.1 Serial Communication Protocol

The MXS provides two RS-422 or RS-232 serial ports that can be used for operational control and command. See UM06945 for pin numbers and connection information for Com0 and Com1, and for data rate and format information.

When one serial communication port is used for sending and receiving host messages, the other RS422/RS232 port is reserved for GPS-only data if the Host system includes a standalone GPS sensor.

WARNING: Using the same COM port for both GPS and either host messages or ADS-B In reports will cause unpredictable behavior.

COM Port	Data Rate	Data Format
Com0	User adjustable via Installation Message 230.4 KBPS default [1] [2]	"8-N-1", 1 start bit, 8 data bits[3], no parity, 1 stop bit
Com1	User adjustable via Installation Message 230.4 KBPS default [1] [2]	"8-N-1", 1 start bit, 8 data bits[3], no parity, 1 stop bit

2.2 Ethernet Communication Protocol

Operational control and command messages may also be sent by Ethernet User Datagram Protocol (UDP) packets. See UM06945 for pin numbers and connection information. The IP address, net mask, and port number are configured using the Installation Message (Section 3.1.2).

RTCA/DO-260B Minimum Operational Performance Standard (MOPS) requires that a Class A2 ADS-B receiver must support 400 target reports. Ethernet bandwidth is required to support this requirement.

[1] During power up, the MXS will send a one-time start-up default message that always transmits at 38.4 KPBS regardless of selected data rate.
[2] The factory default Com port baud rate is set to 230.4 KBPS. The design default is 38.4KPBS.
[3]Transmitted least significant bit first.

2.3 Serial and Ethernet Message Format

Table 2-1 defines the packet structure of the Host serial and Ethernet interface.

Table 2-1 MXS Host Communication Packet Structure

Message Field	Field Description	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, except for asynchronous Target reports which use a message ID that is generated by the MXS. 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. [4]	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

[4] GPS data provided in floating point notation (GPS Height, HPL, HFOM, VFOM) is transmitted least significant byte (LSB) first.

3.0 Host and MXS Message Interface

In this document, the messaging protocol used to communicate between the MXS, and the host (typically a Flight Computer or Autopilot) will be referred to as the Host Interface.

3.1 Messages Sent to the MXS

3.1.1 Overview

Table 3-1 provides an overview of the command messages that can be sent to the MXS.

Table 3-1 Messages Received by the MXS

Command Message Name	Message Type	Payload Length (Bytes)	MXS Response	Frequency	Doc Section
Installation	0x01	36	ACK + Message	Once at installation	3.1.2
Flight ID	0x02	12	ACK + Message	At least once every five seconds	3.1.3
Operating	0x03	12	ACK	At least once every second	3.1.4
GPS Navigation Data	0x04	63	ACK	At least once every second	3.1.5
Data Request	0x05	4	ACK + Message	As needed	3.1.6
Reserved	0x06-0x0A		Reserved		
Target Request	0x0B	7	ACK + Message(s)	As needed	3.1.7
Mode	0x0C	5	ACK + Message	As needed	3.1.8
Reserved	0x2A		Reserved		
Reserved	0x10-11		Reserved		
Reserved	0x20		Reserved		
Reserved	0x22-29		Reserved		
Reserved	0x2B-2D		Reserved		
Reserved	0xA0		Reserved		
Reserved	0xB0		Reserved		
Reserved	0xC0-0xC4		Reserved		

3.1.2 Installation Message: Type 0x01

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

Table 3-2 provides an overview of the payload structure for the Installation Message. Table 3-3 provides a detailed description of the Installation Message payload.

Table 3-4 provides an example Installation Message with the content of the message in its entirety, including pre- and post-payload bytes.

Note: The transponder must be in maintenance mode and in OFF mode for the Installation message to be received and processed. The message is ignored if not in maintenance or OFF mode.

Table 3-2 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 3-3 Installation Message Payload Structure Detail

ICAO Address

Byte Offset	Byte Name
00	ICA0
01	ICA1
02	ICA2

Field Description

ICA0	ICA1	ICA2	ICAO Address
0x1C	0xA6	0xB2	1CA6B2
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. If assigned as octal numbers, convert to hexadecimal. If the ICAO Address is set to either all ONES or all ZEROS, the transponder will not send Extended Squitters.

NOTE: If the installation message is being sent to modify the ICAO address after the original MXS installation, the operator must reboot the transponder to implement that change.

Aircraft Registration

Byte Offset	Byte Name
03	AR0
04	AR1
05	AR2
06	AR3
07	AR4
08	AR5
09	AR6

Field Description

AR0	AR1	AR2	AR3	AR4	AR5	AR6	Aircraft Registration
0x31	0x32	0x33	0x33	0x30	0x32	0x01	1233021

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 characters.

Only the following characters are valid:

- 0x20 (Space)
- 0x30-0x39 (0-9)
- 0x41-0x5A (A-Z)

The most significant byte 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).

Reserved		
Byte Offset	**Byte Name**	**Field Description**
10	RE0	**Any value in this field is ignored**
11	RE1	

COM Port 0			
Byte Offset	**Byte Name**	**Field Description**	
12	C00	**C00**	**Baud Rate Setting**
		0x00	38400 Bits per Second
		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 (Default)
		0x08	19200 Bits per Second
		0x09	460800 Bits per Second
		0x0A	921600 Bits per Second
		0x0B-0xFF	Reserved
		If a baud rate change is requested of the same port that the Installation Message was received on, the change is postponed until the 'acknowledge' has been sent. The baud rate change is immediate for the port not used to receive the Installation Message.	

COM Port 1			
Byte Offset	**Byte Name**	**Field Description**	
13	C10	**C10**	**Baud Rate Setting**
		0x00	38400 Bits per Second
		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 (Default)
		0x08	19200 Bits per Second
		0x09	460800 Bits per Second
		0x0A	921600 Bits per Second
		0x0B-0xFF	Reserved
		If a baud rate change is requested of the same port that the Installation Message was received on, the change is postponed until the 'acknowledge' has been sent. The baud rate change is 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 net mask, 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	**PRT0**	**PRT1**	**Port Number**
23	PRT1	0x27	0x10	10,000
		16-bit UDP port number used to communicate with the Transponder.		

GPS Integrity[5]			
Byte Offset	**Byte Name**	**Field Description**	
24	GI0	**GIO** *(Most significant nibble)*	**GPS Integrity – SIL (per flight hour)**
		0x0 0x1 0x2 0x3 0x4-0xF	Unknown; > $1x10^{-3}$ (Uncertified GPS) Low; ≤ $1x10^{-3}$ Medium; ≤ $1x10^{-5}$ High ≤ $1x10^{-7}$ Reserved
		GIO *(Least significant nibble)*	**System Integrity – SDA (per flight hour)**
		0x0 0x1 0x2 0x3 0x4-0xF	Unknown/No safety effect (DAL E); >$1x10^{-3}$ Minor (DAL D); ≤ $1x10^{-3}$ Major (DAL C); ≤ $1x10^{-5}$ Hazardous (DAL B); ≤ $1x10^{-7}$ Reserved
		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. **System Design Assurance (SDA)** The SDA indicates the probability of a system malfunction causing false or misleading position information or position quality metrics to be transmitted. SDA should be set by a qualified expert. *SDA is set according to the results of an aircraft system safety assessment (SSA) as defined in FAA Advisory Circular AC 20-165B. SDA must be set to 0 until a SSA is completed to determine the appropriate setting.*	

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

Emitter Category Set			
Byte Offset	**Byte Name**	**Field Description**	
25	ES0	**ES0**	**Category Set**
		0x00 0x01 0x02 0x03 0x04-0xFF	Category Set A Category Set B Category Set C Category Set D Reserved
		Emitter Category Set defines the set of vehicles that includes the host vehicle. See following Emitter Category table.	

Emitter Category			
Byte Offset	**Byte Name**	**Field Description**	
26	EC0	**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
		0x08-0xFF	Reserved
		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
		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
		EC0	**Set D (ES0=0x03) Categories**
		0x00	Unknown
		0x01-0xFF	Reserved

Aircraft Size				
Byte Offset	**Byte Name**	**Field Description**		
27	AS0	**AS0**	**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

Max Airspeed			
Byte Offset	**Byte Name**	**Field Description**	
28	MA0	**MA0**	**Maximum Airspeed**
		0x00	Unknown
		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 0x7F	0x00 0x00 0xFF	-32,768 ft 0 ft 32,767 ft
			Altitude Encoder Offset *Note: This field exists for legacy support. It must be set to zero for MXS.*		

Reserved		
Byte Offset	**Byte Name**	**Field Description**
31	RE2	Any value in this field is ignored
32	RE3	

Install Configuration			
Byte Offset	**Byte Name**	**Field Description**	
33	IC0	**IC0**	**Install Configuration Setting**
		Bits 1-0 0b00 0b01 0b10 0b11	Antenna Install (Reserved) Bottom Antenna Only *(Note: If only one antenna is used it must be the bottom antenna.)* (Reserved) Top and Bottom Antennas
		Bit 2	Reserved
		Bit 3 0b0 0b1	Host Altitude Resolution 25 feet 100 feet
		Bit 4 0b0 0b1	Heading Type (HDG) Magnetic True
		Bit 5 0b0 0b1	Airspeed Type Indicated True
		Bit 6 0b0 0b1	Pressure Sensor Heater Switch Heater Disabled Heater Enabled
		Bit 7(msb) 0b0 0b1	Weight-On-Wheels WOW Input Not Connected WOW Input Connected

Reserved		
Byte Offset	**Byte Name**	**Field Description**
34	RE4	Any value in this field is ignored
35	RE5	

Table 3-4 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	SIL = LOW, SDA = Hazardous	[13]
	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.	[F7]

3.1.3 Flight ID Message: Type 0x02

The Flight ID Message sets the optional Flight Identification number. If set, the transponder will use Fight ID instead of the aircraft registration number in applicable Squitter messages. Flight ID must be periodically sent to the transponder at a rate of at least one message every 5 seconds. If the Flight ID is not received for 10 seconds, the transponder defaults to using the aircraft registration number provided in the Installation Message.

Note: Flight ID message is not a required input and is commonly not used in UAS or general aviation operations.

An overview of the Flight ID Message is in Table 3-5, details of the message payload are found in Table 3-6, and an example message is in Table 3-7.

Table 3-5 Flight ID Message Payload Structure Overview

Payload Index	Message Field	Bytes
0	Flight ID	8
8	Reserved	4

Table 3-6 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. 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-181E 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 number is used instead. 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)								
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 3-7 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.	[46]

3.1.4 Operating Message: Type 0x03

The operating message:

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

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. Altitude data from an external source may be used. However, Sagetech recommends that configuring the MXS to use the pressure altitude source integrated with the MXS.

An overview of the Operating Message is shown in Table 3-8. Table 3-9 provides the detailed message definition. An example of the Operating Message is found in Table 3-10.

Table 3-8 Operating Message Payload Structure Overview

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

Table 3-9 Operating Message Payload Structure Detail

Squawk Code				
Byte Offset	**Byte Name**	**Field Description**		
00	SQK0	**SQK0**	**SQK1**	**Squawk Code**
01	SQK1	0x02	0x9C	1234
		Mode A “Squawk” Code – A string of 4 3-bit (octal) numbers, padded with 4 leading zeros. For example, Squawk 1234 is formatted as: 0000 001 010 011 100 (0x029C) *NOTE: All changes to Squawk Code made using the Operating Message will be saved in non-volatile memory. Default Squawk codes will be set to 1200.*		

Mode/Configuration			
Byte Offset	**Byte Name**	**Field Description**	
02	MOD0	**MOD0**	**Mode/Configuration Setting**
		Bit 1-0 0b00 0b01 0b10 0b11	Transponder Operation Mode Off On Standby ALT
		Bit 2 0b0 0b1	Power Up State If MX-12B is not in Maintenance Mode, or if Bit 2 is set to 0, then the power up state of the MX-12B is not affected. If the MX-12B is in Maintenance Mode, and Bit 2 is set to 1, then the Mode in this message is stored in non-volatile memory and used on power up.

