U.S. Department of Transportation

Federal Aviation Administration

Interface Requirements Document

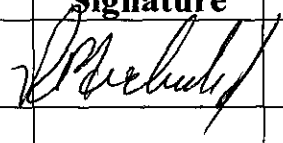
NAS-IR-82530001, Revision B

June 1, 2015

Surveillance and Broadcast Services (SBS)
Service Delivery Point (SDP) to ATC Automation and Service Monitoring
User Subsystems

Interface Requirements Document
Approval Signature Page

Surveillance and Broadcast Services (SBS)
Service Delivery Point (SDP) to ATC Automation and Service Monitoring User Subsystems

Approval Signatures			
Participant	**Name**	**Signature**	**Date**
AJM-23	Surveillance Services		7/20/2015
AJM-21	Air Traffic Management Program		
AJM-25	En Route and Oceanic 2nd Level Engineering		
AJM-24	Terminal 2nd Level Engineering		
ANG-B1	NAS Requirements and Interface Management Group		

Interface Requirements Document
Approval Signature Page

Surveillance and Broadcast Services (SBS)
Service Delivery Point (SDP) to ATC Automation and
Service Monitoring User Subsystems

Approval Signatures			
Participant	**Name**	**Signature**	**Date**
AJM-23	Surveillance Services		
AJM-21	Air Traffic Management Program		07/29/15
AJM-25	En Route and Oceanic 2nd Level Engineering		
AJM-24	Terminal 2nd Level Engineering		
ANG-B1	NAS Requirements and Interface Management Group		

Interface Requirements Document
Approval Signature Page

Surveillance and Broadcast Services (SBS)
Service Delivery Point (SDP) to ATC Automation and Service Monitoring User Subsystems

Approval Signatures			
Participant	**Name**	**Signature**	**Date**
AJM-23	Surveillance Services		
AJM-21	Air Traffic Management Program		
AJM-25	En Route and Oceanic 2nd Level Engineering		6/5/2015
AJM-24	Terminal 2nd Level Engineering		
ANG-B1	NAS Requirements and Interface Management Group		

Interface Requirements Document
Approval Signature Page

Surveillance and Broadcast Services (SBS)
Service Delivery Point (SDP) to ATC Automation and Service Monitoring User Subsystems

Approval Signatures			
Participant	**Name**	**Signature**	**Date**
AJM-23	Surveillance Services		
AJM-21	Air Traffic Management Program		
AJM-25	En Route and Oceanic 2nd Level Engineering		
AJM-24	Terminal 2nd Level Engineering FOR JOAN SANDY	Patricia McNeill	6/9/15
ANG-B1	NAS Requirements and Interface Management Group		

Interface Requirements Document
Approval Signature Page

Surveillance and Broadcast Services (SBS)
Service Delivery Point (SDP) to ATC Automation and Service Monitoring User Subsystems

Approval Signatures			
Participant	**Name**	**Signature**	**Date**
AJM-23	Surveillance Services		
AJM-21	Air Traffic Management Program		
AJM-25	En Route and Oceanic 2nd Level Engineering		
AJM-24	Terminal 2nd Level Engineering		
ANG-B1	NAS Requirements and Interface Management Group		7/21/15

REVISION RECORD

Revision	Date	Description	Approval
Rev.-	7/27/ 2010	NCP 32296 / ATO0E-SBS-1003	NAS CCB
Rev. A	2/23/2012	NCP 34095 / AJE06-SBS-1015	NAS CCB
Rev. B	06/01/2015	NCP 35618/ JM232-SBS-1007	NAS CCB

Table of Contents

List of Tables

List of Figures

1 Scope

This Interface Requirements Document (IRD) establishes requirements for Surveillance and Broadcast Services (SBS) Service Delivery Points (SDP) interfaces to ATC automation systems and the SBS Monitor.

This IRD applies to the interfaces between SBS SDPs and user systems designated by the FAA. Any other authorized users, proposed by the Service Provider and approved by the FAA, may interface as agreed upon by the Service Provider and authorized user.

Surveillance and Broadcast Services is comprised of five distinct Services:

1. Automatic Dependent Surveillance-Broadcast (ADS-B),
2. Automatic Dependent Surveillance-Rebroadcast (ADS-R),
3. Traffic Information Service-Broadcast (TIS-B),
4. Flight Information Service-Broadcast (FIS-B), and
5. Wide Area Multilateration (WAM).

The Service requirements are documented in three separate specifications:

1. Surveillance and Broadcast Services Critical Services System Specification Document (SSD),
2. Surveillance and Broadcast Services Essential Services System Specification Document (SSD), and
3. Surveillance and Broadcast Services Wide Area Multilateration (WAM) Critical Service Specification.

The ADS-B Service will support critical Air Traffic Control (ATC) Surveillance applications in the NAS. The ADS-R Service will support specified air-to-air applications involving aircraft which are equipped with different ADS-B links.

The TIS-B/FIS-B Services will provide traffic, weather, and NAS Status information to equipped aircraft/vehicles, supporting airborne applications.

The WAM Service will support critical ATC Surveillance applications in the NAS. The service will also provide a backup surveillance capability in the event of an ADS-B Service outage.

1.1 Scope

SBS will provide data to automation systems and the SBS Monitor via Federal Aviation Administration (FAA) defined Service Delivery Points (SDP). The SDPs are the physical demarcation points between the Services and the systems which ultimately use the data on the ground. SDPs associated with ATC automation systems will receive data only from SBS Services. SDPs associated with systems monitoring the performance of the Services, the SBS Monitor systems, will receive data from all Services. Table 1-1 summarizes the Report types provided by each of the Services and the associated formats.

The Report formats, FAA CAT033, FAA CAT023, FAA CAT010, and FAA CAT019, are based upon ASTERIX (see EUROCONTROL document SUR.ET1.ST05.2000-STD-01-01) and are being harmonized with EUROCONTROL.

Note: *Some automation systems will interface to SBS via a CD-2 interface in early implementations. The CD-2 interface is detailed in NAS-IR-82530002.*

Table 1-1: Report Summary

Report Type	***Format***	***Services Providing***	***Systems Receiving***
ADS-B Report	*FAA CAT033 (Appendix B)*	*ADS-B*	*ATC Automation, SBS Monitor*
TIS-B Report	*FAA CAT033 (Appendix B)*	*TIS-B*	*SBS Monitor*
FIS-B Report	*To be defined by the Service Provider*	*FIS-B*	*SBS Monitor*
Service Status Report	*FAA CAT023 (Appendix A)*	*All Services*	*ATC Automation, SBS Monitor*
ADS-R ACK/NACK Report	*SBS SDP ADS-R ACK/NACK (Appendix C)*	*ADS-R*	*SBS Monitor*
TIS-B/ADS-R Service Status Reports	*TIS-B/ADS-R Service Status Reports for 1090-ES (Appendix F)*	*TIS-B and ADS-R*	*SBS Monitor*
WAM Report	*FAA CAT010 (Appendix D)*	*WAM*	*ATC Automation, SBS Monitor*
WAM Service Status Report	*FAA CAT019 (Appendix E)*	*WAM*	*ATC Automation, SBS Monitor*

Per Table 1-1, if all Services are provided, then all Report types may be sent to an SDP. If a subset of the Services is provided, then only the corresponding Reports may be sent to an SDP. For example, if only ADS-B Services are provided, then the Reports transferred between SBS and an SDP are limited to ADS-B Reports and Service Status Reports. SBS offers configurability for each SDP interface to identify the Report types that are sent to the SDP. Therefore, while Table 1-1 defines the maximum set of Report

types that may be sent to the SDP, the configuration of the interface at the SBS ultimately determines which of the maximum set of Report types are sent.

The SBS SDP interface is a one-way interface, with data flowing from SBS SDP to the receiving systems. Figure 1-1 provides a notional set of SBS SDP interfaces and the application level data transferred between them. A given SDP may be provided data from Critical Services only, Essential Services only, or both Critical and Essential Services.

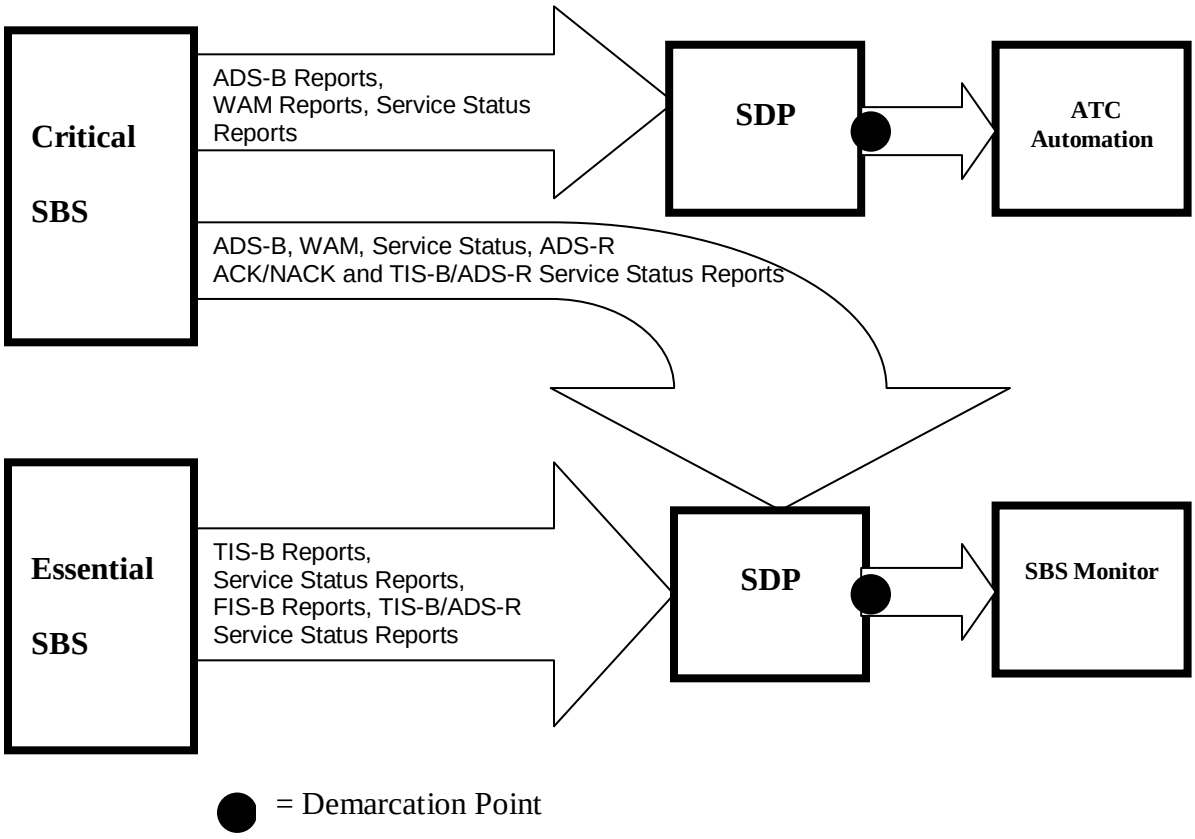


Figure 1-1 Application Level Summary (Notional SDPs)

1.2 Subsystem Responsibility List

NAS Subsystem	*Common Name*	*Responsible FAA Organization*
ASDE-X	*Airport Surface Detection Equipment*	*AJM-23*
ASSC	*Airport Surface Surveillance Capability*	*AJM-23*
ATOP	*Advanced Technologies and Oceanic Procedures*	*AJM-25*
SBS	*Surveillance and Broadcast Services*	*AJM-23*
CARTS	*Common Automated Radar Tracking System*	*AJM-24*
STARS	*Standard Terminal Automation Replacement System*	*AJM-24*
ERAM	*En Route Automation Modernization*	*AJM-21*
MEARTS	*Microprocessor En Route Automated Radar Tracking System*	*AJM-25*
SBSM	*SBS Monitor*	*AJM-23*

2 Applicable Documents

2.1 Government Documents

FAA Documents:	**Title:**
FAA-E-3011	Surveillance and Broadcast Services Critical Services System Specification Document (SSD), Revision -, June 17, 2010
FAA-E-3006	Surveillance and Broadcast Services Essential Services System Specification Document (SSD), Revision -, May 1, 2010.
FAA-E-3024	Surveillance and Broadcast Services Wide Area Multilateration (WAM) Critical Service Specification, Revision -, February 8, 2012
FAA-G-2100H	U.S. Department of Transportation, Federal Aviation Administration, Specification, Electronic Equipment, General Requirements, May 9, 2005

FAA-STD-019E	U.S. Department of Transportation, Federal Aviation Administration, Standard, Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment, December 2005
FAA-STD-025F	U.S. Department of Transportation, Federal Aviation Administration, Standard, Preparation of Interface Documentation, November 30, 2007
FAA-STD-039C	U.S. Department of Transportation, Federal Aviation Administration, Standard Practice, National Airspace System (NAS) Open System Architecture and Protocols, August 14, 2003
FAA SVDD	SBS Service Volume Definition Document spreadsheet, Version 2.0, October 3, 2011
NAS-IR-82530002	Surveillance and Broadcast Services (SBS) Service Delivery Point (SDP) Common Digitizer-2 (CD-2) to En Route ATC Automation and Service Monitoring User Subsystems Interface Requirements Document (IRD), Revision -, October 7, 2010
FAA Order 6030.20	Electrical Power Policy (Current Version)
FAA Order 6950.2	Electrical Power Policy Implementation at National Airspace System Facilities (Current Version)
FCC Documents	
	Code of Federal Regulations Title 47 Part 15, for Class B digital devices for unintentional radiators, February 27, 2009

2.2 Non-Government Documents

Other Documents:	**Title:**
SUR.ET1.ST05.2000-STD-01-01	Eurocontrol Standard Document for Surveillance Data Exchange, Part 1: All Purpose Structured Eurocontrol Surveillance Information Exchange (ASTERIX), Edition 1.29, February 2002
EIA-568-B.1	Commercial Building Telecommunications Cabling Standard – Part 1: General Requirements, May 2001

Other Documents:	Title:
IEEE Transactions on Communications, Vol. COM-30, No. 1	Fletcher, J.G., "An Arithmetic Checksum for Serial Transmissions," IEEE Transactions on Communications, Vol. COM-30, No. 1, January 1982, pp. 247-252
IEEE 802.3	CSMA/CD Access Method (Ethernet), 26 December 2008
IETF STD 3 (RFC 1122)	Requirements for Internet Hosts – Communication Layers, October 1989
IETF STD 3 (RFC 1123)	Requirements for Internet Hosts – Application and Support, October 1989
IETF STD 5 (RFC 791)	Internet Protocol (IPv4) Specification, September 1981
IETF STD 5 (RFC 792)	Internet Control Message Protocol, September 1981
IETF STD 5 (RFC 919)	Broadcasting Internet Datagrams, October 1984
IETF STD 5 (RFC 922)	Broadcasting Internet Datagrams in the Presence of Subnets, October 1984
IETF STD 5 (RFC 950)	Internet Standard Subnetting Procedure, August 1985
IETF STD 5 (RFC 1112)	Extensions for IP Multicasting, August 1989
IETF STD 6 (RFC 768)	User Datagram Protocol, August 1980
IETF STD 37 (RFC 826)	Ethernet Address Resolution Protocol, November 1982
IETF STD 41 (RFC 894)	Standard for the Transmission of IP Datagrams over Ethernet Networks, April 1984
IETF STD 43 (RFC 1042)	Standard for the Transmission of IP Datagrams over IEEE 802 Networks, February 1988
ISO-7498-1	Open System Interconnection Model, 1994
RFC 2460	Internet Protocol, Version 6 (IPv6) Specification, December 1998
RFC 2464	Transmission of IPv6 Packets over Ethernet Networks, December 1998
RFC 4291	Internet Protocol Version 6 Addressing Architecture, February, 2006
RFC 4443	Internet Control Message Protocol Version 6 for the Internet Protocol Version 6 Specification, March 2006

2.3 Documentation Sources

2.3.1 Electronic Industries Alliance Documents

Copies of Electronic Industries Alliance (EIA) standards may be obtained from the Electronic Industries Alliance, Technology Strategy and Standards Department, 2500 Wilson Boulevard, Arlington, VA 22201-3834, or by calling (703) 907-7500, or through their web site at http://www.eia.org .

2.3.2 ISO/IEC Documents

Copies of International Standards Organization documents may be obtained from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York City, NY 10036. Telephone: (212) 642-4900, Telefax: (212) 398-0023, Email: info@ansi.org , web site: http://www.ansi.org or http://www.iso.org .

2.3.3 IEEE/ANSI Documents

Copies of IEEE/ANSI documents may be obtained from IEEE Computer Service, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, or by calling (800) 701-4333 (in the U.S. and Canada), or (732) 981-0060 (outside of the U.S. and Canada), or through their standards web site at: http://www.ieee.org/web/standards/home/index.html

2.3.4 IETF Standard (RFC) Documents

Copies of the RFC documents may be obtained through the web site:
http://www.rfc-editor.org/rfc-index2.html

2.3.5 Eurocontrol Documents

Copies of Eurocontrol documents may be obtained through the web site:
http://www.eurocontrol.int/asterix/public/standard_page/documents.html

3 Interface Requirements/Characteristics

3.1 General Characteristics

3.1.1 Human System Interface Requirements

This IRD provides requirements for the SBS SDP interface to automation systems and the SBS Monitor, a service to system interface. Therefore, no human system interface requirements are specified herein.

3.2 Functional Requirements /Design Characteristics

3.2.1 Application Processes

SBS will have an application that provides for the transmission of the Reports to the receiving system via the SDP. The receiving system must have an application that receives those reports.

3.2.1.1 Identification of Each Application Process

a. The SBS **shall [1]** output Reports to the receiving system via the SDP, per the SBS configuration.

b. The receiving system **shall [2]** receive and process all Reports from the SBS SDP.

3.2.1.2 Category of Services Required by the Application Process

The Category of Service requirements are specified within the SBS Specifications as Service level performance requirements that are measured at the SDP and thus include interface contributions. Each SDP will be designated as either an essential or a critical level SDP. See the Surveillance and Broadcast Services Critical Services SSD Section §3.3.2.2.5, the Surveillance and Broadcast Services Essential Services SSD Sections §3.3.2.9 for TIS-B and §3.3.3.4 for FIS-B, and the Surveillance and Broadcast Services WAM Critical Service SSD §3.3.2.16.

3.2.1.3 Information Units

a. The ADS-B Reports sent from the SBS SDP **shall [3]** contain the fields specified in the FAA CAT033 Report format defined in Appendix B.

b. The TIS-B Reports sent from the SBS SDP **shall [4]** contain the fields specified in the FAA CAT033 Report format defined in Appendix B.

c. The Service Status Reports sent from the SBS SDP **shall [5]** contain the fields specified in the FAA CAT023 Report format defined in Appendix A.

d. The FIS-B Reports sent from the SBS SDP **shall [6]** contain the fields specified in the format provided by the Service Provider and approved by FAA.

e. The ADS-R ACK/NACK Reports sent from the SBS SDP **shall [7]** contain the fields specified in the ACK/NACK format defined in Appendix C.

f. The WAM Reports sent from the SBS SDP **shall [73]** contain the fields specified in the FAA CAT010 Report format defined in Appendix D.

g. The WAM Service Status Reports sent from the SBS SDP **shall [74]** contain the fields specified in the FAA CAT019 Report format defined in Appendix E.

h. The TIS-B/ADS-R Service Status Reports for 1090-ES sent from the SBS SDP **shall [80]** contain the fields specified in the TIS-B/ADS-R Service Status Reports format defined in Appendix F.

3.2.1.4 Quality of Service

The Quality of Service requirements, including integrity, latency, etc., are specified within the SBS Specifications as Service level requirements that are measured at the SDP and thus include interface contributions.

3.2.1.5 AP Error Handling

As receiving systems could host an array of applications with different error handling needs, the following represent desired characteristics of the application AP Error Handling, rather than requirements.

a. The receiving system **should** verify that the Data Source Qualifier provided in the Report is from a valid list of assigned Data Source Qualifiers.

b. The receiving system **should** compare the Time of Applicability (TOA) in the Report to an adapted acceptable elapsed time parameter.

c. The receiving system **should** verify that the Integrity and Accuracy parameters (NIC/NAC/SIL) are within an adapted threshold.

3.2.1.6 Interface Summary Table

Table 3-1 summarizes the data flow between the Surveillance Broadcast Services System (SBSS) and the ATC Automation and SBS Monitor Systems.

Table 3-1: Interface Summary

SBSS	***Reports***	***Direction***	***Receiving Systems***
Data Provider	*ADS-B Reports*	→ →	*Data User*
	TIS-B Reports	→ →	
	FIS-B Reports	→ →	
	Service Status Reports	→ →	
	ADS-R ACK/NACK Reports	→ →	
	TIS-B/ADS-R Service Status Reports	→ →	
	WAM Reports	→ →	
	WAM Service Status Reports	→ →	

3.2.2 Protocol Implementation

All protocols developed **shall [8]** be in accordance with FAA-STD-039C.