Mode/Configuration			
		Bit 3	Extended Squitter Enable 0b0 Disable output of Extended Squitters 0b1 Enable output of Extended Squitters
		Bit 4	Reserved
		Bit 5-7	Reserved

Emergency/Ident Byte			
Byte Offset	**Byte Name**	**Field Description**	
03	EMG0	**EMG0**	**Emergency/Ident**
		Bits 2 – 0	Emergency/Priority Status 0b000 (0) No Emergency 0b001 (1) General Emergency 0b010 (2) Lifeguard/Medical Emergency 0b011 (3) Minimum Fuel 0b100 (4) No Communications 0b101 (5) Unlawful Interference 0b110 (6) Downed Aircraft 0b111 (7) Reserved
		Bit 3	Identification of Position (I/P) Feature 0b0 I/P condition is off 0b1 I/P condition is on *The I/P feature (also known as IDENT) is manually initiated by the host and remains active for 18 ±1 seconds. The I/P condition may be reinitiated at any time, which will reset the 18 second period. The I/P feature does not affect Mode C replies.*
		Bits 7(msb)-4	Reserved

Altitude			
Byte Offset	**Byte Name**	**Field Description**	
04	ALT0	**ALT0:ALT1**	**Altitude Setting**
05	ALT1	Bits 13-0 0b00:0x000 0b00:0x00C 0b00:0x4FF 0b00:0x000 0b00:0x030 0b01:0x3FC	Altitude Data -1200 ft, 100 ft scaling 0 ft., 100 ft. scaling 126,700 ft., 100 ft. scaling -1200 ft., 25 ft. scaling 0 ft., 25 ft. scaling 126,700 ft., 25 ft. scaling The aircraft barometric altitude is measured to a reference 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.
		Bit 14 0b0 0b1	Host Altitude Available Host altitude unavailable Host altitude available
		Bit 15(msb) 0b0 0b1	Internal Altitude Enable Do not use internal sensor altitude 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	**HDG0**		**HDG1**	**Heading Setting**
09	HDG1	Bits 14-12	Bits 11-8	Bits 7-0	Heading
		0b000	0x0	0x00	0° (0 * 360)
		0b000	0x0	0x10	0.17578125° (0.000488281)
		0b001	0x0	0x00	45° (0.125 * 360)
		0b010	0x0	0x00	90° (0.25 * 360)
		0b100	0x0	0x00	180° (0.50 * 360)
		0b101	0x0	0x00	225° (0.625 * 360)
		0b111	0x0	0x00	315° (0.875 * 360)
		0b111	0xF	0xF0	359.824219° (0.999511719 * 360)
		The Heading field units and resolution are specified as a fraction of a circle. Most significant bit = 0.5, the next 0.25, the next 0.125, etc. (0.5 = 180°, 0.25 = 90°, etc.)			
		Bit 15			Heading Valid
		0b0			Heading is invalid
		0b1			Heading is valid

Airspeed

Byte Offset	Byte Name	Field Description			
10	TAS0	**TAS0**		**TAS1**	**Airspeed Setting**
11	TAS1	Bits 14-12	Bits 11-8	Bits 7-0	Airspeed (Knots)
		0b000	0x0	0x00	0
		0b000	0x0	0x01	1
		0b000	0x1	0x00	256
		0b000	0x2	0x00	512
		0b000	0x3	0x00	768
		0b000	0x3	0xC6	966
		0b000	0xF	0xFF	4095
		0b001	0x0	0x00	4096
		Airspeed is an unsigned field measured in knots.			
		Bit 15 (msb)			Airspeed Valid
		0b0			Airspeed invalid
		0b1			Airspeed valid

Table 3-10 Operating Message Example Data

	Message Field	Byte Values (original)	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 = ON, Power Up State = 1, ADS-B Out is turned off. Standby = 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]

3.1.5 GPS Navigation Data Message: Type 0x04

The GPS Data Message:

- Provides the MXS with GPS data, including - latitude, longitude, height, groundspeed, track, 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.
- Includes payload data representing figures of merit that are only reported by certified GPS receivers, e.g. HFOM or NACv. If this data is not provided, the GPS Navigation Data Message can still be used by setting these values to zero.

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.

Note: If a GPS message is received by the MXS that contains improper data, e.g. altitude that is out of range, the MXS will ignore the message and not acknowledge.

An overview of the GPS Navigation Data Message is shown in Table 3-11, Table 3-12 provides the detailed message definition. An example of the GPS Navigation Data Message is found in Table 3-13.

Table 3-11 GPS Navigation Data Message Payload Structure Overview

Payload Index	Message Field	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[6]	4
50	HPL[6]	4
54	HFOM[6]	4
58	VFOM[6]	4
62	NAC_V	1

Table 3-12 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** (Degree° Minute')
01	LON1	0x31	0x32	0x32	0x31	0x39	0x2E	0x37	0x35	0x30	0x30	0x32	122°19.75002’
02	LON2	0x30	0x35	0x38	0x33	0x33	0x2E	0x39	0x31	0x34	0x38	0x32	58° 33.91482’
03	LON3	0x31	0x32	0x32	0x32	0x30	0x2E	0x39	0x34	0x36	0x30	0x30	122° 20.946’
04	LON4												
05	LON5	GPS Longitude											
06	LON6	Current GPS longitude is sent as ASCII characters, formatted as degrees, minutes, and fractions of minutes: *dddmm.mmmmm*											
07	LON7												
08	LON8												
09	LON9	*Note: The Hemisphere Byte contains a bit to declare if the longitude is E or W.*											
10	LON10												

[6] Field is transmitted in Little Endian format as the hexadecimal equivalent of a Single Precision Floating Point number.

GPS Latitude

Byte Offset	Byte Name
11	LAT0
12	LAT1
13	LAT2
14	LAT3
15	LAT4
16	LAT5
17	LAT6
18	LAT7
19	LAT8
20	LAT9

Field Description

LAT0	LAT1	LAT2	LAT3	LAT4	LAT5	LAT6	LAT7	LAT8	LAT9	GPS Latitude (Degree° Minute')
0x34	0x37	0x33	0x37	0x2E	0x32	0x32	0x34	0x30	0x30	47° 37.224’
0x34	0x39	0x31	0x37	0x2E	0x31	0x31	0x32	0x36	0x36	49° 17.11266’
0x32	0x37	0x35	0x39	0x2E	0x32	0x38	0x33	0x33	0x36	27° 59.28336’

GPS Latitude

Current GPS latitude is sent as ASCII characters, formatted as degrees, minutes, and fractions of minutes:
ddmm.mmmmm

Note: The Hemisphere Byte contains a bit to declare if the Latitude is N or S.

Speed Over Ground

Byte Offset	Byte Name
21	SOG0
22	SOG1
23	SOG2
24	SOG3
25	SOG4
26	SOG5

Field Description

SOG0	SOG1	SOG2	SOG3	SOG4	SOG5	Speed Over Ground
0x31	0x31	0x32	0x36	0x2E	0x30	1126.0
0x31	0x32	0x35	0x2E	0x38	0x30	125.80
0x30	0x36	0x35	0x2E	0x35	0x30	65.50
0x30	0x34	0x38	0x2E	0x33	0x32	48.32

Speed Over Ground

Current GPS speed over ground in knots. The data is sent as ASCII characters.
Note that two formats are available:

- Speeds of 1000 kn or higher follow the format: dddd.d
- Speeds lower than 1000 kn Follow the format: ddd.dd

Both formats are shown in the examples above. Notice the shift of the decimal point [2E].

Ground Track

Byte Offset	Byte Name
27	CRS0
28	CRS1
29	CRS2
30	CRS3
31	CRS4
32	CRS5
33	CRS6
34	CRS7

Field Description

CRS0	CRS1	CRS2	CRS3	CRS4	CRS5	CRS6	CRS7	Ground Track
0x30	0x37	0x37	0x2E	0x35	0x32	0x30	0x30	77.5200
0x31	0x38	0x35	0x2E	0x32	0x30	0x30	0x30	185.2000
0x32	0x37	0x35	0x2E	0x34	0x30	0x30	0x30	275.4000

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)

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
		Bit 0	N / S Hemisphere Indicator
		0b0	Latitude is South
		0b1	Latitude is North
		Bit 1	E / W Hemisphere Indicator
		0b0	Longitude is West
		0b1	Longitude is East
		Bit 5 - 2	Reserved
		Bit 6	SVERROR State
		0b0	Fault Detection and Exclusion (FDE) function has not detected any satellite failures or has detected and excluded the failed satellite from the position solution.
		0b1	FDE has detected a satellite failure that cannot be excluded within the time-to-alert
		Bit 7(msb)	Navigation Receiver Status
		0b0	GPS data is valid
		0b1	GPS data is invalid

Time of Fix (UTC)												
Byte Offset	**Byte Name**	**Field Description**										
36	TOF0	**TOF0**	**TOF1**	**TOF2**	**TOF3**	**TOF4**	**TOF5**	**TOF6**	**TOF7**	**TOF8**	**TOF9**	**Time of Fix (UTC)**
37	TOF1	0x32	0x32	0x33	0x33	0x32	0x33	0x2E	0x30	0x30	0x30	22:33:23.000
38	TOF2	0x31	0x35	0x32	0x34	0x33	0x33	0x2E	0x31	0x31	0x30	15:24:33.110
39	TOF3	0x30	0x38	0x35	0x36	0x30	0x31	0x2E	0x30	0x31	0x30	08:56:01.010
40	TOF4	0x20	0x20	0x20	0x20	0x20	0x20	0x2E	0x20	0x20	0x20	Not Available
41	TOF5	Time of Fix 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. hhmmss.sss If Time of Fix is not available, this field may be populated with Space characters (0x20) and the decimal character in the correct place. Note that if the decimal character is missing or placed incorrectly then the MXS will consider the entire message invalid.										
42	TOF6											
43	TOF7											
44	TOF8											
45	TOF9											

GPS Height (WGS-84)[6]						
Byte Offset	**Byte Name**	**Field Description**				
46	HT0	**HT0**	**HT1**	**HT2**	**HT3**	**GPS Height (WGS-84)**
47	HT1	0x00	0x00	0x48	0xC3	-200 meters
48	HT2	0x00	0x00	0x70	0x41	15 meters
49	HT3	0x00	0x28	0xD2	0x45	6725 meters
		GPS Height (WGS-84) All zeros – Altitude not available Else Floating point height (meters) above WGS-84 ellipsoid.				

Horizontal Protection Limit (HPL)[6]						
Byte Offset	**Byte Name**	**Field Description**				
50	HP0	**HP0**	**HP1**	**HP2**	**HP3**	**Horizontal Protection Limit**
51	HP1	0x00	0x00	0xA0	0x40	5 meters
52	HP2	0x00	0x00	0x70	0x42	60 meters
53	HP3	0x00	0x00	0x3E	0x43	190 meters
		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.				

Horizontal Figure of Merit (HFOM)[6]						
Byte Offset	**Byte Name**	**Field Description**				
54	HM0	**HM0**	**HM1**	**HM2**	**HM3**	**HFOM**
55	HM1	0x00	0x00	0x40	0x41	12 meters
56	HM2	0x00	0x00	0x30	0x43	176 meters
57	HM3	0x00	0x90	0xE7	0x45	7410 meters
		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%.				

Vertical Figure of Merit (VFOM)[6]						
Byte Offset	**Byte Name**	**Field Description**				
58	VM0	**VM0**	**VM1**	**VM2**	**VM3**	**VFOM**
59	VM1	0x00	0x00	0xA0	0x41	20 meters
60	VM2	0x00	0x00	0x96	0x42	75 meters
61	VM3	0x00	0x00	0x48	0x43	200 meters
		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%.				

Navigation Accuracy for Velocity (NAC_v)			
Byte Offset	**Byte Name**	**Field Description**	
62	NAV0	**NAV0**	**Navigation Accuracy for Velocity**
		Bits 7-4(MSN) 0x0 0x1 0x2 0x3 0x4 0x5-0xF	NAC_V (Most Significant Nibble) Unknown or ≥ 10 m/s < 10 m/s < 3 m/s < 1 m/s < 0.3 m/s Reserved The field is used to declare the accuracy of own-vehicle velocity. The value is based on GPS figure of merit for horizontal velocity *Note: If the NACv received is a reserved value, the data is considered improper and the message ignored and not acknowledged.*
		Bits 3-0(LSN)	Reserved

Table 3-13 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
PAYLOAD	Longitude	12129.1248 Degrees	[31 32 31 32 39 2E 31 32 34 38 30]
	Latitude	4543.6632 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	N hemisphere, W hemisphere; No SVERROR fault, GPS data is valid	[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]

3.1.6 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 3-14. Table 3-15 provides the detailed message definition. An example of the Data Request Message is found in Table 3-16.

Table 3-14 Data Request Message Payload Structure Overview

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

Table 3-15 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	Flight ID Response Message
		0x83	Status Response Message
		0x84	Reserved
		0x85	Reserved
		0x86-0x8B	Reserved
		0x8C	Mode Settings Message
		0x8D	Health Monitor Response Message
		0x8E	Version Response Message
		0x8F	Serial Number Response Message
		0xD0	Operating Response Message
		0xD2-0xD6	Reserved
		0xD7	Civil Settings Response Message
		D8-0xDF	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 3-16 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]
PAYLOA	**Request Message Type**	Installation Response Message	[81]
	Reserved		[00 00 00]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[39]

3.1.7 Target Request Message: Type 0x0B

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

Once Auto-report has been set, the MXS will send target reports every time an ADS-B transmission is received. The MXS will send a report that includes ownship data every 5 seconds if no targets exist, ownship is selected, and the aircraft is motionless on the ground.