3.2.2.1 Application Services

The application layer **shall [9]** support the transfer of the following application services from the SBS to receiving systems, via the SDP:

- ADS-B Report,
- TIS-B Report,
- FIS-B Report,
- Service Status Report
- ADS-R ACK/NACK Reports,
- TIS-B/ADS-R Service Status Reports
- WAM Report,
- WAM Service Status Report

3.2.2.1.1 ADS-B Reports

a. The SBS **shall [10]** send ADS-B Reports to the receiving system per the Configuration parameters associated with the interface.

b. The ADS-B Reports **shall [11]** be in the FAA CAT033 encoding structure as detailed in Appendix B.

3.2.2.1.2 TIS-B Reports

a. The SBS **shall [12]** send TIS-B Reports to the receiving system for each radar sensor report update with a minimum time interval between updates of no less than 1 second, per the Configuration parameters associated with the interface.

Note 1: One or more Reports may be sent in accordance with the ASTERIX data block definition documented in Appendix B.

Note 2: Two types of TIS-B Reports are defined, Type A and Type B. Type A Reports provide the source data for generating TIS-B Messages. This data is based on inputs from all sensors (including radar and ADS-B) and provide a complete picture of air traffic in a Service Volume. A TIS-B Type A Report is sent each time a radar report is received, whether or not the TIS-B Message is transmitted. Bit 1 of FRN 3, Link Technology, indicates whether or not the TIS-B Message was actually transmitted. Type B Reports provide a view of the as-broadcast TIS-B Messages. A TIS-B Type B Report is sent each time a radio acknowledges successful transmission of a TIS-B message. Details of both types of these reports are provided in Appendix B.

b. The TIS-B Reports **shall [13]** be in the FAA CAT033 encoding structure as detailed in Appendix B.

3.2.2.1.3 FIS-B Reports

a. The SBS **shall [14]** send FIS-B Reports to the receiving system per the Configuration parameters associated with the interface.

b. The FIS-B Reports **shall [15]** be in the format defined by the Service Provider.

Note: *The FAA will review and approve the formats defined by the Service Provider.*

3.2.2.1.4 Service Status Reports

a. The SBS **shall [16]** send Service Status Reports to the receiving system per the Configuration parameters associated with the interface.

b. The Service Status Reports **shall [17]** be in the FAA CAT023 encoding structure as detailed in Appendix A.

c. Each CAT023 SDP Status Report **shall [18]** be reported to the SBS Monitor with an update interval every 5 sec ± 2 sec.

d. A CAT023 SDP Status Report **shall [19]** be generated for each Automation SDP and sent to the SBS Monitor for each Service Volume in which the SDP is located.

3.2.2.1.5 ADS-R ACK/NACK Reports

a. The SBS **shall [20]** send ADS-R ACK/NACK Reports to the receiving system per the Configuration parameters associated with the interface.

b. The ADS-R ACK/NACK Reports **shall [21]** be in the SBS SDP ADS-R ACK/NACK format defined in Appendix C.

3.2.2.1.6 TIS-B/ADS-R Service Status Reports

a. The SBS **shall [81]** send TIS-B/ADS-R Service Status Reports for 1090-ES to the receiving system per the Configuration parameters associated with the interface.

b. The 1090-ES TIS-B/ADS-R Service Status Reports **shall [82]** be in the report format defined in Appendix F.

3.2.2.1.7 WAM Reports

a. The SBS **shall [75]** send WAM Reports to the receiving system per the Configuration parameters associated with the interface.

b. The WAM Reports **shall [76]** be in the FAA CAT010 encoding structure as detailed in Appendix D.

3.2.2.1.8 WAM Service Status Reports

a. The SBS **shall [77]** send WAM Service Status Reports to the receiving system per the Configuration parameters associated with the interface.

b. The WAM Service Status Reports **shall [78]** be in the FAA CAT019 encoding structure as detailed in Appendix E.

3.2.2.2 Network Services

3.2.2.2.1 Presentation Layer: Broadcast Services Data Unit (BSDU)

The Broadcast Services Data Unit (BSDU) serves the following functions:

- Delimit Application Elements or to aggregate for transmission elements of like type
- Identify Application Elements
- Provide error detection of the Application Elements that may occur in transmission between the SBS SDP and the receiving system.

a. The format of the BSDU **shall [22]** be as described in Figure 3-1.

b. All Application Elements **shall [23]** be encapsulated in a Broadcast Services Data Unit

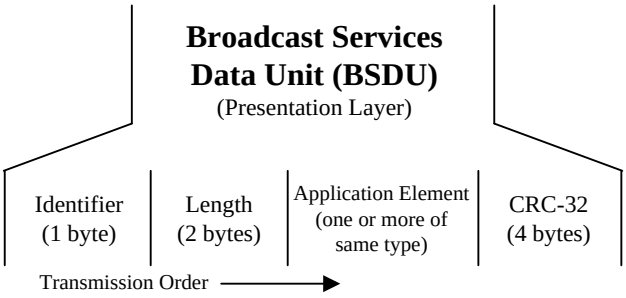


Figure 3-1: BSDU Construct

3.2.2.2.1.1 Identifier

This byte is used to distinguish between the different BSDU types indicated in Table 3-2 below. Since ADS-B Reports and Service Status Reports use the ASTERIX construction, the BSDU identifier is synonymous with the ASTERIX Category.

a. The SBS **shall [24]** assign an Identifier value per Table 3-2.

Table 3-2: BSDU ID Byte Values

Application Elements	Value (decimal)	Direction (To/From SBS)
ADS-B Reports	033	From
TIS-B Reports	033	From
FIS-B Reports	To Be Assigned	From
Service Status Reports	023	From
ADS-R ACK/NACK Reports	To Be Assigned	From
TIS-B/ADS-R Service Status Reports	To Be Assigned	From
WAM Report	010	From
WAM Service Status Report	019	From

3.2.2.2.1.2 Length

This is a two-byte field that gives the length in bytes of the BSDU components including, the Identifier, the Length, the Application Element, and the CRC field.

a. The SBS **shall [25]** encode the length in bytes of the BSDU components including the Identifier, Length, Application Element, and CRC field as a 16 bit binary integer with the Most Significant Byte transmitted first and the Least Significant Byte transmitted last.

3.2.2.2.1.3 Application Element

The encoding for each Application Element is given in Appendices to this document. The BSDU supports the packing of multiple Application Elements of the same type per ASTERIX construction rules in the EUROCONTROL document SUR.ET1.ST05.2000-STD-01-01 available on the EUROCONTROL website. ASTERIX based Application Elements contain the ASTERIX CAT and LEN fields and one or more ASTERIX records of the same CAT.

3.2.2.2.1.4 CRC-32

The CRC-32 algorithm has been derived from: Fletcher, J.G., "An Arithmetic Checksum for Serial Transmissions," IEEE Transactions on Communications, Vol. COM-30, No. 1, January 1982, pp. 247-252.

The following symbols are used:

C0, C1, C2, C3 are variables used by the algorithm;

"i" is the number (i.e., position) of an octet within the BSDU;

"L" is the Length of the BSDU, as described in Section 3.2.2.2.1.2; and

"Xj" is the value of the "jth" octet of the Extended 32-bit Checksum Parameter (in transmission order)

Arithmetic Conventions:

a. Addition **shall [26]** be performed in modulo 255.

b. The Extended 32-bit Checksum **shall [27]** be created by the following algorithm:

1. The Extended 32-bit Checksum Parameter value field set to ZERO will be set up
2. Initialize C1, C1, C2 and C3 to ZERO;
3. Process each octet in the BSDU sequentially from i=1 to "L" -4 (as defined in Section 3.2.2.2.1.2, but exclude the CRC) by:

   a. adding the value of the octet to C0; then

   b. adding the value of C0 to C1, C1 to C2, and C2 to C3;

4. Set the octets of the Extended 32-bit Checksum parameter as follows:

a. X0 = 255-(C0 + C1 + C2 + C3)-1;

b. X1 = C1 + 2*C2 + 3*C3;

c. X2 = 255-(C2 + 3*C3)-1; and

d. X3 = C3;

c. The Extended 32-bit Checksum **shall [28]** be validated as follows:

1. Initialize C0, C1, C2 and C3 to ZERO;
2. Process each octet in the BSDU sequentially from i=1 to "L" (see Section 3.2.2.2.1.2) by:
   a. adding the value of the octet to C0, then
   b. adding the value of C0 to C1, C1 to C2, and C2 to C3;
3. If, when all the octets have been processed, one or more of the variables C0, C1, C2 or C3 do not have the value ZERO, then the Checksum validation has failed.

3.2.2.2.2 Transport Layer and Network Services

a. All transport and network layer protocols **shall [29]** be in accordance with IETF STD 3 (RFC 1122 and RFC 1123).

b. User Datagram Protocol (UDP) **shall [30]** be implemented for the transport layer in accordance with IETF STD 6 (RFC 768).

Note: *The choice of UDP is consistent with the nature of a broadcast services / broadcast receipt system and with existing surveillance sensor backhaul protocols.*

c. The SBS **shall [31]** support both IP Versions 4 and 6 as a configuration item for the network layer in accordance with IETF STD 5 (RFC 791), as well as IETF RFC 2460, 2464, 4291, and 4443.

d. The SBS **shall [32]** support IP multicasting to conformance level 2 as per IETF STD 5 (RFC 1112).

Note: *This requires mandatory support of IP multicasting in IP Version 4. Support for IP multicasting in IPv6 is inherent to the IPv6 specification.*

e. The SBS/SDP **shall [33]** utilize a predefined transport layer port number and the network layer broadcast IP address of the subnet for each Application Element type supported.

f. The predefined transport layer port number **shall [34]** take the form of one of the following mutually exclusive configuration options:

   1. Each Application Element is sent on its own unique transport layer port.
   2. All Application Elements are sent on one common transport layer port.

   Note: *The SBS and SDP need not establish a Transport Layer connection since UDP is a connectionless unacknowledged protocol.*

g. The network **shall [35]** support Internet Control Message Protocol (ICMP) in accordance with IETF STD 5 (RFC 792).

h. Address Resolution Protocol (ARP) **shall [36]** be implemented in accordance with IETF STD 37 (RFC 826).

i. The network **shall [37]** support IETF STD 5 (RFC 922), broadcasting internet datagrams.

j. The network **shall [38]** support IETF STD 5 (RFC 950), internet standard subnetting procedure.

k. The SBS/SDP **shall [79]** utilize a unique multicast group IP address for each type of service provided when IP multicasting is used (e.g., ADS-B Service or WAM Service).

3.2.2.3 Medium Services

a. The data link layer **shall [39]** utilize the industry standard Ethernet in accordance with IEEE 802.3.

b. The data link layer implementation **shall [40]** be in accordance with IETF STD 41 (RFC 894) and IETF STD 43 (RFC 1042).

c. The physical layer **shall [41]** provide the bandwidth necessary to provide Reports to the SDP while meeting all performance requirements for the Service Volume.