An overview of the Target Request Message is shown in Table 3-17. Table 3-18 provides the detailed message definition. An example of the Target Request Message is found in Table 3-19.

Table 3-17 Target Request Message Payload Structure Overview

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

Table 3-18 Target Request Message Payload Structure Detail

Request Type			
Byte Offset	**Byte Name**	**Field Description**	
00	RT0	**RT0**	**Message Settings**
		Bits 1,0 (lsb) 0b00 0b01 0b10 0b11	Request Type Turn on Auto-Output of specified reports for Number of Targets [7] Return Summary of # Targets (and turn off Auto-Output) [7] Return requested reports for Target ID (and turn off Auto-Output) Turn off all report output.
		Bits 5-2	Reserved
		Bits 7(msb),6 0b00 0b01 0b10 0b11	XMIT Port Transmit report on port where Target Request was received Transmit report on COM0 Transmit report on COM1 Transmit report on Ethernet ***WARNING**: Using the same COM port for both GPS and either host messages or ADS-B In reports will cause unpredictable behavior.*

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

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	**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	Raw TIS-B
		5	Enable/Disable Tracking of Military Aircraft
		6	Comm-A
		7(msb)	Include Own Aircraft

Table 3-19 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	7	[07]
PAY-LOAD	Request Type	Turn on Auto-Output of specified reports for targets (count is provided in "Number of Participants" field). Transmit report on port where Target Request was received	[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.	[02]

3.1.8 Mode Message: Type 0x0C

The Mode Message is sent to the transponder to command a software reboot. After the MXS sends an ack to this request it will reboot.

An overview of the Mode Message is shown in Table 3-20. Table 3-21 provides the detailed message definition and Table 3-22 provides a detailed example of message data.

Table 3-20 Mode Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Mode Settings**	2
02	**Reserved**	3

Table 3-21 Mode Message Payload Structure Detail

Mode Settings					
Byte Offset	**Byte Name**	**Field Description**			
00	MDE0	**Byte Name**	**Bits**	**Mode Field Description**	
01	MDE1	**MDE0**	**Bits 0 – 7**	**Reserved**	
02	RSV0	**MDE1**	**Bit 0 (lsb) - 4**	**Reserved**	
03	RSV1		Bit 5 0b0 0b1	**Reboot MXS**: Effectively a power-on restart Reboot not active Reboot activated	
04	RSV2		**Bits 6 – 7 (msb)**	**Reserved**	
		RSV0		**Reserved**	
		RSV1			
		RSV2			

Table 3-22 Mode Message Example Data

	Message Field	Byte Values (original)	Hex Content
	Start Byte	AA	[AA]
	Message Type	Mode Message – 0x0C	[0C]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[00]
	Payload Len	5	[05]
PAYLOAD	MDE0	0	[00]
	MDE1	0	[00]
	Reserved		[00]
	Checksum	8-bit arithmetic sum message - Start Byte to last payload byte.	[F5]

3.1.9 Civil Settings Message: Type 0xC3

The Civil Settings Message is sent to the transponder to set the priority SQUAWK code (sometimes referred to as the loss of comms SQUAWK code). The value for this SQUAWK code is returned in response to this message or obtained using the Data Request Message (0xD7) to request the Civil Settings Response Message.

To use the priority SQUAWK code pin 39 must be grounded. The priority SQUAWK code function can be used to allow users to set a preprogrammed SQUAWK code without sending an operating message or it can also be used to set a loss of communications SQUAWK code. In the event of a loss of communications the flight computer/autopilot can be programmed to ground this pin.

NOTE: Use Operating Message (Type 0x03) to actively change Mode 3/A SQUAWK code.

NOTE: This message is only acknowledged by the MXS if the unit is in OFF mode and maintenance mode is enabled.

An overview of the Civil Settings Message is shown in Table 3-23. Table 3-24 provides the detailed message definition and provides a detailed example of message data.

Table 3-23 Civil Settings Message Payload Structure Overview

Payload Index	Message Field	Number bytes
00	**Civil Settings**	13

Table 3-24 Civil Settings Message Payload Structure Detail

Civil Settings					
Byte Offset	**Byte Name**	**Field Description**			
00	**MIL0**	**Byte**	**Mode Field Description**		
01	**MIL0**	**MIL0**	Reserved		
02	**MIL0**	**MIL1**	Reserved		
03 04	**MIL3** **MIL4**	**MIL2**	Reserved		
05 06	**MIL5** **MIL6**	**MIL3-4**	Reserved		
07 08	**MIL7** **MIL8**	**MIL5-6**	Reserved		
09 10	**MIL9** **MIL10**	**MIL7-8**	**Loss of Comms Code:** Squawk Code to use during Loss of Communications		
11 12	**MIL11** **MIL12**		Example:	4444	1001 0010 0100	0x0924
			Loss of Squawk code is a string of 4 3-bit (octal) numbers, padded with 4 leading zeros.		
		MIL9-10	Reserved		
		MIL11-12	Reserved		

Table 3-25 Civil Settings Message Example Data

	Message Field	Byte Values (original)	Hex Content
	Start Byte	AA	[AA]
	Message Type	Military Settings Message – 0xC3	[C3]
	Msg ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[03]
	Payload Len	13	[0D]
PAYLOAD	MIL0	0	[00]
	MIL1	0	[00]
	MIL2	RRD	[00]
	MIL3-4	Mode 1 Code: 1234	[00 00]
	MIL5-6	Mode 2 Code: 1234	[00 00]
	MIL7-8	Loss of Comms Code: 4444	[09 24]
	MIL9-10	PIN: 16245	[00 00]
	MIL11-12	Reserved	[00 00]
	Checksum	8-bit arithmetic sum message - Start Byte to last payload byte.	[AA]

3.2 Messages Sent from the MXS

3.2.1 Overview

Table 3-26 lists the message types sent from the MXS to the Host.

Table 3-26 Messages Sent from the MXS

Message Name	Message Type	Payload Length (Bytes)	Document Section
Reserved	0x20		
Reserved	0x23-27		
Reserved	0x29		
Reserved	0x2B		
Acknowledge	0x80	6	3.2.2
Installation Response	0x81	36	3.2.3
Flight ID Response	0x82	12	3.2.4
Status Response	0x83	10	3.2.5
Reserved	0x84		
Comm-A Report	0x85	Maximum 253	3.2.6
Reserved	0x8C		
Health Monitor Response Message	0x8D	3	3.2.7
Version Response Message	0x8E	6	3.2.8
Serial Number Response Message	0x8F	96	3.2.7
Target Summary Report	0x90	Varies	3.2.10.1
ADS-B State Vector Report	0x91	24-48	3.2.10.2
ADS-B Mode Status Report	0x92	16-36	3.2.10.3
TIS-B State Vector Report	0x93	24-48	3.2.11.1
TIS-B Mode Status Report	0x94	25	3.2.11.2
TIS-B Coarse Position Report	0x95	18	3.2.11.3
TIS-B/ADS-R Management Report	0x96	12	3.2.11.4
ADS-B Target State Report	0x97	23	3.2.10.4
ADS-B Air Referenced Velocity Report	0x98	14	3.2.10.5
Reserved	0xD2-D7		

3.2.2 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[8].

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 3-27. Table 3-28 provides the detailed message definition. An example of the Acknowledge Message is found in Table 3-29.

Table 3-27 Acknowledge Message Payload Structure Overview

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

Table 3-28 Acknowledge Message Payload Structure Overview

ACK'd Message Type			
Byte Offset	**Byte Name**	**Field Description**	
00	AMT0	**AMT0**	**ACK'd Message Type**
		This field is populated with the address of the message type being ACK'ed	

[8] 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 in the ACK message.

ACK'd Message ID			
Byte Offset	**Byte Name**	**Field Description**	
01	AMTI	**AMTI**	**ACK'd Message ID**
		0x00 0x01 … 0xFF	[0000 0000] [0000 0001] … [1111 1111]
		ACK'd Message ID Contains the ID of the message being acknowledged. The exception is Target Reports that are transmitted asynchronously, which use a message ID that is generated by the MXS.	

System State Byte			
Byte Offset	**Byte Name**	**Field Description**	
02	SSB0	**SSB0**	**System State Byte indicating current Transponder State Information**
		Bit 0 0b0 0b1	Transponder Fail Flag Transponder self-test pass Transponder self-test failure The Status message can be queried to determine the cause of the error.
		Bit 1 0b0 0b1	System Fail Flag Transponder required system input is valid A required system input is not available. The Status message can be queried to determine the cause of the failure.
		Bit 2	Reserved
		Bit 3 0b0 0b1	Weight on Wheels WoW discrete is false indicating the aircraft is airborne or WoW input is not connected as indicted by the Installation Message (Byte IC0). WoW discrete input is connected and true indicating the aircraft is on the ground.
		Bit 4 0b0 0b1	Maintenance Mode OFF ON
		Bit 5 0b0 0b1	Altitude Source Transponder internal pressure sensor Host System via Operating Message
		Bits 7-6 0b00 0b01 0b10 0b11	Transponder Operational Mode Off On Standby 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 selected altitude source. The data is barometric altitude in feet with reference to a pressure of 29.9213” Hg (101325 Pascals) for zero feet indication. The most significant byte 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 3-29 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]
	ACK’d Message ID	0	[00]
	System State Byte	System Fail Flag and Weight on Wheels are set.	[0A]
	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]

3.2.3 Installation Response Message: Type 0x81

The Installation Response Message is sent when a valid Installation Message (0x01) is received, or in response 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 3-30 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**[9]	2
33	**Install Configuration**	1
34	**Reserved**[9]	2

The data elements of the Installation Response Message are defined exactly as in the Installation Message. Table 3-2 and Table 3-3 provide the definitions for these data elements. Table 3-31 shows an example of a valid and complete Installation Response Message with nearly the same data as the Installation Data Message example from Table 3-4. Only the Message Type and Checksum differ.

Table 3-31 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		
PAYLOAD	**ICAO Address**	(Hex) 1CA6B2	[1C A6 B2]
	Aircraft Registration	(ASCII) 1233021	[31 32 33 33 30 32 31]
	Reserved	0x00 00	[00 00]

[9] The values returned in the Reserved fields of this message should be ignored.

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	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]
	Platform Identification	0x00 00	[00 00]
	Checksum	8-bit arithmetic sum of message starting from Start Byte to last byte of the Payload Data	[64]

3.2.4 Flight ID Response Message: Type 0x82

The Flight ID Response Message is sent when a valid Flight ID Message (0x02) is received, or in response to a Data Request Message (0x05) that specifies a Requested Message Type of Flight ID (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 the same as that of the Flight ID Message.

Table 3-32 Flight ID Response Message Payload Structure Overview

Payload Index	Message Field	Bytes
00	Flight ID	8
08	Reserved	4

The data elements of the Flight ID Response Message, found in Table 3-32, are defined exactly as in the Flight ID Message. Table 3-6 provides the definitions for these data elements. Table 3-33 shows an example of a valid and complete Flight ID Response Message with the same data as the Flight ID Message example from Table 3-7. (Only the Message Type and Checksum differ).

Table 3-33 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 = 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.	[C6]

3.2.5 Status Response Message: Type 0x83

The Status Response Message is sent when a valid Data Request Message is received that specifies a Requested Message Type of 0x83. This message contains the software and complex electronic hardware (i.e., firmware) versions of the MXS, the cyclic redundancy check value of both the installed software and firmware, 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 can 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 used to indicate all the BIT tests results. 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 3-34. Table 3-35 provides the detailed message definition. An example of the Status Response Message is found in Table 3-36.

Table 3-34 Status Response Message Payload Structure Overview

Payload Index	Message Field	Bytes
0	SW Version	1
1	FW Version	1
2	Cyclic Redundancy Check (CRC)	4
6	Built-In-Test (BIT)	4

Table 3-35 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**
		0x01 0x02 …	FW version 1 FW version 2 …
		FW Version Contains the firmware version of the Transponder.	

Cyclic Redundancy Check						
Byte Offset	**Byte Name**	**Field Description**				
02	CRC0	**CRC0**	**CRC1**	**CRC2**	**CRC3**	**CRC**
03	CRC1	0x55	0xC9	0x1E	0x2C	0x55C91E2C
04	CRC2	0x1A	0x4F	0xB2	0xD9	0x1A4FB2D9
05	CRC3	CRC Contains the check value of the Software and Firmware executables installed on the Transponder.				