3.2.3 Security

The SBS to SDP transmission security follows the IPsec standards, using authentication, encryption, and integrity to deliver an Encapsulated Security Payload (ESP) to the SDP. The interface from the SDP to the receiving system **shall [42]** be within a physically secured government facility staffed by cleared personnel. Protection for the interface is provided through the physical and personnel security measures.

3.2.4 Interface Design Characteristics Table

Table 3-3: Interface Requirements Table

Report Type	***Format***	***Type***	***Application Level Maximum Size without Buffering (bytes)***	***Transmission Frequency (peak)***
ADS-B Report	*FAA CAT033*	*Packed Binary*	*52*	*A function of the particular Service Volume (SV) or CTV*
TIS-B Report	*FAA CAT033*	*Packed Binary*	*51*	*A function of the particular SV*
FIS-B Report	*To be provided by the Service Provider*	*Packed Binary*	*To be provided by the Service Provider*	*A function of the particular SV*
Service Status Report	*FAA CAT023*	*Packed Binary*	*Variable*	*A function of the particular SV or CTV*
ADS-R ACK/NACK Report	*SBS SD ADS-R ACK/NACK*	*Packed Binary*	*19*	*A function of the particular SV*
TIS-B/ADS-R Service Status Report	*TIS-B/ADS-R Service Status for 1090-ES*	*Packed Binary*	*25*	*A function of the particular SV*
WAM Report	*FAA CAT010*	*Packed Binary*	*44*	*A function of the particular SV*
WAM Service Status Report	*FAA CAT019*	*Packed Binary*	*Variable*	*A function of the particular SV*

3.3 Physical Design Characteristics

The physical requirements for the SBS SDP interface will be as described below.

3.3.1 Electrical Power and Electronic Requirements/Characteristics

Electrical connection requirements for the Ethernet interfaces **shall [43]** be as specified in IEEE 802.3.

3.3.1.1 Connectors

The connectors used for the interfaces are described below.

3.3.1.1.1 Ethernet Connectors

a. For Ethernet connections, the SBS SDP **shall [44]** provide jacks for the attachment of standard RJ-45 connectors.

b. The Ethernet connectors **shall [45]** be secured by means of a tab on the connector which mates with the jack, thereby preventing improper attachment and preventing detachment during normal movement of the unit.

c. Connector wiring **shall [46]** be as specified by EIA/TIA connector wiring specification T568B.

Note: *Specification T568B is part of standard TIA/EIA-568-A.*

d. Each SBS SDP **shall [47]** provide a minimum of 10 Ethernet port connections.

3.3.1.1.2 Input Power Connectors

Power connectors **shall [48]** be compliant with FAA-G-2100H, §3.1.1.1.1.

3.3.1.2 Wiring/Cabling

Wiring and cabling used for the SBS SDP is described below. All cables located in the plenum area must be plenum rated.

3.3.1.2.1 Cabling for Ethernet

All cabling **shall [49]** be Cat 5e and conform to the specifications of IEEE-802.3.

3.3.1.3 Electrical Power Referencing (Grounding)

Within the electrical interfaces, grounding **shall [50]** comply with FAA-STD-019E, FAA-G-2100, and the respective IEEE specification.

3.3.1.4 Fasteners

All fasteners **shall [51]** be in accordance with FAA-G-2100.

3.3.1.5 Electromagnetic Compatibility

a. Electromagnetic emission and susceptibility of the SBS SDP equipment **shall [52]** be in accordance with Code of Federal Regulations Title 47 Part 15, for Class B digital devices for unintentional radiators.

3.3.1.6 Electrical Power Requirements

The following electrical power requirements apply only to the critical power bus connection in the facility. The SBS SDP power supply is up to the service provider, but must be implemented such that the availability requirements are met.

a. Power for the SBS SDP **shall [53]** be in accordance with FAA-STD-019E and FAA-G-2100.

b. Power consumption for the SBS SDP **shall [54]** not exceed 800 watts.

3.3.1.7 Seismic Requirements

The SBS SDP equipment seismic requirements **shall [55]** be in accordance with FAA-G-2100H.

3.3.2 Physical Equipment Requirements

a. All equipment used to implement the SBS SDP **shall [56]** be rack mountable in a single standard 19 inch rack that is 72 inches in height.

   Note: *This includes all primary and any redundant equipment.*

4 Quality Assurance Provisions

4.1 Responsibility for Verification

The test program will include both Service Provider and Government verification tests. The Government may delegate its verification activities to other organizations, independent contractors, and/or the Service Provider.

a. The Service Provider **shall [57]** develop and execute a quality assurance program that ensures all services provided meet all requirements specified in section 3, as modified by the contract, and continue to meet the specified requirements on an ongoing basis.

b. The Service Provider **shall [58]** execute a testing program that verifies the achievement of the requirements specified in section 3.

c. Upon successful completion of Service Provider and Government qualification tests, the service implementation provided by the Service Provider **shall [59]** be an approved baseline configuration.

d. Additional service volumes provided by the Service Provider **shall [60]** be of the same baseline configuration.

4.2 Special Verification Requirements

There are no special verification requirements.

4.3 Verification Requirements Traceability Matrix

The Service Provider **shall [61]** develop a VRTM to illustrate the compliance to all Section 3 requirements in this specification.

> ***Note:*** *The Service Provider is required by contract to deliver a VRTM (CDRL SV-1).*

4.3.1 Verification Levels

There are three test phases defined in the following sections. Each phase include tests events for which the Service Provider is responsible. The Service Provider's verification tests will include Service Provider Qualification Tests, Implementation Service Acceptance Tests, Life Cycle Tests (in the event of configuration changes from the approved baseline) and Service Performance Monitoring.

In the event that changes to the baseline configuration are required, the Service Provider **shall [62]** perform Government approved Service Re-qualification tests as defined below.

4.3.1.1 First Article

a. Upon successful completion of Service Provider and Government Qualification Tests, the service implementation provided by the Service Provider **shall [63]** be an approved baseline configuration.

b. Additional service volumes provided by the Service Provider **shall [64]** be of the same baseline configuration.

4.3.1.1.1 Service Provider Qualification Tests

4.3.1.1.1.1 Factory Acceptance Test (FAT)

a. The Service Provider **shall [65]** perform Factory Acceptance Tests to verify the functional and performance requirements of the service at the Service Provider's facility. The FAT may be conducted at the Service Provider's facility or some other Service Provider designated facility approved by the Government.

4.3.1.1.1.2 Service Integration Test (SIT)

a. The Service Provider **shall [66]** perform Service Integration Tests at the Government designated integration key site(s) to verify the hardware, software, and/or functional requirements necessary to integrate with each unique automation platform designated within the National Airspace System (e.g., SBS Monitor, ERAM, MEARTS, STARS and CARTS).

4.3.1.1.1.3 Service Acceptance Test (SAT)

a. The Service Provider **shall [67]** perform Service Acceptance Tests at key sites prior to independent testing and assessment by the Government. The SAT will be utilized in the implementation phase defined in section §4.3.1.2.

4.3.1.1.2 Government Qualification Tests

The Government may determine to utilize some of the results obtained during FAT, SIT and SAT to support the independent evaluation of the services.

4.3.1.1.2.1 End-to-End System Test (EEST)

a. At the completion of each key site SAT, the Government will conduct a performance assessment of the end-to-end services. The Service Provider will be required to provide assistance to the government in the conduct of this testing.

4.3.1.1.2.2 Operational Test and Evaluation (OT&E)

a. Upon the completion of EEST, the Government will conduct an operational user assessment of the services at the key site. The Service Provider will be required to provide assistance to the government in the conduct of this testing.

4.3.1.1.2.3 Independent Operational Test and Evaluation (IOT&E)

a. Tests conducted by the FAA Office of IOT&E after the service achieves Initial Operating Capability (IOC). The Service Provider will be required to provide assistance to the government in the conduct of this testing.

4.3.1.2 Implementation

4.3.1.2.1 Implementation Service Acceptance Test (ISAT)

a. The Service Provider **shall [68]** perform Implementation Service Acceptance Tests at each post-key site installation prior to independent testing and assessment by the Government.

4.3.1.2.2 Implementation System Test (IST)

a. At the completion of each ISAT, the Government will conduct a performance assessment of the End-to-End ADS-B and ADS-R services. The Service Provider will be required to provide assistance to the government in the conduct of this testing.

4.3.1.3 Life Cycle

4.3.1.3.1 Service Re-Qualification Test (SRQT)

a. The Service Provider **shall [69]** perform Service Re-Qualification Tests whenever the service baseline is modified.
b. The SRQT **shall [70]** verify that the service performance is maintained whenever changes are implemented by the Service Provider.

4.3.1.3.2 Service Performance Monitoring (SPM)

a. The Service Provider **shall [71]** perform Service Performance Monitoring Tests once a service volume is certified and operational.
b. SPM tests **shall [72]** verify the system continues to meet section 3 requirements on an ongoing basis.

4.3.1.3.3 Government Performance Monitoring (GPM)

a. The Government will independently monitor the performance of each service volume to ensure the service remains certified and operational.

4.3.2 Verification Methods

The acceptable methods for verifying each requirement are the following:

a. **Inspection**: This method is used to determine compliance without using special laboratory equipment, procedures, or services and consists of a nondestructive static-state examination of hardware, software, and/or technical data and documentation.

b. **Demonstration**: This is a method in which qualitative determination of properties is made for a configuration item, including software and/or the use of technical data and documentation. The items being verified are observed, but not quantitatively measured, in a dynamic state.

c. **Analysis**: This is a method in which hardware or software designs are compared with known scientific and technical principles, procedures, and practices to estimate the capability of the proposed design to meet the mission and system requirements.

d. **Test**: This is a method in which performance is measured during or after the controlled application of functional and/or environmental stimuli. Quantitative measurements are analyzed to determine the degree of compliance. The process uses standardized laboratory equipment, procedures, and/or services.

5 Preparation for Delivery

Not applicable as this is a service to system interface and no equipment will be delivered. Contractor equipment will reside in the FAA facility.

6 Notes

6.1 Definitions

Broadcast Services Data Unit (BSDU) – The BSDU is at the Presentation Layer and serves the following functions:

- Delimit Application Elements or to aggregate for transmission elements of like type
- Identify Application Elements
- Provide error detection of the Application Elements that may occur in transmission between the SBS SDP and the receiving system.

Composite Traffic Volume (CTV) – A collection of Service Volumes from which the data from each SV is aggregated and duplicate targets are filtered. The CTV can employ a geographic filter to select the desired area within which data will be provided.

Demarcation Point – The demarcation point is the point at which operational control or ownership of communications changes from one organizational entity to another.

Service – One of the five distinct services provided as part of SBS: ADS-B, TIS-B, FIS-B, ADS-R, and WAM.

Service Provider – The vendor or entity providing the SBS.

Service Volume (SV) – This is a geographically defined volume of airspace within which ADS-B services are provided.

6.2 Abbreviations and Acronyms

ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-R	Automatic Dependent Surveillance-Rebroadcast
ASDE-X	Airport Surface Detection Equipment – Model X
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
A/V	Aircraft/Vehicle
BSDU	Broadcast Services Data Unit
CARTS	Common Automated Radar Terminal System
CD	Common Digitizer
CRC	Cyclic Redundancy Check
EEST	End-to-End System Test
EPU	Estimated Position Uncertainty
ERAM	En Route Automation Modernization
FAA	Federal Aviation Administration
FAT	Factory Acceptance Test
FIS-B	Flight Information Service - Broadcast
FRN	Field Reference Number
FSPEC	Field Specification (ASTERIX)
FX	Field Extension
GNSS	Global Navigation Satellite System
GPM	Government Performance Monitoring
GPS	Global Positioning System
HAE	Height Above Ellipsoid
HDOP	Horizontal Dilution of Position
HFOM	Horizontal Figure of Merit
HPL	Horizontal Protection Limit
IOT&E	Independent Operational Test and Evaluation
in. Hg.	Inches of mercury
IP	Internet Protocol
IRD	Interface Requirements Document
ISAT	Implementation Service Acceptance Test
IST	Implementation System Test
LSB	Least Significant Bit
MEARTS	Microprocessor En Route Automated Radar Tracking System
MSB	Most Significant Bit
MST	Multi Sensor Tracker
NAC	Navigation Accuracy Categories
NAC_p	Navigation Accuracy Categories for position
NAC_v	Navigation Accuracy Categories for velocity
NAS	National Airspace System
NIC	Navigation Integrity Categories
OT&E	Operational Test and Evaluation
PDOP	Percent Dilution of Position

RNP	Required Navigational Performance
Rpt	Report
SA	Selective Availability
SAC	System Area Code
SAT	Service Acceptance Test
SBS	Surveillance and Broadcast Services
SBSS	Surveillance and Broadcast Services System
SDA	System Design Assurance
SDP	Service Delivery Point
SIC	System Identification Code
SIL	Surveillance Integrity Levels
SIT	Service Integration Test
SPM	Service Performance Monitor
SRQT	Service Re-Qualification Test
STARS	Standard Terminal Automation Replacement System
TIS-B	Traffic Information Service-Broadcast
TOA	Time of Applicability
TOMR	Time of Message Reception
TPM	Technical Performance Measure
UAT	Universal Access Transceiver
UDP	User Datagram Protocol
UTC	Universal Coordinated Time
VFOM	Vertical Figure of Merit
VHP	Very High Power
VPL	Vertical Protection Limit
VRTM	Verification Requirements Traceability Matrix
WAAS	Wide Area Augmentation System
WAM	Wide Area Multilateration

Appendix A FAA Category 023 Format

A.1 Message Structure

The ASTERIX CAT023 Report is an Application Element in the BSDU. ASTERIX based Application Elements contain the ASTERIX CAT and LEN fields and one or more ASTERIX records (FSPEC and the specified Field Reference Numbers (FRN)) of the same Report type (i.e., Service Status Report) (See SUR.ET1.ST05.2000-STD-01-01, Figure 2).

The FRN establishes the order of the items in the FSPEC, and along with the Category code, serves to uniquely identify each data item. The FSPEC is the first byte(s) of the Report and indicates which FRNs are present in the Report (1=FRN is included, 0=FRN is not included). Within each data item, byte 1 is transmitted first. "FX" is the Field Extension bit. A one in this bit indicates that the field extends into the next byte. As twenty FRNs are identified for the Service Status Report, up to three bytes are required for the FSPEC depending on the information to be reported.

Service Status Report Construction Example (Equipment Context)

Time →

FSPEC	***FRN 1*** *Service Volume Identifier*	***FRN 2*** *Version Number*	***FRN 3*** *Time of Status Report*	***FRN 4*** *Transmitter / Receiver Status*	***FRN 5*** *Internal GPS Integrity and Accuracy Parameters*	***FRN 6*** *Latitude/ Longitude*

F1	***F2***	***F3***	***F4***	***F5***	***F6***	***F7***	***FX***
1	*1*	*1*	*1*	*1*	*1*	*0*	*0*

A.2 User Application Profile and Construction for the FAA CAT023 Service Status Report

The FAA CAT023 format is used to report service-related status in one of 5 distinct contexts: 1) an equipment (transmitter/receiver) context on a periodic basis, 2) a service volume context on a periodic basis, 3) a TIS-B sensor/tracker context only when a fault condition exists, 4) a ADS-B SDP context on a periodic basis for each Automation SDP, to be delivered to the SBS Monitor, and 5) a WAM SDP context on a periodic basis for each Automation SDP. Each FAA CAT023 report will address only one context. The FRNs included in the FAA CAT023 vary depending on the context being reported. Table A-1 identifies the FRNs and also when they are included in the Report. The Data Source Qualifier identifies either equipment (transmitter, receiver, transmitter/receiver combination or a single SDP.

Table A-1: FAA CAT023 (v3) User Application Profile and Construction

FRN	Data Item	Length in Bytes (when present)	Criteria for Inclusion: A=Always; x=Never				
			Equipment Context (Tx/Rx)	SV/CTV Context	TIS-B Sensor Context	SDP (ADS-B) Context	SDP (WAM) Context
1	Service Volume Identifier (§A.3.1)	2	A	A	A	A	A
2	Version Number (§A.3.2)	1	A	A	A	A	A
3	Time of Status Report (§A.3.3)	3	A	A	A	A	A
4	Transmitter/Receiver Status (§A.3.4)	6	A	x	x	x	x
5	Internal GPS Integrity and Accuracy Parameters (§A.3.5)	2	A	x	x	x	x
6	Latitude/Longitude (§A.3.6)	6	A	x	x	x	x
7	ADS-B Reports Discarded (§A.3.7)	2	x	A	x	x	x
8	TIS-B Messages Discarded (§A.3.8)	2	x	O (note 2)	x	x	x
9	UAT Ground Uplink Messages Discarded (§A.3.9)	2	x	O (note 2)	x	x	x
10	ADS-R/TIS-B Messages Transmitted (§A.3.10)	2	x	O (note 2)	x	x	x
11	UAT Ground Uplink Messages Transmitted (§A.3.11)	2	x	O (note 2)	x	x	x
12	ADS-B Messages Received and Sent to the SDP (§A.3.12)	2	x	A	x	x	x
13	Service Status (§A.3.13)	4	x	A	x	x	x
14	1090ES Position Outlier Count (§A.3.14)	2	x	A	x	x	x
15	TIS-B Sensor Status (§A.3.15)	5	x	x	A	x	x
16	Data Source Qualifier (§A.3.16)	3	A	x	A	A	A
17	ADS-R Messages Discarded (§A.3.17)	2	x	O (note 2)	x	x	x
18	SDP Status (§A.3.18)	1	x	x	x	A	A
19	SDP Message Count (§A.3.19)	7	x	x	x	A	x
20	ADS-B Duplicate Reports Discarded (§A.3.20)	3	x	A	x	x	x
21	WAM SDP Message Count (§A.3.21)	9	x	x	x	x	A

Notes:

1. *Systems receiving FAA CAT023 Reports must parse the FSPEC for proper decoding since some Data Items are optional in any given report.*

2. *The FRNs designated optional in the Service Volume Context are not included when the applicable services are not supported in the service volume.*

A.3 Format and Encoding of FAA CAT023 (V 3) Data Items

A.3.1 FRN 1: Service Volume Identifier (SVID)

Definition: Identification of the Service Volume or CTV supplying the data.

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb							Lsb	Msb							Lsb
—SAC--								--SIC--							

Encoding:
SAC - The SAC consists of a two-digit hexadecimal encoded data number as defined in the ASTERIX Standard. SAC codes hexadecimal A0-C3 and DA-DF are reserved for the US. The SAC codes are assigned as follows:

Bits 16/13: Service Area

- Eastern Service Area: 0xA
- Western Service Area : 0xB
- Composite Traffic Volume: 0xC
- Central Service Area: 0xD

Note: *CTVs may cover multiple Service Areas. Therefore, CTVs have been assigned a unique value to indicate this case.*

Bits 12/9: Domain

- CTV feeding an En Route SDP: 0x1
- CTV feeding a Terminal SDP: 0x2
- CTV feeding a User Defined SDP: 0x3
- En Route Class A: 0xA
- Terminal Class B: 0xB
- Terminal Class C: 0xC
- Terminal Class D: 0xD
- Terminal Other: 0xE
- Surface: 0xF

Bits 8/1: The SIC is a unique numerical identifier for service volumes or composite traffic volumes of each Domain – up to 255 individual codes can be assigned.

Notes:

1. *See the SBS Service Volume Definition Document (SVDD) spreadsheet for the Service Volume Identifier assigned to each Service Volume. Examples are as follows:*

   - *Phoenix Terminal is SVID #1 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB01*

   - *LAX Terminal is SVID #2 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB02*

   - *ZAB (Albuquerque) is SVID #154 in the SVDD spreadsheet. This is in the Western Service Area and En Route Class A airspace. The SAC/SIC code would be: BA9A. It is the first En Route SV in the SVDD that falls in the Western Service Area.*

2. *For CTVs, the SAC field will be based upon the CTV identifier within the Service Area sub-field (0xC), the SDP being provided the CTV data, and the SIC field will be a unique identifier that will be determined when the CTV is defined.*

Note: *The SVID field is applied as follows:*

CAT 023 Message Context	***Description***
Equipment	*The SVID is that of the Service Volume in which the radio receiver resides. If a radio receiver supports multiple Service Volumes, an Equipment Context report is sent for each Service Volume with a different SVID. If a radio receiver supports a CTV, the SVID is set to a unique identifier for the CTV.*
Service Volume/ Composite Traffic Volume	*The SVID is that of the reporting Service Volume or Composite Traffic Volume.*
TIS-B Sensor	*The SVID is that of the En Route Service Volume over which the Sensor provides coverage. If the Sensor provides coverage within more than one En Route SV, multiple copies of each Report are made by the TIS-B Server and sent with different En Route SVIDs. The stream of Sensor Context Reports is sent within the Monitor multicast for the applicable En Route SV.*
SDP (ADS-B)	*The SVID is that of the Service Volume or Composite Traffic Volume in which ADS-B Reports are being delivered to the Automation SDP.*
SDP (WAM)	*The SVID is that of the Service Volume in which WAM Reports are being delivered to the Automation SDP.*

A.3.2 FRN 2: Version Number

Definition: Version of this FAA CAT023 format.
Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Reserved bit	Reserved bit	Version Status	Msb				Lsb
			Version Number				

Encoding:
Bits 8/7: Reserved bits set to ZERO (0).
Bit 6: ZERO (0) = Version is for operational use;
ONE (1) = Version is for experimental use only.
Bits 5/1: FAA CAT023 Version Number encoded as binary numeral in the range of 1 to 31 (Value of ZERO (0) represents "unknown" version regardless of "Version Status").