Built-In-Test				
Byte Offset	**Byte Name**	**Field Description**		
06	BIT0	**Byte**	**Bit**	**Built-In Test (BIT)[10]**
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	Reserved
		BIT1	7 (msb)	RF Loopback Test Pass
			6	53V Power Valid
			5	ADC Ready
			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 Monitor
			5	Transmitter Duty Cycle in Range
			4	System Latency In Range
			3	Transmit Power Failure
			2	Reserved
			1	Reserved
			0	Reserved
		BIT3	7 (msb)	Input Power In Range
			6	ICAO Address Valid
			5	GPS Position Valid
			4	Reserved
			3-0	Reserved

[10] A logic ONE indicates that the test passed, or the monitored condition is true. Conversely a logic ZERO indicates a failure or the monitored condition is false.

Table 3-36 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	9	[09]
	Firmware Version	9	[09]
	Cyclic Redundancy Check (CRC)	55C91E2C	[55 C9 1E 2C]
	Built-In Test (BIT)	All tests have passed	[DF FF F0 E0]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[64]

3.2.6 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 18 interrogations in a response message. Each Comm-A packet occupies 14 bytes in the message. The total payload message length will be 14 times the number of Comm-A packets included.

An overview of the Comm-A Report Message is shown in Table 3-37. Table 3-38 provides the detailed message definition.

Table 3-37 Comm-A Report Message Payload Structure Overview

Payload Index	Packet Number (*p*) Where $0 < p \leq 18$	Field Position (*f*) Where $0 \leq f < 14$	Byte Name
00	Packet 1	0	CA10
01		1	CA11
…		…	…
13		13	CA113
14	Packet 2	0	CA20
15		1	CA21
…		…	…
27		13	CA213
(p * 14) + *f*	Packet *p*	*f*	CA*pf*
…		…	…

Table 3-38 Comm-A Report Message Payload Structure Detail

Comm-A Report Packets			
Byte Offset	**Field Position**	**Byte Name**	**Field Description**
Comm-A Message Data Packet 1			The MXS can buffer up to 18 interrogations in a Comm-A Report message. Each Comm-A packet occupies 14 bytes in the message. The total payload message length will be 14 times the number of Comm-A packets included.
00	0	CA10	
01	1	CA11	
02	2	CA12	
…	…	…	
13	13	CA113	
Comm-A Message Data Packet 2			
14	0	CA20	
15	1	CA21	
…	…	…	
27	13	CA213	
… Comm-A Message Data Packet *p* where 0 > *p* ≤ 18			
(*p* * 14) + *f*	0 ≤ *f* < 14	CA*pf*	

3.2.7 Health Monitor Response Message: Type 0x8D

The Health Monitor Response Message is sent when a valid Data Request Message is received that specifies a Requested Message Type of 0x8D. The MXS will then transmit the Health Monitor Response Message which contains three different temperatures: for the System on a Chip (SOC), the RF, and the Pressure Transducer.

An overview of the Health Monitor Response Message is shown in Table 3-39. Table 3-40 provides the detailed message definition. An example of the Status Response Message is found in Table 3-41.

Table 3-39 Health Monitor Response Message Payload Structure Overview

Payload Index	Message Field	Bytes
0	SOC Temperature in Degrees C	1
1	RF Temperature in Degrees C	1
2	Pressure Transducer Temperature in Degrees C	1

Table 3-40 Health Monitor Response Message Payload Structure Detail

SOC Temperature in Degrees C			
Byte Offset	**Byte Name**	**Field Description**	
00	HM0	**SWV0**	**SW Version**
		Bits 0-7	Binary temperature measured in degrees.
		Temperature is in degrees centigrade with values between 127 degrees to negative 128 in Degrees C.	

RF Temperature in Degrees C			
Byte Offset	**Byte Name**	**Field Description**	
01	HM1	**FWV0**	**FW Version**
		Bits 0-7	Binary temperature measured in degrees.
		Temperature is in degrees centigrade with values between 127 degrees to negative 128 in Degrees C. RF temperature is only VALID during ON/STBY/ALT modes of operation.	

PT Temperature in Degrees C			
Byte Offset	**Byte Name**	**Field Description**	
01	HM2	**FWV0**	**FW Version**
		Bits 0-7	Binary temperature measured in degrees.
		Temperature is in degrees centigrade with values between 127 degrees to negative 128 in Degrees C. PT temperature is only VALID during ON/STBY/ALT modes of operation.	

Table 3-41 Health Monitor Response Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x8D Health Monitor Response Message	[8D]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[00]
	Payload Length	3	[03]
PAYL	SOC Temperature	62 Degrees C	[3E]
	RF Temperature*	53 Degrees C	[35]

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	PT Temperature*	52 Degrees C	[34]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[E1]

3.2.8 Version Response Message: Type 0x8E

The Version Response Message is sent when a valid Data Request Message is received that specifies a Requested Message Type of 0x8E. This message contains the software and complex electronic hardware (i.e., firmware) versions of the MXS and the SVN revisions of software and firmware code repositories.

An overview of the Version Response Message is shown in Table 3-42.

Table 3-43 provides the detailed message definition. An example of the Version Response Message is found in Table 3-44.

Table 3-42 Version Response Message Payload Structure Overview

Payload Index	Message Field	Bytes
00	Software Version	1
01	Firmware Version	1
02	Software SVN Revision	2
04	Firmware SVN Revision	2

Table 3-43 Version Response Message Detailed Field Description

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 MXS.	

Firmware Version			
Byte Offset	**Byte Name**	**Field Description**	
01	FWV0	**FWV0**	**FW Version**
		0x01 0x02 …	FW version 1 FW version 2 …
		FW 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 3-44 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]
PAYLOAD	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]

3.2.9 Serial Number Response: Type 0x8F

The Serial Number Response Message is sent when a valid Data Request Message is received that specifies a Requested Message Type of 0x8F. This message contains the serial numbers of the RF and Interface boards along with the Serial number of the MXS.

An overview of the Serial Number Response Message is shown in Table 3-45. Table 3-46 provides the detailed message definition. An example Serial Number Response Message is found in Table 3-47.

Table 3-45 Serial Number Response Message Payload Structure Overview

Payload Index	Message Field	Bytes
00	Interface Board Serial Number	32
32	RF Board Serial Number	32
64	Transponder Serial Number	32

Table 3-46 Serial Number Response Message Detailed Field Description

Interface Board Serial Number		
Byte Offset	**Field Name**	**Field Description**
0 - 31	INTSN	32-byte ASCII string of Interface Board Serial Number

RF Board Serial Number		
Byte Offset	**Field Name**	**Field Description**
32 - 63	RFSN	32-byte ASCII string of RF Board Serial Number

Transponder Serial Number		
Byte Offset	**Field Name**	**Field Description**
64 - 95	MXSN	32-byte ASCII string of MXS Board Serial Number

Table 3-47 Serial Number Response Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x8F Serial Number Response	[8F]
	Message ID	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	[9D]

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Payload Length	96	[60]
PAYLOAD	Interface Board Serial Number	ABCDEFGHIJKLMNOPQRSTUVWXYZ123456	[41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 50 51 52 53 54 55 56 57 58 59 5A 31 32 33 34 35 36]
	RF Board Serial Number	234567890ABCDEFGHIJKLMNOPQRSTUVW	[32 33 34 35 36 37 38 39 30 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 50 51 52 53 54 55 56 57]
	Transponder Serial Number	7890ABCDEFGHIJKLMNOPQRSTUVWXYZ01	[37 38 39 30 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F 50 51 52 53 54 55 56 57 58 59 5A 30 31]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[12]

3.2.10 ADS-B In Report Message Overview

Extended Squitter messages received by the MXS report Position, Velocity, Identification and Category, Target State and Status, and Aircraft Operational Status. To output this data, the MXS generates ADS-B, TIS-B and ADS-R reports for delivery to the host system which processes the data as required.

ADS-B In Reports are sent when target position data becomes available and thereafter as participant data changes. ADS-B In reports are stopped for a participant if the data for a given ADS-B In participant[11] has not been updated for a specified amount of time.

If enabled in the Target Request Message, the MXS sends out ADS-B In Report Messages for the host aircraft's (ownship) 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 specific target using the Target Request Message.

Table 3-48 lists ADS-B Reports and associated Message Types, lengths and document sections.

Table 3-48 ADS-B Report Messages

Message Name	Message Type	Payload Length (Bytes)	Document Section
Target Summary Report	0x90	Varies	3.2.10.1
ADS-B State Vector Report	0x91	24-48	3.2.10.2
ADS-B Mode Status Report	0x92	16-36	3.2.10.3
ADS-B Target State Report	0x97	23	3.2.10.4
ADS-B Air Referenced Velocity Report	0x98	14	3.2.10.5

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

3.2.10.1 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 3-50 is transmitted.

The report lists the nearest N targets (with N specified in the Target Request Message) in range order. Since each report can contain at most, 85 targets, multiple reports may be transmitted for a single request.

An overview of the Target Summary Report Message is shown in Table 3-49, and message payload detail is found in Table 3-50.

Table 3-49 Target Summary Report Message Payload Structure Overview

Payload Index	Target Range	Byte Name	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 3-50 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	0x01	0x02	000102
02	IDA2	0x03	0xFE	0x14	03FE14
		Nearest Target ID ICAO Address for Target closest to aircraft			

Next Nearest Target ID					
Byte Offset	**Byte Name**	**Field Description**			
03	IDB0	**IDB0**	**IDB1**	**IDB2**	**Next Nearest Target ID**
04	IDB1	0x00	0x01	0x02	000102
05	IDB2	0x03	0xFE	0x14	03FE14
		Next Nearest Target ID ICAO Address for the next closest Target			

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

3.2.10.2 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 an 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.

An overview of the ADS-B State Vector Report Message is shown in Table 3-51. The table shows all possible fields of the State Vector report. 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.

Table 3-52 provides the detailed message definition. An example of the ADS-B State Vector Report Message is found in Table 3-53.

Table 3-51 ADS-B State Vector Report Message Payload Structure Overview

Payload Index	Message Field	Bytes
00	Report Type and Structure ID	3
03	Validity Flags	2

Payload Index	Message Field	Bytes
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 [12]	2
44	Estimated E/W Velocity [12]	2
46	Surveillance Status	1
47	Report Mode	1

Table 3-52 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 & E/W Velocity, Baro Altitude, Vertical Rate, and Estimated Lat/Long and Velocity.

[12] The MXS does not report Estimated Velocity

Report Type and Structure ID

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 is performed for each data field that is reported.

The below table outlines the Structure ID layout:

Byte	Bit	State Vector Data Parameters to be Reported
RSO (LSN)	3 (msb)	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(msb)	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/Barometric
	1	Navigation Integrity Category
	0	Estimated Latitude
RS2	7(msb)	Estimated Longitude
	6	Estimated North/South Velocity
	5	Estimated East/West Velocity
	4	Surveillance Status/Discrete
	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 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**			
05	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
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 (same ICAO Address as another tracked target)
		0x81	ADS-R Target
		Address Qualifier Byte Indicates the type of participant address 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	0x00	0x58	0x00	0x70	0x00	0x80	Estimated Position and Velocity: 0.6875 seconds Position: 0.875 seconds Velocity: 1.000 seconds
11	RA2							
12	RA3	0x28	0x30	0x28	0x52	0x28	0x60	Estimated Position and Velocity: 80.375 seconds Position: 80.641 seconds Velocity: 80.750 seconds
13	RA4							
14	RA5	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 Latitude is sent as 24-bit 2's complement number representing a range of possible values from -90 Degrees to +90 Degrees. The first bit of EL0 indicates the sign (hemisphere), zero is positive (North) and one is negative by 2's complement (South). The last bit of EL2 represents a value of $\frac{180}{2^{23}}$ Examples: Decode the Latitude when, $EL0 \quad EL1 \quad EL2 = 28 \quad 00 \quad 80$ 0x280080 in hexadecimal converts to 2621568 in decimal. Latitude = 2621568 *(180/2^{23}) = 56.252747 Degrees Decode the Latitude when,			

Latitude	
	$EL0 \quad EL1 \quad EL2 = CB \quad 54 \quad E9$ 0xCB54E9 in hexadecimal 2's complement is -3451671 decimal. Latitude = -3451671 *(180/2^{23}) = -74.064825 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 Longitude is sent as 24-bit 2's complement number representing a range of possible values from -180 Degrees to +180 Degrees. The first bit of EG0 indicates the sign (hemisphere), zero is positive (East) and one is negative by 2's complement (West). The last bit of EG2 represents a value of $\frac{180}{2^{23}}$ Examples: Decode the Longitude when, $EG0 \quad EG1 \quad EG2 = A0 \quad 00 \quad 80$ 0xA00080 in hexadecimal 2's complement converts to -6291328 decimal. Latitude = -6291328 *(180/2^{23}) =-134.997253 Degrees Decode the Longitude when, $EL0 \quad EL1 \quad EL2 = 04 \quad 25 \quad 09$ 0x042509 in hexadecimal converts to 271625 decimal. Longitude = 271625 *(180/2^{23}) = 5.828440 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 Geometric Altitude is sent as 24-bit 2's complement. The first bit of GA0 indicates the sign, zero is positive and one is negative by 2's complement. The geometric altitude is sent in feet with a resolution of 0.015625 feet. Example: Decode the Geometric Altitude when $GA0 \quad GA1 \quad GA2 = 01 \quad 28 \quad 30$ 0x012830 in hexadecimal converts to 75824 decimal. Geometric Altitude = 75824 *(0.015625) = 1184.75 feet Decode the Geometric Altitude when $GA0 \quad GA1 \quad GA2 = FF \quad C7 \quad C0$ 0XFFC7C0 in hexadecimal 2's complement converts to -14400 decimal. Geometric Altitude = -14400*(0.015625) = -225 feet 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	20.88 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 (SMddddddddddddddL, 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 0x86 0x96	56.25 Degrees -171.5625 Degrees -149.0625 Degrees
		Heading while on Surface The data is sent as an 8-bit 2's complement number. The first bit indicates the sign, zero is positive and one is negative by 2's complement. The heading is sent in degrees with a resolution of 1.40625 degrees. Example: Decode Heading While on Surface when HS0 = [28] 0x28 in hexadecimal converts to 40 decimal. Heading While on Surface = 40*1.40625 = 56.25 Degrees. Decode Heading While on Surface when HS0 = [86] 0x86 in hexadecimal 2's complement converts to -122 decimal. Heading while on Surface = -122*1.40625 = -171.5625 Degrees 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 Barometric Altitude is sent as 24-bit 2's complement. Barometric Altitude is decoded the same as Geometric Altitude. 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: Sddddddd 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, 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 estimated latitude is decoded the same as the latitude.			

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 estimated longitude is decoded the same as the longitude.			

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 0x2 0x4 0x6 0x7-0xF	No Condition Information Available Permanent Alert Condition (Emergency) Temporary Alert Condition[13] Special Position Identification (SPI) Condition Reserved
		SSO(LSN)	**Intent Change Flag**
		0x0 0x1 0x2 0x3-0xF	No Change in Intent Reserved Intent Change Reserved
		Surveillance Status This field reports two sets of data. The most significant nibble (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 0x01 0x02 0x03-0xFF	No Report Generation Capability Acquisition Mode Track Mode Reserved
		Report Mode This field is used to indicate the current reporting mode of the ADS-B participant.	

Table 3-53 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 Identified in Structure ID bytes)	[2A]
PAYLOAD	Report Type and Structure ID	No: Ground Speed While on Surface, Heading While on Surface, Estimated Velocity	[1F CF 98]
	Validity Flags	Invalid: Ground Speed While on Surface, Heading While on Surface, Vertical Rate Geometric, Estimated Velocity	[E5 80]

[13] Change in Mode Identity Code other than emergency condition

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	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]

3.2.10.3 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 an 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 3-54. Table 3-55 provides the detailed message definition. An example ADS-B Mode Status Report Message is found in Table 3-56.

Table 3-54 ADS-B Mode Status Report Message Payload Structure Overview

Payload Index	Message Field	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	1
	SV Quality – SIL Supplement	
	SV Quality – System Design Assurance	
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 3-55 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 Target
02	RS2	0x2	0xF	0x7E	0xE0	Version 1 Airborne Target
		0x2	0xF	0xFE	0xE0	Version 1 Surface Target
		0x2	0xF	0x7F	0xE0	Version 2 Airborne Target
		0x2	0xF	0xFF	0xE0	Version 2 Surface Target

Report Type and Structure ID

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 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 reported data field.

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

Byte Name	Bit #	Mode Status Reported Data
RS0 (LSN)	3(msb)	Time of Applicability
	2	ADS-B Version
	1	Call Sign
	0	Emitter Category
RS1	7(msb)	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(msb)	SV Quality – NIC_{BARO}
	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(msb) 6 5 4 3 2 0-1	Capability Codes Operational Mode SV Quality - NACp SV Quality - NACv SV Quality - SIL Emergency/Priority Status Reserved
		Validity Flags These flags indicate whether 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 is the ICAO address or other address type.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
07	AQ0	**AQ0**	**Address Qualifier Description**
		Address Qualifier Byte Indicates the type of participant address reported and what the emitter category is set to for the given participant. See State Vector Report (3.2.10.2) for examples.	

Report Time of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
08	RA0	**RA0**	**RA1**	**Report Times of Applicability**
09	RA1	0x00 0x28	0x80 0x60	Time of Applicability: 1.0 seconds 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 0x01 0x02 0x03-0xFF	Conformant to DO-260/ED-102 and DO-242 Conformant to DO-260A and DO-242A Conformant to DO-260B/ED-102A and DO-242B Reserved
		ADS-B Version Indicates the formats and protocol used by 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 ASCII characters. Valid ASCII characters are outlined below: 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 ADS-B participant type of aircraft or vehicle.	

A/V Length and Width Code				
Byte Offset	**Byte Name**	**Field Description**		
20	LW0	**Aircraft Size**		
		LW0	**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**	
		Bit	**Capability Class Codes**
22	CC0	4-7(msb)	Reserved
		3	B2 Low –Surface vehicle transmitting less than 70 watts
		0-2	Reserved

Capability Class Codes			
23	CC1	7(msb) 6 5 4 3 2 1 0	TCAS Operational – TCAS is operational 1090ES In – ADS-B 1090ES receive capability ARV – Capable of messages to support Air-Referenced Velocity Reports TS Report – Capable of messages to support Target State Reports TC Report – See table below TC Report – See table below UAT In – ADS-B UAT receive capability Reserved
24	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:	
		Bit 3-2	**TC Report**
		0b00 0b01 0b10 0b11	No capability to send messages that support Trajectory Change Reports Capability to send messages to support TC+0 Report only Capability to send messages to support multiple TC Reports Reserved

Operational Mode			
Byte Offset	**Byte Name**	**Field Description**	
		Bit	**Operational Mode**
25	OM0	7(msb) 6 5 4 3 2 1 0	OM Format – Set to “ZERO” to indicate the formatting below. OM Format – Set to “ZERO” to indicate the formatting below. TCAS RA Active – TCAS II or ACAS Resolution Advisory is in effect IDENT Switch – IDENT is active Reserved Single Antenna Flag – ADS-B participant is operating with a single antenna Reserved Reserved
26	OM1	7(msb) 6 5 4 3 2 1 0	Lateral Axis GPS Antenna Offset Lateral Axis GPS Antenna Offset Lateral Axis GPS Antenna Offset Longitudinal Axis GPS Antenna Offset Longitudinal Axis GPS Antenna Offset Longitudinal Axis GPS Antenna Offset Longitudinal Axis GPS Antenna Offset Longitudinal Axis GPS Antenna Offset
		Operational Mode These flags indicate the operational mode of the ADS-B participant. A bit is set to “ONE” indicates that the mode is true. All reserved bits should be “ZERO”. The *Lateral Axis GPS Antenna Offset* field in byte OM1 is encoded as follows:	
		Bit 7-5	**GPS Antenna Upper Bound Offset Left or Right of Longitudinal Axis Along Lateral Axis**

Operational Mode		
	0b000	No Data
	0b001	Left – 2 meters
	0b010	Left – 4 meters
	0b011	Left – 6 meters
	0b100	Right – 0 meters
	0b101	Right – 2 meters
	0b110	Right – 4 meters
	0b111	Right – 6 meters
	The *Longitudinal Axis GPS Antenna Offset* field in byte OM1 is encoded as follows:	
	Bit 4-0	**GPS Antenna Upper Bound Offset Aft from Aircraft Nose Along Longitudinal Axis**
	0b00000	No Data
	0b00001	Position Offset Supplied by Sensor
	0b00010	2 meters
	0b00011	4 meters
	0b00100	6 meters
	*	***
	*	***
	0b11111	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**	
		Bit	**SV Quality - SIL**
29	SL0	5-7(msb)	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 can support. See the table below for SDA format:

Bit 4-3	Supported Failure Condition	Probability of Undetected Fault Causing Transmission of False Information	Software & Hardware Design Assurance Level
0b00	Unknown/No safety effect	>$1x10^{-3}$ per flight hour or unknown	N/A
0b01	Minor	≤ $1x10^{-3}$ per flight hour	D
0b10	Major	≤ $1x10^{-5}$ per flight hour	C
0b11	Hazardous	≤ $1x10^{-7}$ per flight hour	B

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 1-0	Probability of Exceeding the NIC Containment Radius (Rc)
0b00	Unknown or > $1x10^{-3}$ per flight hour or per sample
0b01	≤ $1x10^{-3}$ per flight hour or per sample
0b10	≤ $1x10^{-5}$ per flight hour or per sample
0b11	≤ $1x10^{-7}$ 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 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 3-56 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	Address: AC82EC	[AC 82 EC]
	Address Qualifier	Non-ICAO Address; Unknown Emitter Category	[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: Left 2 meters	[00 20]
	SV Quality - NACp	NACp: EPU < 10 m	[0A]
	SV Quality - NACv	NACv: Horizontal Velocity Error < 3 m/s	[02]
	SV Quality – SDA. 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	Ground track relative to true north being reported	[00]
	Vertical Rate Type	Vertical Rate Type: Geometric Altitude	[01]
	Checksum	8-bit arithmetic sum of message from Start Byte to last byte of the Payload Data.	[32]

3.2.10.4 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 provide data on an ADS-B In participant. The ADS-B Target State Report Message:

- Is sent for aircraft/vehicles 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 3-57. Table 3-58 provides the detailed message definition.

Table 3-57 ADS-B Target State Report Message Payload Structure Overview

Payload Index	Message Field	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 3-58 ADS-B Target State Report Message Payload Structure Detail

<table>
<tr><th colspan="7">Report Type and Structure ID</th></tr>
<tr><th>Byte Offset</th><th>Byte Name</th><th colspan="5">Field Description</th></tr>
<tr><td>00</td><td>RS0</td><td>RS0 (MSN)</td><td>RS0 (LSN)</td><td>RS1</td><td colspan="2">Report Type and Structure ID</td></tr>
<tr><td>01</td><td>RS1</td><td>0x5</td><td>0xF</td><td>0xF8</td><td colspan="2">Target State Report; All data fields are supported</td></tr>
<tr><td colspan="2" rowspan="4"></td><td colspan="5"><u>Report Type and Structure ID</u>
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 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”, the field is not reported for the current message and the Target State message will not include that field. The Target State Message will concatenate the next field to be included into the report, following the previous reported field. This is performed for each reported data field.

The below table outlines the Structure ID layout:</td></tr>
<tr><td colspan="2">Byte</td><td>Bit #</td><td colspan="2">Target State Data Parameters to Report</td></tr>
<tr><td colspan="2">RS0
(LSN)</td><td>3(msb)
2
1
0</td><td colspan="2">Selected Altitude: Selected Altitude Type
Selected Altitude: MCP/FCU or FMS
Barometric Pressure Setting (Minus 800 millibars)
Selected Heading</td></tr>
<tr><td colspan="2">RS1</td><td>7(msb)
6
5
4
3
0-2</td><td colspan="2">Mode Indicators: Autopilot Engaged
Mode Indicators: VNAV Mode Engaged
Mode Indicators: Altitude Hold Mode
Mode Indicators: Approach Mode
Mode Indicators: LNAV Mode Engaged
Reserved</td></tr>
</table>

Validity Flags				
Byte Offset	**Byte Name**	**Field Description**		
02	VF0	**Byte**	**Bit**	**Data Field(s)**
03	VF1	VF0	0 - 7	Reserved
		VF1	7(msb) 6 5 4 0-3	Selected Altitude Barometric Pressure Setting Selected Heading MCP/FCU Mode Reserved
		Validity Flags These flags indicate whether 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	**AQ0**	**Address Qualifier Description**
		Address Qualifier Indicates the type of participant address reported and what the emitter category is set to for the given participant. See State Vector Report (3.2.10.2) for examples.	