FAA CAT023 messages conforming to this document will be encoded with the value THREE (3) in the Version Number field (Bits 5/1).

Notes:

1. *This provides an upgrade path for evolution of this Category, without incrementing the Category number modulo 32.*

A.3.3 FRN 3: Time Of Status Report

Definition: Time at which the report information was recorded.
Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Msb --Time of Status Report--							

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--Time of Status Report-- Lsb															

Encoding:
Bits 24/8: Whole seconds elapsed since UTC midnight binary encoded
Bits 7/1: Fractional seconds elapsed since UTC midnight binary encoded

Notes:

1. *The time of the day value is reset to 0 at every midnight. The time of the day is specified in UTC.*

2. *The Lsb represents 1/128 of a second.*

A.3.4 FRN 4: Transmitter/Receiver Location Identification (ID) Status

Definition: Reports of the Location ID and status of the Transmitter/Receiver functional elements. The Location ID is that of the radio station, and is specified in five bytes in ASCII format. A sixth byte provides the status of the specified transmitter/receiver channel. Each Radio Station has multiple transmitter/receiver channels. Multichannel radios have four 1090ES channels and one UAT channel. Single channel radios have one 1090ES channel and one UAT channel. Each of these channels at a radio station has the same ASCII Location ID, but each is uniquely defined by the Data Source Qualifier (DSQ) in FRN 16 of the Equipment Status Report. When a radio station is configured with a Backup radio, the radio channel is redundant; one is chosen by the SBSS as Primary and one as Backup. Both the Primary and Backup channels have the same the DSQ. This FRN 4 reports on the level of redundancy for the radio channel.

Structure: Six bytes fixed length data item.

Byte 1								**Byte 2**							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
Msb Location ID (ASCII Character 5) Lsb								Msb Location ID (ASCII Character 4) Lsb							
Byte 3								**Byte 4**							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Msb Location ID (ASCII Character 3) Lsb								Msb Location ID (ASCII Character 2) Lsb							

Byte 5							
16	15	14	13	12	11	10	9
Msb Location ID (ASCII Character 1) Lsb							

Byte 6							
8	7	6	5	4	3	2	1
Timing Status	Receiver Status	Transmitter Status	Alarm	Msb Mode		Lsb	Alert

Encoding:
Bits 48/41: Location ID Character 5 (ASCII) - first character as you read (right-to-left)
Bits 40/33: Location ID Character 4 (ASCII)
Bits 32/25: Location ID Character 3 (ASCII)
Bits 24/17: Location ID Character 2 (ASCII)
Bits 16/9: Location ID Character 1 (ASCII) – last character as you read (right-to-left)

Note: *(Character 1 is the first character in the string, Character 5 is the last).*

Bit 8: Timing Status of the Primary Radio Channel: ONE = UTC coupled; ZERO = non-UTC coupled (i.e., coasting)

Bit 7: Receiver Status of the Primary Radio Channel: ONE = Normal; ZERO = Alarm condition (i.e., Radio -detected fault)

Bit 6: Transmitter Status of the Primary Radio Channel: ONE = Normal; ZERO = Alarm condition (i.e., Radio -detected fault)

Bit 5: Alarm Status: ONE = Primary Channel Timing, Receiver and Transmitter Status is normal and Mode (bits 4/2) is ONLINE; ZERO = Timing, Receiver, or Transmitter Status of Primary Channel is not normal (i.e. one or more of the status files bits 8/6 are set to ZERO) or Mode (bits 4/2) is OFFLINE, then Alarm Status field is set to ZERO.

Bits 4/2: Mode: (see table below)

Bit 1: Alert Status: provides status of the Backup Radio Channel
If the Radio Station is configured without a Backup Radio, Alert=ONE
If the Radio Station is configured with a Backup Radio:

- Alert=ONE if the Backup Radio Channel is not alarmed (Timing, Receiver and Transmitter Status are normal and Backup Radio ADS-B mode is ONLINE)
- Alert=ZERO if the Backup Radio Channel is alarmed (Timing, Receiver or Transmitter Status of Backup Radio Channel is not normal or Backup Radio ADS-B mode is OFFLINE)

Mode Bits Msb Lsb	**Meaning**
000	Primary Radio ADS-B in Offline State of Operational Mode (failed self test or commanded offline)
001	Primary Radio ADS-B in Online State of Operational Mode (passes self test)
010	Primary Radio in Test Mode
011-111	Not Offered

Notes:

1. *Only the On Line and Test mode is reportable in a Status report since only the equipment providing operational data (Reports) output sends Status reports.*

2. *This field represents the overall unit state if Tx/Rx are combined.*

A.3.5 FRN 5: Internal GPS Indicators of GPS System Health Status

Definition: This data item conveys the GPS system health parameters reported by the transmitter/receiver internal GPS timing source.

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb		Lsb	Msb	Lsb	Msb									Lsb	
RCVR Status			Antenna		Geometry										reserved

Encoding:

Bits 16-14: GPS Receiver Status

Status bits (Msb Lsb)	Meaning
111	3D Fix
110	2D Fix
101	Propagate Mode
100	Position Hold
011	Acquiring Satellites
010	Bad Geometry
001	Reserved
000	Not Receiving Status Message from GPS Module (ignore remainder of FRN 5)

Bits 13-12: Antenna Sense

Antenna Sense (Msb Lsb)	Meaning
00	OK
01	Over Current
10	Under Current
11	No Voltage

Bits 11-2: Geometry (PDOP for 3D fix, HDOP for 2D fix)

Geometry Msb Lsb	**Meaning**
0000000000	0.0
0000000001	0.1
0000000010	0.2
…	…
1111100101	99.7
1111100110	99.8
1111100111	99.9

Bit 1: Reserved bit always set to ZERO.

A.3.6 FRN 6: Latitude and Longitude

Definition: Latitude and longitude position as determined from the survey location.
Structure: Six byte fixed length data item.

Byte 1								Byte 2							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
Msb --Latitude--															
Byte 3								**Byte 4**							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
--Latitude-- Lsb								Msb --Longitude--							
Byte 5								**Byte 6**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--Longitude-- Lsb															

Encoding:
Bits 48/1: Latitude and Longitude

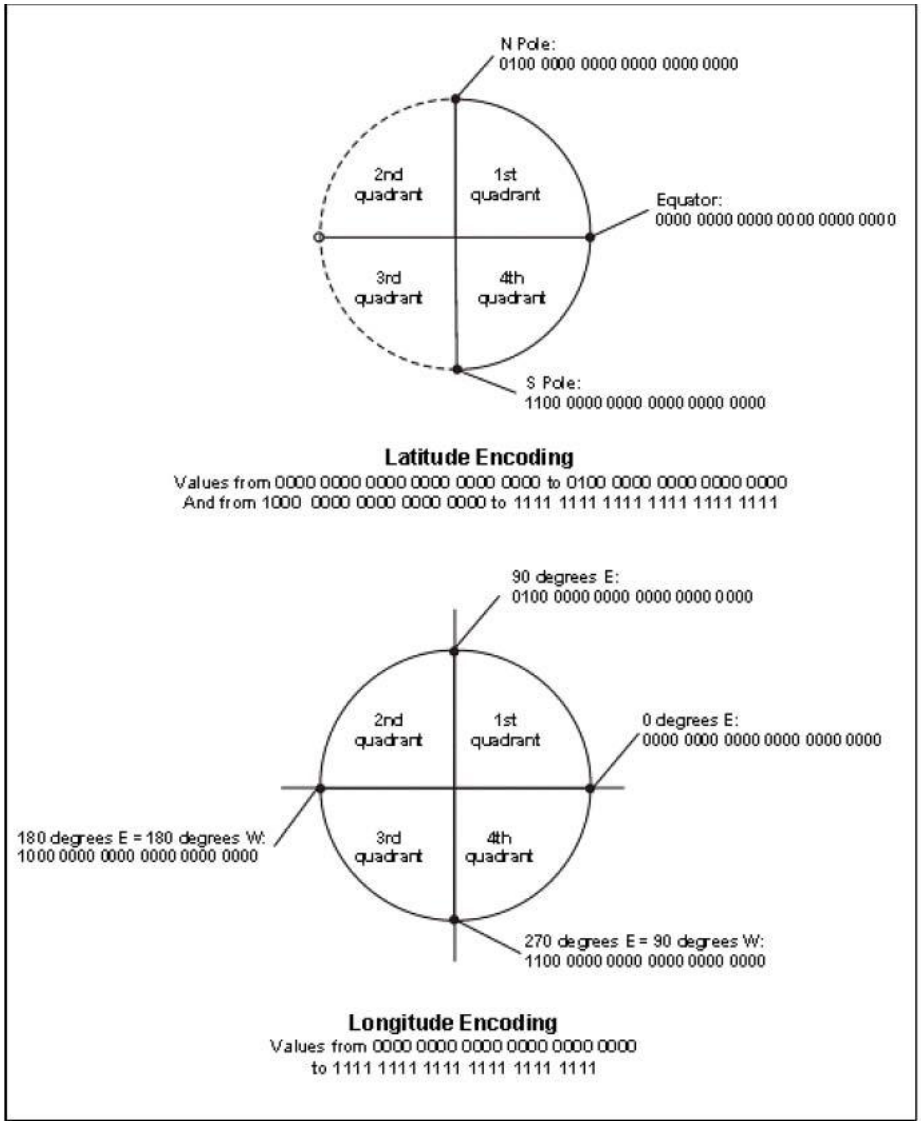
LATITUDE AND LONGITUDE

Quadrant	Latitude or Longitude bits (Msb … Lsb)	Meaning $INCR = Lsb = \frac{360}{2^{24}} = 0.0000214_6$	
		Latitude	**Longitude**
1st quadrant	0000 0000 0000 0000 0000 0000	ZERO degrees (Equator)*	ZERO degrees (Prime Meridian)*
	0000 0000 0000 0000 0000 0001	*INCR* degrees North	*INCR* degrees East
	…	…	…
	0011 1111 1111 1111 1111 1111	(90-*INCR*) degrees North	(90-*INCR*) degrees East
2nd quadrant	0100 0000 0000 0000 0000 0000	90 degrees North (North Pole)	90 degrees East
	0100 0000 0000 0000 0000 0001	<Illegal Values>	(90+*INCR*) degrees East
	…	<Illegal Values>	…
	0111 1111 1111 1111 1111 1111	<Illegal Value>	(180-*INCR*) degrees East
3rd quadrant	1000 0000 0000 0000 0000 0000	<Illegal Value>	180 degrees East or West
	1000 0000 0000 0000 0000 0001	<Illegal Value>	(180-*INCR*) degrees West
	…	<Illegal Values>	…
	1011 1111 1111 1111 1111 1111	<Illegal Values>	(90+INCR) degrees West
4th quadrant	1100 0000 0000 0000 0000 0000	90 degrees South (South Pole)	90 degrees West
	1100 0000 0000 0000 0000 0001	(90-*INCR*) degrees South	(90-*INCR*) degrees West
	…	…	…
	1111 1111 1111 1111 1111 1111	*INCR* degrees South	*INCR* degrees West