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
08	RA0	**RA0**	**RA1**	**Report Times of Applicability**
09	RA1	0x00 0x28	0x80 0x60	Time of Applicability: 1.0 second 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 0x01 0x02-0xFF	Selected altitude derived from Control Panel Selected altitude derived from Flight Management System (FMS) 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 0x00 0x00 0x07	0x01 0x02 0x03 0xFF	0 feet 32 feet 64 feet 65472 feet
		Selected Altitude Selected altitude is sent in the following format*: ddd 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 0x00 0x00 0x01	0x01 0x02 0x03 0xFF	800.0 millibars 800.8 millibars 801.6 millibars 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 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 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 Indicates whether altitude hold mode is active.	

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

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

3.2.10.5 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 an ADS-B In participant. The ADS-B Air Referenced Velocity Report Message:

- Is sent for aircraft/vehicles 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 3-59 and

Table 3-60 provides the detailed message definition.

Table 3-59 ADS-B Air Referenced Velocity Report Message Payload Structure Overview

Payload Index	Message Field	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 3-60 ADS-B Air Referenced Velocity Report Message Payload Structure Detail

<table>
<tr><th colspan="6">Report Type and Structure ID</th></tr>
<tr><th>Byte Offset</th><th>Byte Name</th><th colspan="4">Field Description</th></tr>
<tr><td>00</td><td>RS0</td><td>RS0 (MSN)</td><td>RS0 (LSN)</td><td>RS1</td><td>Report Type and Structure ID</td></tr>
<tr><td>01</td><td>RS1</td><td>0x4</td><td>0x0</td><td>0x07</td><td>Air Referenced Velocity Report;
All data fields are supported</td></tr>
<tr><td colspan="2"></td><td colspan="4"><u>Report Type and Structure ID</u>
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 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 Air Referenced Velocity Message will not include that field. The Air Referenced Velocity Message will concatenate the next field to be included into the report, following the previous reported field. This is performed for each data reported field.

The below table outlines the Structure ID layout:</td></tr>
<tr><td colspan="2"></td><td>Byte</td><td>Bit #</td><td colspan="2">Air Referenced Velocity Data Parameter to Report</td></tr>
<tr><td colspan="2"></td><td>RS0 (LSN)</td><td>0-3</td><td colspan="2">Reserved</td></tr>
<tr><td colspan="2"></td><td>RS1</td><td>3-7(msb)
2
1
0</td><td colspan="2">Reserved
Airspeed
Airspeed Type and Validity
Heading While Airborne</td></tr>
</table>

Validity Flags			
Byte Offset	**Byte Name**	**Field Description**	
02	VF0	**Bit**	**Data Field**
		2-7(msb) 1 0	Reserved Airspeed Heading
		Validity Flags: These flags indicate whether 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 Contains the address of the transmitting installation. This field contain up to 6 hex characters. This can be the ICAO address or some other address type.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
06	AQ0	**AQ0**	**Address Qualifier Description**
		Address Qualifier Indicates the type of participant address reported and what the emitter category is set to for the given participant. See State Vector Report (3.2.10.2) for examples.	

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
07	RA0	**RA0**	**RA1**	**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 Time 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 convert to 0.6875 seconds.		

Airspeed				
Byte Offset	**Byte Name**	**Field Description**		
09	AS0	**AS0**	**AS1**	**Airspeed**
10	AS1	0x00 0x00 0x01	0x00 0xCE 0x0D	0 knots 206 knots 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 0x01 0x02 0x3-0xFF	Invalid True Indicated Reserved
		Airspeed Type Indicates the type of airspeed.	

Heading				
Byte Offset	**Byte Name**	**Field Description**		
12	HD0	**HD0**	**HD1**	**Heading**
13	HD1	0x00 0x01 0x02 0x03	0x01 0x02 0x00 0xFF	0.3515625 degree 90.703125 degrees 180.00000 degrees 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).		

3.2.11 TIS-B Reports Overview

Traffic Information Service – Broadcast (TIS-B) is a supplemental service provided by ground stations that collates the latest information from the best available ground surveillance sources to provide surveillance data on aircraft that are not equipped for 1090 MHz ADS-B.

Like ADS-B In Reports, TIS-B In Reports are sent when a TIS-B participant has entered the Track state. If the position data for a TIS-B participant has not been updated in 125 seconds, TIS-B In Reports are no longer sent for that participant.

The data available in Fine messages is like the data contained in ADS-B position messages 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 position message is combined into a single Coarse Position Report, containing all the coarse position data available for the TIS-B participant.

Table 3-61 lists TIS-B Reports and associated Message Types, lengths and document sections.

Table 3-61 TIS-B Reports

Message Name	Message Type	Payload Length (Bytes)	Document Section
TIS-B State Vector Report	0x93	24-48	3.2.11.1
TIS-B Mode Status Report	0x94	16-27	3.2.11.2
TIS-B Coarse Position Report	0x95	18	3.2.11.3
Raw TIS-B Report	**0x96**	13 or 19	3.2.11.4
TIS-B Air Referenced Velocity Report	0x98	14	3.2.11.5

3.2.11.1 TIS-B State Vector Report: Type 0x93

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 different
- Bit b2 of the Surveillance Status field changes from “Intent Change” to “Reserved”

An overview of the TIS-B State Vector Report Message is shown in Table 3-62. The table shows all possible fields of the State Vector report. 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.

Table 3-63 provides the detailed message definition. An example of the TIS-B State Vector Report Message is found in Table 3-64.

Table 3-62 TIS-B State Vector Report Message Payload Structure Overview

Payload Index	Message Field	Bytes
00	Report Type and Structure ID	3
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 [14]	2
44	Estimated E/W Velocity [14]	2
46	Surveillance Status	1
47	Report Mode	1

[14] The MX-12B does not report Estimated Velocity

Table 3-63 TIS-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 & E/W Velocity, Baro Altitude, 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 is performed for each data field that is reported.

The below table outlines the Structure ID layout:

Byte	**Bit**	**State Vector Data Parameters to be Reported**
RSO (LSN)	3 (msb)	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(msb)	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/Barometric
	1	Navigation Integrity Category
	0	Estimated Latitude
RS2	7(msb)	Estimated Longitude
	6	Estimated North/South Velocity
	5	Estimated East/West Velocity
	4	Surveillance Status/Discrete
	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 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			
05	PA0	**PA0**	**PA1**	**PA2**	**Participant Address**
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**
		0x02	ICAO Address; Aircraft
		0x03	Non-ICAO Address; Aircraft
		Address Qualifier Byte Indicates the type of participant address 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**

Report Times of Applicability								
10	RA1	0x00	0x58	0x00	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 The Report Times of Applicability field contains time stamps created when a TIS-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 Latitude is sent as 24-bit 2's complement number representing a range of possible values from -90 Degrees to +90 Degrees. The first bit of EL0 indicates the sign (hemisphere), zero is positive (North) and one is negative by 2's complement (South). The last bit of EL2 represents a value of $\frac{180}{2^{23}}$ Examples: Decode the Latitude when, $EL0 \quad EL1 \quad EL2 = 28 \quad 00 \quad 80$ 0x280080 in hexadecimal converts to 2621568 in decimal. Latitude = 2621568 *(180/2^{23}) = 56.252747 Degrees Decode the Latitude when, $EL0 \quad EL1 \quad EL2 = CB \quad 54 \quad E9$ 0xCB54E9 in hexadecimal 2's complement is -3451671 decimal. Latitude = -3451671 *(180/2^{23}) = -74.064825 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

Longitude is sent as 24-bit 2's complement number representing a range of possible values from -180 Degrees to +180 Degrees. The first bit of EG0 indicates the sign (hemisphere), zero is positive (East) and one is negative by 2's complement (West). The last bit of EG2 represents a value of $\frac{180}{2^{23}}$

Examples:

Decode the Longitude when,

$$EG0 \quad EG1 \quad EG2 = A0 \quad 00 \quad 80$$

0xA00080 in hexadecimal 2's complement converts to -6291328 decimal.

Latitude = -6291328 *(180/2^{23}) =-134.997253 Degrees

Decode the Longitude when,

$$EL0 \quad EL1 \quad EL2 = 04 \quad 25 \quad 09$$

0x042509 in hexadecimal converts to 271625 decimal.

Longitude = 271625 *(180/2^{23}) = 5.828440 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

Geometric Altitude is sent as 24-bit 2's complement. The first bit of GA0 indicates the sign, zero is positive and one is negative by 2's complement. The geometric altitude is sent in feet with a resolution of 0.015625 feet.

Example: Decode the Geometric Altitude when

$$GA0 \quad GA1 \quad GA2 = 01 \quad 28 \quad 30$$

0x012830 in hexadecimal converts to 75824 decimal.

Geometric Altitude = 75824 *(0.015625) = 1184.75 feet

Decode the Geometric Altitude when

$$GA0 \quad GA1 \quad GA2 = FF \quad C7 \quad C0$$

0XFFC7C0 in hexadecimal 2's complement converts to -14400 decimal.

Geometric Altitude = -14400*(0.015625) = -225 feet

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	20.88 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 (SMddddddddddddddL, 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 (SMddddddddddddddL, 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	
	Ground Speed while on Surface The data specifies the status of the “Movement” of the TIS-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 0x86 0x96	56.25 Degrees -171.5625 Degrees -149.0625 Degrees
		Heading while on Surface The data is sent as an 8-bit 2's complement number. The first bit indicates the sign, zero is positive and one is negative by 2's complement. The heading is sent in degrees with a resolution of 1.40625 degrees. Example: Decode Heading While on Surface when HS0 = [28] 0x28 in hexadecimal converts to 40 decimal. Heading While on Surface = 40*1.40625 = 56.25 Degrees. Decode Heading While on Surface when HS0 = [86] 0x86 in hexadecimal 2’s complement converts to -122 decimal. Heading while on Surface = -122*1.40625 = -171.5625 Degrees 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 Barometric Altitude is sent as 24-bit 2's complement. Barometric Altitude is decoded the same as Geometric Altitude. 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 TIS-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: Sddddddd 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, 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 TIS-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 estimated latitude is decoded the same as the latitude.			

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 estimated longitude is decoded the same as the longitude.			

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[15]
		0x6	Special Position Identification (SPI) Condition
		0x7-0xF	Reserved
		SSO(LSN)	**Intent Change Flag**
		0x0	No Change in Intent
		0x1	Reserved
		0x2	Reserved
		0x3-0xF	Reserved
		Surveillance Status This field reports two sets of data. The most significant nibble (MSN) reports the surveillance status of the TIS-B participant. The least significant nibble (LSN) reports the Intent Change Flag of the TIS-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 reporting mode of the TIS-B participant.	

[15] Change in Mode Identity Code other than emergency condition

Table 3-64 TIS-B State Vector Report Message Example Data

	Message Field	Byte Values (original)	Byte Message Content (Hex)
	Start Byte	AA	[AA]
	Message Type	0x91 TIS-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 Identified in Structure ID bytes)	[2A]
PAYLOAD	Report Type and Structure ID	No: Ground Speed While on Surface, Heading While on Surface, Estimated Velocity	[1F CF 98]
	Validity Flags	Invalid: Ground Speed While on Surface, Heading While on Surface, Vertical Rate Geometric, Estimated Velocity	[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]

3.2.11.2 TIS-B Mode Status Report: Type 0x94

TIS-B Mode Status Report has the same Report Type and Structure Identification fields as the ADS-B Mode Status Report structure. In the TIS-B Mode Status Report, this data field is always set to 0x0BCFC0, indicative of the payload structure defined in Table 3-65.

Table 3-65 provides the message overview, and Table 3-66 provides the detailed message definition.