** "Position Unavailable" is encoded as ALL ZEROs for Lat, Lon, NIC, and NAC_P simultaneously*

Note:

1. *This encoding is consistent with that of GPS/GNSS avionics providing Latitude/Longitude inputs to ADS-B (ARINC data labels 110, 111, 120,121). It is also illustrated in the figure below.*



A.3.7 FRN 7: ADS-B Reports Discarded

Definition: A count of ADS-B Reports that were discarded this Status reporting interval (time since the last Service Volume Context Report was sent). These discards are due to the following conditions:

- Bandwidth overload
- Latent reports from an RS
- Erroneous Reports including checksum or other errors in data

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Discard Count--														Lsb

Encoding:

Bit 16/1: Count of discarded ADS-B Reports this Status reporting interval binary encoded

A.3.8 FRN 8: TIS-B Messages Discarded

Definition: A count of TIS-B Messages that were discarded this Status reporting interval.

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Discard Count--														Lsb

Encoding:

Bit 16/1: Count of discarded TIS-B Messages this Status reporting interval binary encoded

A.3.9 FRN 9: UAT Ground Uplink Messages Discarded

Definition: A count of UAT Ground Uplink Messages that were discarded this Status reporting interval.
Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Discard Count--														Lsb

Encoding:
Bit 16/1: Count of discarded UAT Ground Uplink Messages this Status reporting interval binary encoded

A.3.10 FRN 10: ADS-R/TIS-B Messages Transmitted

Definition: A count of ADS-R/TIS-B Messages that were transmitted this Status reporting interval.
Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Transmit Count--														Lsb

Encoding:
Bit 16/1: Count of ADS-R/TIS-B Messages transmitted this Status reporting interval binary encoded

A.3.11 FRN 11: UAT Ground Uplink Messages Transmitted

Definition: A count of UAT ground uplink messages that were transmitted this Status reporting interval.
Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Transmit Count--														Lsb

Encoding:
Bit 16/1: Count of UAT ground uplink messages transmitted this Status reporting interval binary encoded

A.3.12 FRN 12: ADS-B Messages Received and Sent to the SDP

Definition: A count of ADS- B Messages that were received and sent to the SDP this Status reporting interval.
Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--ADS-B Report Count to the SDP--														Lsb

Encoding:
Bit 16/1: Count of ADS- B Messages received and sent to the SDP this Status reporting interval binary encoded

Note: *This field contains the count of the ADS-B reports that were placed onto the multicast address for the SDP receiving the Category 033 data. This report count is based upon the messages received by the radio stations supporting the SDP which generated reports that were placed onto the multicast address. It does not include counts of duplicates or other reports which were filtered from the data stream and not sent to the SDP.*

A.3.13 FRN 13: Service Status

Definition: Service Volume Status information.
Structure: Four byte fixed length data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
ADS-B UAT Status				ADS-B 1090ES Status				ADS-R UAT Status				ADS-R 1090ES Status			

Byte 3								Byte 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TIS-B UAT Status				TIS-B 1090ES Status				FIS-B Status				Reserved			

Encoding:

Bit 32/29: ADS-B UAT Status
Bit 28/25: ADS-B 1090ES Status
Bit 24/21: ADS-R UAT Status
Bit 20/17: ADS-R 1090ES Status

} → Status Encoding →

0000 = Operational -Off-line
0001 = Operational -On-line
0010 = Test
0011 = Not Offered
0100 = Operational - Degraded
0101 – 1111 = Reserved

Bit 16/13: TIS-B UAT Status
Bit 12/9: TIS-B 1090ES Status
Bit 8/5: FIS-B Status

Bits 4/1: Reserved bits set to ALL ZEROs

Note 1: *The status reported includes Mode & Status information. Mode is defined to be a condition that a Service Volume or Composite Traffic Volume is placed in that drives its behavior. Operational, Test and Not Offered are assumed to be different Modes; Status is defined as a condition synonymous with state – it describes Status of the Operational Mode. Online, Offline and Degraded are States of the Operational Mode.*

Note 2: *The overall service status can be interpreted as follows:*

- *Operational – On-line: when the Service status for a given link technology configured as Operational, and is provided everywhere in the Service Volume or Composite Traffic Volume.*
- *Operational – Degraded: when the Service status for a given link technology is configured as Operational, and is not being provided in some portion of the Service Volume or Composite Traffic Volume.*
- *Operational – Off-line: when the Service status for a given link technology is configured as Operational, and is not being provided anywhere in the Service Volume or Composite Traffic Volume.*
- *Test: when the Service Mode for a given link technology is configured as "Test";*
- *Not Offered: when either the Service at UAT or 1090ES is "Not Offered".*

A.3.14 FRN 14: 1090ES Position Outlier Count

Definition: A count of messages containing position information identified as position outliers received on 1090ES this Status reporting interval.
Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Count--														Lsb

Encoding:
Bit 16/1: Count of messages containing position information identified as position outliers on 1090ES this Status reporting interval binary encoded

A.3.15 FRN 15: TIS-B Sensor Status

Definition: An indication of TIS-B sensor status. *(note 1)*

Structure: Fixed length data item.

Byte 1								Byte 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
Msb Sensor ID (ASCII Character 4) Lsb								Msb Sensor ID (ASCII Character 3) Lsb							

Byte 3								Byte 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb Sensor ID (ASCII Character 2) Lsb								Msb Sensor ID (ASCII Character 1) Lsb							

Byte 5							
8	7	6	5	4	3	2	1
Reserved bit	Reserved bit	Sensor Type		Reserved bit	Fault Condition		FX

Encoding:
Bits 40/33: Sensor ID Character 4 (ASCII) (Null for sensors having 3 char ID's) – first character (when reading from right-to-left)
Bits 32/25: Sensor ID Character 3 (ASCII)
Bits 24/17: Sensor ID Character 2 (ASCII)
Bits 16/9: Sensor ID Character 1 (ASCII) – last character (when reading from right-to-left)

Note: *(Character 1 is the first character in the string, Character 4 is the last)*

Bits 8/7: Reserved, set to ALL ZEROs
Bits 6/5: Sensor Type
Bit 4: Reserved, set to ZERO
Bits 3/2: Fault condition
Bit 1: FX
0 = End of data item

1 = Extension into next extent (e.g., next error condition)

Note:

1. *This data item is populated by the TIS-B service provider rather than a surveillance sensor.*

A.3.16 FRN 16: Data Source Qualifier

Definition: Identification of the data source supplying status data.

Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Msb Reserved		Lsb	Msb Equipment Type				Lsb

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb Location Identifier							Lsb	Msb Instance							Lsb

Encoding:
Bits 24/22: Reserved bits, always set to binary 111.

Bits 21/17: Type of Equipment

Bits 16/5: Location Identifier: binary coded integer corresponding to a "facility" (similar to FAA LID). Unique assignment for each radio station.

Bits 4/1: Instance: binary coded equipment instance number.

Note: *The Data Source Qualifier field is applied as follows:*

Message Context	***Description***
Equipment	*Radio receiver identification*
Service Volume	*Not used*
TIS-B Sensor	*Sensor that triggered the Report*
SDP (ADS-B)	*Specifies the applicable SDP*
SDP (WAM)	*Specifies the applicable SDP*

A.3.17 FRN 17: ADS-R Messages Discarded

Definition: A count of ADS-R Messages that were discarded this Status reporting interval.
Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Discard Count--														Lsb

Encoding:
Bit 16/1: Count of discarded ADS-R Messages this Status reporting interval binary encoded

A.3.18 FRN 18: SDP Status

Definition: Reports the status of an SDP.
Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Reserved			SDP Alarm	Reserved			SDP Alert

Encoding:
Bit 8/6: Reserved
Bit 5: SDP Alarm: ONE = Normal, ZERO = SDP unable to report reliable status and/or counts
Bits 4/2: Reserved
Bit 1: SDP Alert Status: Notifies recipient if SDP is operating on redundant equipment rather than on primary equipment. ONE = Normal; ZERO = Operational on backup.

A.3.19 FRN 19: SDP Message Counts

Definition: A count of the number of reports received by the SDP during the status reporting interval for each data type to be received by Automation. Counts include all Reports on the designated port (i.e. Test Message Reports and Reports with Duplicate Address Flag) for a particular Service Volume. Counts are cumulative from the time the last SDP Message Count Report was sent. Reports are generated every 5 ± 2 seconds.

Structure: Seven byte fixed length data item.

Byte 1								Byte 2							
56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41
Msb	-- ADS-B UAT Count--														Lsb

Byte 3								Byte 4							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
Msb	--ADSB 1090ES Count--														Lsb

Byte 5								Byte 6							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb	--Equipment Status Count--														Lsb

Byte 7							
8	7	6	5	4	3	2	1
Msb	--Service Volume Status Count						Lsb

Encoding:

Bit 56/41: ADS-B UAT Count is the total number of ADS-B UAT reports (including test target reports) received by the SDP during the reporting interval.

Bit 40/25: ADS-B 1090ES Count is the total number of ADS-B 1090ES reports (including test target reports) received by the SDP during the reporting interval.

Bit 24/9: Equipment Status Count is the total number of equipment context status messages received by the SDP during the reporting interval.

Bits 8/1: Service Volume or Composite Traffic Volume Status Count is the total number of service context status messages received by the SDP during the reporting interval.

A.3.20 FRN 20: ADS-B Duplicate Reports Discarded

Definition: A count of ADS-B Duplicate Reports that were discarded this Status reporting interval (time since the last Service Volume Context Report was sent). These discards are due to the following conditions:

- Duplicate Report seen by multiple radios that are not sent to automation SDPs
- Reports discarded to ensure target report rate to the SDP is not more than 1 per second.