Table 3-65 TIS-B Mode Status Report Payload Structure Overview

Payload Index	Message Field	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 3-66 TIS-B Mode Status Report Payload Structure Detail

<table>
<tr><th colspan="8">Report Type and Structure ID</th></tr>
<tr><th>Byte Offset</th><th>Byte Name</th><th colspan="6">Field Description</th></tr>
<tr><td>00</td><td>RS0</td><td>RS0 (MSN)</td><td>RS0 (LSN)</td><td>RS1</td><td>RS2</td><td colspan="2">Report Type and Structure ID</td></tr>
<tr><td>01</td><td>RS1</td><td>0x0</td><td>0xB</td><td>0xCF</td><td>0xC0</td><td colspan="2">0x0BCFC0</td></tr>
<tr><td>02</td><td>RS2</td><td colspan="6"><u>Report Type and Structure ID</u>
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 to0x0BCFC0</td></tr>
<tr><td colspan="2" rowspan="5"></td><td colspan="6"><u>Report Type</u>
The Most Significant Nibble (MSN) of the byte RS0 contains the Report Type</td></tr>
<tr><td colspan="6"><u>Structure ID</u>
The remaining data constitutes the Structure ID, which indicates the fields that are 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:</td></tr>
<tr><td colspan="6"><table>
<tr><th>Byte</th><th>Bit</th><th>Mode Status Data Parameter to Report</th><th>Bytes</th></tr>
<tr><td>RSO (LSN)</td><td>3(msb)</td><td>Time of Applicability</td><td>2</td></tr>
<tr><td></td><td>2</td><td>ADS-B Version</td><td>1</td></tr>
<tr><td></td><td>1</td><td>Call Sign</td><td>8</td></tr>
<tr><td></td><td>0</td><td>Emitter Category</td><td>1</td></tr>
<tr><td>RS1</td><td>7(msb)</td><td>Message Reserved1</td><td>1</td></tr>
<tr><td></td><td>6</td><td>Message Reserved2</td><td>1</td></tr>
<tr><td></td><td>5</td><td>Capability Codes</td><td>2</td></tr>
<tr><td></td><td>4</td><td>Operational Mode</td><td>2</td></tr>
<tr><td></td><td>3</td><td>SV Quality – NACp</td><td>1</td></tr>
<tr><td></td><td>2</td><td>SV Quality – NACv</td><td>1</td></tr>
<tr><td></td><td>1</td><td>SV Quality – SIL</td><td>1</td></tr>
<tr><td></td><td>0</td><td>Message Reserved 3</td><td>1</td></tr>
<tr><td>RS2</td><td>7(msb)</td><td>Message Reserved4</td><td>1</td></tr>
<tr><td></td><td>6</td><td>True/Magnetic Heading (HRD)</td><td>1</td></tr>
<tr><td></td><td>5</td><td>Vertical Rate Type</td><td>1</td></tr>
<tr><td></td><td>4</td><td>Reserved for Flight Mode Specific Data</td><td>1</td></tr>
<tr><td></td><td>3</td><td>Other – Reserved</td><td>1</td></tr>
<tr><td></td><td>0-2</td><td>Reserved</td><td></td></tr>
</table></td></tr>
</table>

Validity Flags			
Byte Offset	**Byte Name**	**Field Description**	
03	VF0	**Bit**	**Data Field(s)**
		6-7(msb) 5 4 3 2 0-1	Reserved SV Quality - NACp SV Quality - NACv SV Quality - SIL Message Reserved2 Reserved
		Validity Flags These flags indicate whether 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 0x2A	0xA6 0x35	0xB2 0x6A	1CA6B2 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 address type.			

Address Qualifier			
Byte Offset	**Byte Name**	**Field Description**	
07	AQ0	**AQ0**	**Address Qualifier Description**
		0x00-0x01 0x02 0x03 0x04-0xFF	Reserved ICAO Address; Aircraft Non-ICAO Address; Aircraft Reserved

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
08	RA0	**RA0**	**RA1**	**Reported Times of Applicability**
09	RA1	0x00 0x28	0x80 0x60	Time of Applicability: 1.0 seconds 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 is the aircraft identification used by the TIS-B participant. Data is sent as unsigned ASCII characters. Valid ASCII characters are outlined below: 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**	
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 TIS-B participant type of vehicle or aircraft.	

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 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	**Bit**	**SV Quality – SIL**
		2-7(msb) 1 0	Reserved SIL SIL
		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 1-0	**Probability of Exceeding the NIC Containment Radius (Rc)**
		0x00 0x01 0x10 0x11	Unknown or > $1x10^{-3}$ per flight hour or per sample ≤ $1x10^{-3}$ per flight hour or per sample ≤ $1x10^{-5}$ per flight hour or per sample ≤ $1x10^{-7}$ per flight hour or per sample

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 0x01 0x02 0x03 0x04-0xFF	Ground track relative to true north being reported Ground track relative to magnetic north reported Heading relative to true north being reported Heading relative to magnetic north being reported Reserved

3.2.11.3 TIS-B Coarse Report: Type 0x95

The TIS-B Coarse Report contains information from received TIS-B Coarse Position and Velocity Messages. This message:

- Is sent for every aircraft/vehicle known to the ATC system not equipped with 1090MHz ADS-B.
- Provides coarse position, coarse velocity and other information.

An overview of the TIS-B Coarse Report is shown in Table 3-67, message detail is provided in Table 3-68, and an example of the message is provided in Table 3-69.

Table 3-67 TIS-B Coarse Report Payload Structure Overview

Payload Index	Message Field	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 3-68 TIS-B Coarse Report 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 address type.			

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

Surveillance Status			
Byte Offset	**Byte Name**	**Field Description**	
04	SS0	**SS0**	**Surveillance Status**
		0x00 0x01 0x02 0x03 0x04-0xFF	No Condition Information Available Permanent Alert Condition (Emergency) Temporary Alert Condition (Change in Mode Identity Code other than emergency condition) Special Position Identification (SPI) Condition Reserved
		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	18,700 Feet
		0xFF	0xF7	-225 Feet
		0x80	0x00	Data is invalid
		Pressure Altitude The data is in 2's complement sent in the following format: *Sddddddd 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 Pressure altitude is sent in feet with a resolution of 25 feet. A value of 0x8000 (-32768 decimal) indicates Pressure Altitude is invalid. 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
		0x30	180.0 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(msb)	Reserved
		Ground Track Angle Is encoded as an unsigned angular weighted binary numeral, with an msb of 180 degrees and a 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:	
		Bit	**Ground Track Status**
		0b0	Ground Track Angle and Ground Speed Not Valid
		0b1	Ground Track Angle and Ground Speed Valid

Ground Speed			
Byte Offset	**Byte Name**	**Field Description**	
09	GS0	**GS0**	**Ground Speed**
		0x00 0x01 0x02 0x03 *** 0x3E 0x3F	No Ground Speed information available Ground Speed < 16 knots 16 knots ≤ GS < 48 knots 48 knots ≤ GS < 80 knots *** 1936 knots ≤ GS < 1968 knots GS ≥ 1968 knots
		Ground Speed This byte encodes ground speed with a resolution of 32 knots. Ground speed is decoded as: Ground Speed = (GS0 – 1)*32 knots	

Report Times of Applicability				
Byte Offset	**Byte Name**	**Field Description**		
10	RA0	**RA0**	**RA1**	**Report Times of Applicability**
11	RA1	0x00 0x28	0x80 0x60	Time of Applicability: 1.0 seconds 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: *SMddddddd ddddddddd ddddddddL* 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 0x80	0x00 0x28	0x80 0x60	-134.997253 Degrees -179.778214 Degrees
17	EG2	0x04	0x25	0x09	5.828440 Degrees
		Longitude The data is sent as a 24-bit 2's complement number: *SMddddddd ddddddddd ddddddddL* 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 3-69 TIS-B Coarse Report 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	3C29EF	[3C 29 EF]
	Address Qualifier	ICAO Address, Aircraft	[02]
	Surveillance Status	SPI condition	[03]
	Service Volume ID	7	[07]
	Pressure Altitude	4575 feet	[00 B7]
	Ground Track Status & Angle	Data valid, 292.5 degrees	[3A]
	Ground Speed	80 ≤ GS < 112 knots	[04]
	Report Times of Applicability	15.625 milliseconds	[00 02]
	Latitude	45.727308 Degrees	[20 84 67]
	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]

3.2.11.4 Raw TIS-B Report: Type 0x96

When enabled by the Host via the Target Request Message, the MXS outputs the content of the following received messages as the Raw TIS-B Report (message type 0x96):

- TIS-B and ADS-R Management Messages
- Fine TIS-B Position Messages
- Coarse TIS-B Position Messages
- TIS-B Velocity Messages
- TIS-B Identification and Category Messages

The MXS outputs all 88 bits of TIS-B and ADS-R Management, TIS-B Position, TIS-B Velocity, and TIS-B Identification and Category messages in Raw Message Reports. The format is as follows:

Table 3-70 Raw TIS-B Report All Except Tracked Pos Squitter Messages Payload Structure Overview

Payload Index	Message Field	Number bytes
01	Report Time Of Applicability	2
03	Extended Squitter bits 01-88	11

Table 3-71 Raw TIS-B Report All Except Tracked Pos Squitter Messages Payload Structure Detail

Report Time Of Applicability		
Byte Offset	**Byte Name**	**Field Description**
00	RTRTA0	Message Reception Time - In units 1/128 second

Extended Squitter bits 01-88		
Byte Offset	**Byte Name**	**Field Description**
00	RTRES0	Extended Squitter bits 01-88 copied directly from the Raw Message payload into the Report to be output.

Position Squitters:

For TIS-B targets that are not being tracked, the MX outputs Position Messages in the same Raw Message format as above, except Compact Position Reporting (CPR) fields are cleared.

- For Fine Position Messages, the CPR field is contained in ES bits 53-88.
- For Coarse Position Messages, the CPR field is contained in ES bits 64-88.

Tracked Position Squitters:

For TIS-B targets that are being tracked, the MXS outputs the squitter content as above, with the CPR field cleared -- however, the position of the target is also included.

The format of the Raw TIS-B report for tracked TIS-B targets is shown below:

Table 3-72 Raw TIS-B Report for Tracked Position Squitter Messages Payload Structure Overview

Payload Index	Message Field	Number bytes
01	Report Time Of Applicability	2
03	Extended Squitter bits 01-88	11
14	Latitude	3
17	Longitude	3

Table 3-73 Raw TIS-B Report for Tracked Position Squitter Messages Payload Structure Detail

Report Time Of Applicability		
Byte Offset	**Byte Name**	**Field Description**
00	RTRCTA0	Message Reception Time - In units 1/128 second

Extended Squitter bits 01-88		
Byte Offset	**Byte Name**	**Field Description**
00	RTRCES0	Extended Squitter bits 01-88 copied directly from the Raw Message payload into the Report to be output.

Latitude		
Byte Offset	**Byte Name**	**Field Description**
00	RTRCLA0	24-bit 2-s complement number (SMddddddddddddddddddddddL, where S=0 for north and 1 for south, M = 90 degrees, and L = 90 * 2^{-22})

Longitude		
Byte Offset	**Byte Name**	**Field Description**
00	RTRCLO0	24-bit 2's complement number (SMddddddddddddddddddddddL, where S=0 for east and 1 for west, M = 90 degrees, and L = 90 * 2^{-22})

3.2.11.5 TIS-B Air Referenced Velocity Report: Type 0x98

The TIS-B Air Referenced Velocity Report contains information received from fine format TIS-B messages. It uses the same report structure 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.

3.2.12 Civil Settings Response Message: Type 0xD7

The Civil settings response message provides the data that was set (priority SQUAWK) using the civil settings message. This message is sent in response to a Civil Settings Message (0xC3) or through the Data Request Message (0x05).

4.0 MXS Use Case Scenarios

MXS can follow these Use Cases to perform common operations.

4.1 Power On

When power is applied to the MXS and internal power supplies are stable, the power-on Built-in-Test (BIT) is executed and the Status Response message is sent to the Flight Computer. The Flight Computer uses the status message to assess the state of the MXS to determine the next operational state. A typical Power-On message sequence is outlined in the following steps and Table 4-1.

1. After the Power-On BIT is executed, the Host sends the Data Request Message requesting the Status Response Message
2. The Host receives and decodes the Acknowledge message
3. The Host receives and recodes the results of the BIT provided in the Status Response Message and confirms that the MXS is Operational
   a. If MXS is Operational, jump to the Operational Use Case (Section 4.3)
   b. If the Status Message indicates an ICAO Address failure but is otherwise functional, jump to the Installation Use Case (Section 4.2)
   c. If the Status Message indicates a failure, Flight Computer should log the failure and take appropriate remedial action

Table 4-1 Message Sequence Example for a Power-On Use Case

Step	Message	Msg Source	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.					
			Message Type	[05]		3.1.6
			Message ID	[00]		
			Packet Length	[04]		
			Request Message Type	[83]	Message Type = Status Response Message. The ACK Message is returned first followed by the Status Response Message.	
			Reserved	[00 00 00]		
			Checksum	[36]		

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
2	Receive and decode Acknowledge Message (ACK)					
	Acknowledge	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[00]		
			Packet Len	[06]		
			Ack'd Mess Type	[05]	Acknowledgement of Data Request Message	
			Ack'd Mess ID	[00]		
			System State	[22]	MXS is in STBY mode, receiving barometric altitude from the host, and maintenance mode is turned off. Weight on wheels is either not connected or airborne, a required system input is unavailable, and the self-test passed. The WOW input is disabled by default in new installations. If the Status Message response displays an ICAO failure in the Built-In Test, this is likely a new installation.	
			Pressure Altitude	[80 00 00]	Pressure altitude is invalid in standby mode.	
			Checksum	[D7]		
3	Receive and decode Status Response Message					
	Status Response	MXS	Start Byte	[AA]		3.2.5
			Mess Type	[83]		
			Mess ID	[00]		
			Packet Len	[0A]		
			SW Version	[09]	This message can be used to verify the correct version of software/firmware is installed.	
			FW Version	[09]		
			Cyclic Redundancy Check (CRC)	[55 C9 1E 2C]	This message can be used in conjunction with SW/FW Version to verify the correct installation.	
			Built-In Test	[9F FF F0 80]	The Built-In Tests have passed except for Continuous, ICAO Address and GPS Position. The continuous failure is linked to the GPS failure, and the ICAO failure is an indication that Installation Data is missing.	
			Checksum	[BF]		

4.2 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 is valid.

The process and command sequences for the Installation Use Case are outlined in the following steps and in Table 4-2.

4. Construct and send a Data Request Message requesting Installation Response Message
5. Receive and decode Acknowledge Message (ACK)
6. Receive and decode Installation Response Message
7. The Installation Message communication fields vary depending on whether Serial or Ethernet communication is used
   a. Serial Communications: Enter values for one of the two COM Port fields
   b. 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
8. If the Installation Response Message indicates a new installation, construct and send Installation Message [16]
9. Receive and decode Acknowledge Message (ACK)
10. Repeat steps 1 – 3 to verify installation data is stored properly

Table 4-2 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 4-2 Installation Use Case Example Data

Step	Message	Msg Source	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 is returned first followed by the Installation Response Message.					
	Data Request	Host	Start Byte	[AA]		3.1.6
			Mess Type	[05]		
			Mess ID	[01]		
			Packet Len	[04]		

[16] Maintenance Mode must be enabled for the installation message to be received into nonvolatile memory

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
			Request Message Type	[81]	Request for Installation Response message.	
			Reserved	[00 00 00]		
			Checksum	[35]		
2	Receive and decode Acknowledge Message (ACK). ACK message is returned to indicate that MXS received the Data Request Message.					
	ACK	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[01]		
			Packet Len	[06]		
			Ack'd Mess Type	[05]	Acknowledging the Data Request message	
			Ack'd Mess ID	[01]		
			System State	[32]	MXS is in STBY mode, receiving barometric altitude from the host, and maintenance mode is turned on. Weight on wheels is either not connected or airborne, a required system input is unavailable, and the self-test passed.	
			Pressure Altitude	[80 00 00]	Pressure altitude is invalid in standby mode.	
			Checksum	[E9]		
3	Receive and decode Installation Response Message					
	Installation Response	MXS	Start Byte	[AA]		3.2.3
			Mess Type	[81]		
			Mess ID	[01]		
			Packet Len	[24]		
			ICAO Address	[00 00 00]	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]	Default value of zero indicating the Installation Data is not yet loaded into MXS nonvolatile memory.	
			Reserved	[00 00]		

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
			Com Port 0	[00] [17]		
			Com Port 1	[00] [17]		
			IP Address	[00 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] [18]		
			Install Configuration	[00]		
			Reserved	[00 00]		
			Checksum	[50]		
4	Construct and send Installation Message if the Installation Response Message indicates a new installation [19]					
	Installation	Host	Start Byte	[AA]		3.1.2
			Mess Type	[01]		
			Mess ID	[02]		
			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	

[17] The MXS response will show a Com Port of [00] in a new installation, which corresponds to a baud rate of 38.4 kbps.

[18] The MXS response will show [00 11] in the reserved field. All values in this or any other reserved field are to be ignored.

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

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
			IP Address	[0A 00 00 01]	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]	Maximum airspeed = 150kt	
			Altitude Encoder Offset	[00 00]	Zero offset	
			Reserved	[00 00]		
			Install Configuration	[81]	Bottom only antenna installed; Host Altitude Resolution is 25 feet; Heading type is Magnetic; Airspeed Type indicated; Pressure Sensor Heater OFF; WOW connected	
			Reserved	[00 00]		
			Checksum	[64]		
5	Receive and decode Acknowledge Message (ACK)					
	ACK	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[02]		
			Packet Len	[06]		
			ACK Mess Type	[01]	MXS received the Installation Message.	
			Ack'd Mess ID	[02]		
			System State	[3A]	Standby Mode; Barometric Altitude via the Host Message; Maintenance Mode enabled; WoW enabled; Required system input not available; Self-test pass	
			Pressure Altitude	[80 00 00]	Pressure altitude is invalid in standby mode.	
			Checksum	[EF]		
6	Receive and decode Installation Response Message					
		MXS	Start Byte	[AA]		3.2.3

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM Section
	Installation Response		Mess Type	[81]	Read installation data and verify load was successful	
			Mess ID	[02]		
			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]	150kt	
			Altitude Encoder Offset	[00 00]	Zero offset	
			Reserved	[00 00]		
			Install Configuration	[81]	Bottom only antenna installed; Host Altitude Resolution = 25 feet; Heading type is Magnetic; Airspeed Type indicated; Pressure Sensor Heater OFF; WOW connected	
			Reserved	[00 00]		
			Checksum	[E4]		

4.3 Operational

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

Note: Before the Operating Message is sent, it may be necessary for the host to send the 'Set Preflight Data' message to the MXS.

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 [20]
5. Receive and decode Acknowledge Message (ACK)
6. Construct and send GPS Navigation Data Message if sourced by Host, (Continue to construct and send GPS Data Message at 1-5 Hz [21]
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

Table 4-3 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 4-3 Operational Use Case Example Data

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM
1	Load Flight ID - Construct and send Flight ID Message.					
	Flight ID	Host	Start Byte	[AA]		3.1.3
			Mess Type	[02]		

[20] The Flight Computer should continue to update the Operating Message at the specified rate throughout the duration of the flight

[21] Typically, at the nominal update rate provided by the GPS hardware. Message updates should be continued throughout the duration of the flight

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM
			Mess ID	[03]		
			Packet Len	[0C]		
			Flight ID	[4E 32 35 36 37 47 41 20]	Load Flight ID = N2567GA [22]	
			Reserved	[00 00 00 00]		
			Checksum	[85]		
2	Receive and decode Acknowledge Message (ACK)					
	ACK	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[03]		
			Packet Len	[06]		
			Ack'd Mess Type	[02]	ACK message is returned to indicate that MXS received the Flight ID Message.	
			Ack'd Mess ID	[03]		
			System State	[2A]	Standby Mode; Barometric Altitude via the Host Message; Maintenance Mode disabled; WoW enabled; Required system input not available; Self-test pass	
			Pressure Altitude	[80 00 00]	Pressure altitude is invalid in standby mode.	
			Checksum	[E2]		
3	Receive and decode Flight ID Response Message					
	Flight ID Response	MXS	Start Byte	[AA]		3.2.4
			Mess Type	[82]		
			Mess ID	[03]		
			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	[05]		

[22] Flight ID is stored in MXS volatile memory and must be loaded whenever power is removed.

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM
4	Construct and send Operating Message (Continue to construct and send Operating Message at 1-5 Hz)					
	Operating	Host	Start Byte	[AA]		3.1.4
			Mess Type	[03]	Establishes MXS Operating Mode [23]	
			Mess ID	[04]		
			Packet Len	[0C]		
			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	[BE]		
5	Receive and decode Acknowledge Message (ACK)					
	ACK	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[04]		
			Packet Len	[06]		
			Ack'd Mess Type	[03]	ACK message is returned to indicate that MXS received the Operating Message	
			Ack'd Mess ID	[04]		
			System State	[C2]	Altitude Mode; Barometric Altitude via internal decoder; Maintenance Mode disabled; WoW disabled; Required system input not available; Self-test pass GPS Data fail is set until user sends GPS position data	

[23] This message must be sent periodically (between 1 to 5 Hz) to maintain Operating mode

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM
			Pressure Altitude	[00 02 C3]	Pressure altitude is 707 feet[24]	
			Checksum	[C2]		
6	Construct and send GPS Navigation Data Message (Continue to construct and send GPS Data Message at 1-5 Hz)					
	GPS Data	Host	Start Byte	[AA]		3.1.5
			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	[05]		
			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]	12:37:22.4	
			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	
			NAC_v	[00]	Unknown or >= 10 m/s	
			Checksum	[CD]		
7	Receive and decode Acknowledge Message (ACK)					
	ACK	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[05]		
			Packet Len	[06]		

[24] The first ACK message will display altitude as invalid [80 00 00]. The altitude displayed in the following messages will vary based on local barometric pressure.

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM
			Ack'd Mess Type	[04]	ACK message is returned to indicate that MXS received the GPS Data Message.	
			Ack'd Mess ID	[05]		
			System State	[C0]	Altitude Mode; Barometric Altitude via internal decoder; Maintenance Mode disabled; WoW disabled; Required system inputs all valid; Self-test pass	
			Pressure Altitude	[00 02 C3]	Pressure altitude is 707 feet	
			Checksum	[C3]		
8	Send Target Request Message					
	Target Request	Host	Start Byte	[AA]		3.1.7
			Message Type	[0B]		
			Message ID	[06]		
			Packet Len	[07]		
			Request Type	[00]	Enable auto-output of ADS-B In data	
			Number of Participants	[00 20]	32 participants	
			Participant ID	[AC 82 EC]	ICAO Address: AC82EC	
			Requested Reports	[01]	State Vector report	
			Checksum	[FD]		
9	Receive and decode Acknowledge Message (ACK)					
	ACK	MXS	Start Byte	[AA]		3.2.2
			Mess Type	[80]		
			Mess ID	[06]		
			Packet Len	[06]		
			Ack'd Mess Type	[0B]	ACK message is returned to indicate that MXS received the Target Request Message.	
			Ack'd Mess ID	[06]		
			System State	[C0]		
			Pressure Altitude	[00 02 C3]		
			Checksum	[CC]		

Step	Message	Msg Source	Field Name	Data Values (Hex)	Data/Functional Description	SDIM
10	Receive and decode ADS-B In Report Message. MXS will send ADS-B In reports as ADS-B messages are processed. ADS-B Reports will continue as long as this Operating Mode is maintained. Example ADS-B In information is shown below.					
	ADS-B State Vector Report	MXS	Start Byte	[AA]		3.2.10.2
			Message Type	[91]	ADS-B State Vector Report Message	
			Message ID	[06]	An arbitrary number between 0 and 255 (inclusive) that uniquely identifies the message.	
			Payload Length	[2A]	42, omitted fields reported in Structure ID	
			Report Type and Structure ID	[1F CF 98]	State vector for airborne target, omitting Ground Speed/Heading on Surface and Estimated Velocity	
			Validity Flags	[E6 80]	Invalid: Ground Speed and Heading on Surface, Estimated Velocity	
			Participant Address	[AC 82 EC]	ICAO Address: AC82EC	
			Address Qualifier	[00]	Unknown Emitter Category	
			Report Times of Applicability	[66 2A 66 29 65 E9]	Est. Pos. TOA: 204.328s Position TOA: 204.320s Velocity TOA: 203.820s	
			Latitude	[21 FA 92]	Latitude: 47.782674 Degrees	
			Longitude	[A9 06 46]	Longitude: -122.309289 Degrees	
			Geometric Altitude	[0D 0F C0]	13,515 feet	
			N/S Velocity	[07 D0]	North/South Velocity: 250kt North	
			E/W Velocity	[FF 00]	East/West Velocity: 32kt West	
			Baro. Altitude	[0C EA 40]	13,225 feet	
			Vertical Rate	[00 80]	128 feet/min.	
			NIC	[08]	Rc < 0.1 NM	
			Estimated Latitude	[21 FA 92]	Estimated Latitude: 47.782674 Degrees	
			Estimated Longitude	[A9 06 46]	Estimated Longitude: -122.309289 Degrees	
			Surveillance Status	[00]	No alert condition	
			Report Mode	[02]	Track Mode	
			Checksum	[94]	8-bit arithmetic sum of message Start to last byte of Payload Data.	

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 AS8003	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.

Revision History

Rev	Summary of Changes	Effective Date	Approval
01	Initial Release	May 2021	CR00370
02	Major Modifications. Where common functionality exists, MXS SDIM changed to reflect delivered MX12B vetted MX12B SDIM. Split into a separate User Manual all specific Installation information and System Description. File renamed from MXS_SDIM to MXS_Host_ICD	Feb 2022	CR00468
03	Added message D0 for a data request for operating message response	Feb 2022	CR00498

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.

Host Interface: The messaging protocol used to communicate between the MXS and the host (typically a Flight Computer or Autopilot)

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.

LSB: Least significant byte (8 bits).

LSN: Least significant nibble (4 bits).

MOPS: Minimum Operational Performance Specification.

msb: Most significant bit

MSB: Most significant byte (8 bits).

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 transponder-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)