Structure: Three byte fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb --Duplicate Discard Count--															

Byte 3							
8	7	6	5	4	3	2	1
--Duplicate Discard Count--							Lsb

Encoding:

Bit 24/1: Count of discarded duplicate ADS-B Reports this Status reporting interval binary encoded

A.3.21 FRN 21: WAM SDP Message Count

Definition: A count of the number of reports received by the SDP during the status reporting interval for each data type to be received by automation. Counts include all reports on the designated port for a particular Service Volume. Counts are cumulative from the time the last WAM SDP Message Count Report was sent. Reports are generated every 5 ± 2 seconds.

Structure: Nine byte fixed length data item.

Byte 1								Byte 2							
72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57
Msb WAM Target Report Count - ATCRBS															

Byte 3								Byte 4							
56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41
WAM Target Report Count - UAT															

Byte 5								**Byte 6**							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
WAM Target Report Count – 1090ES															

Byte 7								**Byte 8**							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
WAM Target Report Count – Mode-S															

Byte 9							
8	7	6	5	4	3	2	1
WAM Status Report Count							Lsb

Encoding:

Bits 72/57 WAM Target Report Count for Link Technology is the total number of WAM Target reports (including Certification Target reports) received by the SDP via ATCRBS during the reporting interval.

Bits 56/41 WAM Target Report Count for UAT Link Technology is the total number of WAM Target reports (including Certification Target reports) received by the SDP via UAT during the reporting interval.

Bits 40/25 WAM Target Report Count for 1090ES Link Technology is the total number of WAM Target reports (including Certification Target reports) received by the SDP via 1090ES during the reporting interval.

Bits 24/9 WAM Target Report Count for Mode S Link Technology is the total number of WAM Target reports (including Certification Target reports) received by the SDP via Mode S during the reporting interval.

Bits 8/1: WAM Status Report Count is the total number of WAM status reports received by the SDP during the reporting interval.

Appendix B – FAA Category 033 Format

B.1 Message Structure

The ASTERIX CAT033 Report is an Application Element in the BSDU. ASTERIX based Application Elements contain the ASTERIX CAT and LEN fields and one or more ASTERIX records (FSPEC and the specified Field Reference Numbers (FRN)) of the same Report type (i.e., ADS-B Report, TIS-B Report) (See SUR.ET1.ST05.2000-STD-01-01, Figure 2).

The FRN establishes the order of the items in the FSPEC, and along with the Category code, serves to uniquely identify each data item. The FSPEC is the first byte(s) of the Report and indicates which FRNs are present in the Report (1=FRN is included, 0=FRN is not included). Within each data item, byte 1 is transmitted first. "FX" is the Field Extension bit. A one in this bit indicates that the field extends into the next byte. As twenty-four FRNs are identified for the ADS-B Report, four bytes are required for the FSPEC depending on the information to be reported.

ADS-B/TIS-B Report Construction Example

Time →

FSPEC	***FRN 1*** *Service Volume Identifier*	***FRN 2*** *Version Number*	***FRN 3*** *Link Technology Indicator*	***FRN4*** *Time of Applicability*	***FRN 5*** *Target Address*	***FRN 6*** *Integrity and Accuracy Parameters*	***FRN 7*** *Latitude/ Longitude*	***FRN 8*** *Pressure Altitude*	***FRN 9*** *Velocity (Airborne)*	***FRN 18*** *Time of Message Reception*

F1	***F2***	***F3***	***F4***	***F5***	***F6***	***F7***	***FX***	***F8***	***F9***	***F10***	***F11***	***F12***	***F13***	***F14***	***FX***	***F15***	***F16***	***F17***	***F18***	***F19***	***F20***	***F21***	***FX***
1	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*

B.2 User Application Profile and Construction for the FAA CAT033 ADS-B Report

Table B-1: FAA CAT033 (v3) User Application Profile and Construction

FRN	Data Item	Length in Bytes (when present)	Criteria for Inclusion: A=Always, O=Optional, x=Never				
			ADS-B	1090 Test Rpt	UAT Test Rpt	TIS-B Rpt (A)	TIS-B Rpt (B)
1	Service Volume Identifier	2	A	A	A	A	A
2	Version Number	1	A	A	A	A	A
3	Link Technology Indicator	1	A	A	A	A	A
4	Time of Applicability	4	A	A	A	A	A
5	Target Address	4	A	A	A	A	A
6	Integrity and Accuracy Parameters	3	A	A	A	A	A
7	Latitude/Longitude	6	A	A	A	A	A
8	Pressure Altitude	2	A	A	A	A	A
9	Velocity (Airborne)	5	O (note 2)	A	A	O (note 2)	O (note 2)
10	Velocity (Surface)	4	O (note 2)	x	x	O (note 2)	O (note 2)
11	Mode 3/A Code	2	O (note 3)	x	x	O (note 6)	O (note 7)
12	Target Identification	6	O (note 3)	x	x	O (note 6)	O (note 6)
13	Emitter Category	1	O (note 3)	x	x	O (note 6)	O (note 6)
14	Target Status	1	O (note 3)	A	x	O (note 6)	O (note 6)
15	Geometric Altitude	2	O (note 3)	x	x	O (note 6)	O (note 6)
16	Modes and Codes	2	O (note 3)	x	x	O (note 6)	O (note 6)
17	TCAS RA Messages	6	O (note 4)	x	x	x	x
18	Time of Message Reception	4	A	A	A	x	x
19	GPS Antenna Offset	1	O (note 8)	x	x	x	x
20	Target State Data	5	O (note 9)	x	x	x	x
21	ADS-B Data Quality Parameters	2	A	A	A	x	x
22	Data Source Qualifier	3	A	A	A	A	A
23	Report Identifier	3	A	A	A	A	A
24	Time of Origination	3	x	x	x	A	A

Notes:

1. *Systems receiving FAA CAT033 Reports must parse the FSPEC for proper decoding since some Data Items are optional in any given report.*
2. *One form of velocity (FRN 9 OR 10) is required in every report.*

3. *Required for 1090ES and UAT only when at least one element of the FRN is within the validity period. Present for TIS-B if ADS-B fused track and data is available.*
4. *This FRN is used for downlinking TCAS RA information as defined in the RTCA DO-260B MOPS. It is required to be sent in the CAT033 when an aircraft reports this information.*
5. *Reserved.*
6. *Present when data field is an attribute of the track.*
7. *This field is set to all ZEROs.*
8. *The GPS antenna offset will normally be provided by aircraft operating on the surface so the FRN will not be available when an aircraft is airborne. This FRN is required to be sent when the aircraft provides its GPS Antenna Offset.*
9. *When Target State Data is received from an aircraft, this FRN is to be populated and sent to the SDP.*

B.3 Format and Encoding of FAA CAT033 Data Items

B.3.1 FRN 1: Service Volume Identifier

Note: *See the SBS Service Volume Definition spreadsheet for the Service Volume Identifier assigned to each Service Volume.*

Definition: Identification of the Service Volume that is providing data to the SDP. When a CTV data set is provided to the SDP, this field contains the identifier for the CTV.

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb							Lsb	Msb							Lsb
—SAC--								--SIC--							

Encoding:
SAC - The SAC consists of a two-digit hexadecimal encoded data number as defined in the ASTERIX Standard. SAC codes hexadecimal A0-C3 and DA-DF are reserved for the US. The SAC codes are assigned as follows:

Bits 16/13: Service Area

- Eastern Service Area: 0xA
- Western Service Area: 0xB
- Composite Traffic Volume: 0xC
- Central Service Area: 0xD

Note: *CTVs may cover multiple Service Areas. Therefore, CTVs have been assigned a unique value to indicate this case.*

Bits 12/9: Domain

- CTV feeding an En Route SDP: 0x1
- CTV feeding a Terminal SDP: 0x2
- CTV feeding a User Defined SDP: 0x3
- En Route Class A: 0xA
- Terminal Class B: 0xB
- Terminal Class C: 0xC
- Terminal Class D: 0xD
- Terminal Other: 0xE
- Surface: 0xF

Bits 8/1: The SIC is a unique numerical identifier for service volumes or composite traffic volumes of each Domain – up to 255 individual codes can be assigned.

Notes:

1. *See the SBS Service Volume Definition Document (SVDD) spreadsheet for the Service Volume Identifier assigned to each Service Volume. Examples are as follows:*

   - *Phoenix Terminal is SVID #1 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB01*

   - *LAX Terminal is SVID #2 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB02*

   - *ZAB (Albuquerque) is SVID #154 in the SVDD spreadsheet. This is in the Western Service Area and En Route Class A airspace. The SAC/SIC code would be: BA9A. It is the first En Route SV in the SVDD that falls in the Western Service Area.*

2. *For CTVs, the SAC field will be based upon the CTV identifier within the Service Area sub-field (0xC), the SDP being provided the CTV data, and the SIC field will be a unique identifier that will be determined when the CTV is defined.*

Note: *The SVID field is applied as follows:*

Report Type	***Description***
ADS-B	*Identifies the Service Volume or CTV for the SDP. When aggregating a set of SVs into a CTV, the SVID field represents a unique ID for the CTV.*
Test Target	*The SVID is that of the Service Volume or CTV in which the radio receiver resides. If a radio receiver supports multiple Service Volumes, an ADS-B Report containing the test target information is sent for each Service Volume with the SVID set to that for each respective SV. If a radio receiver supports a CTV, then an ADS-B test target report is sent with the SVID set to a unique identifier for the CTV.*

Report Type	***Description***
TIS-B Target Type A (direct response of a sensor input to the multi-sensor tracker)	*Identifies the Service Volume in which the aircraft providing the surveillance data that resulted in the Report resides. Identifies the single En Route SV that the multi-sensor tracker serves, or the Surface Domain that that the ASDE-X serves.*
TIS-B Target Type B (direct response to the receipt of an Ack from the TIS-B Radio)	*Identifies the SV of the Client(s) for the target.*

B.3.2 FRN 2: Version Number

Definition: Version of this FAA CAT033 format.
Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Reserved bit	Reserved bit	Version Status	Msb — Version Number — Lsb				

Encoding:
Bits 8/7: Reserved bits set to ZERO (0).
Bit 6: ZERO (0) = Version is for operational use;
ONE (1) = Version is for experimental use only.
Bits 5/1: FAA CAT033 Version Number encoded as binary numeral in the range of 1 to 31 (Value of ZERO (0) represents "unknown" version regardless of "Version Status".)

FAA Category 33 messages conforming to this document will be encoded with the value THREE (3) in the Version Number field (Bits 5/1).

Notes:

1. *This provides an upgrade path for evolution of this Category, as Category 65 has already been assigned, and therefore incrementing the Category number modulo 32 is not feasible.*

B.3.3 FRN 3: Link Technology Indicator

Definition: Used to specify the data link or link(s) to which the Target Report is applicable.

Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Known / Unknown	Link Version #			1090 ES	UAT	Non ADS-B Detection	TIS-B Transmit Flag

Encoding:

Bit 8: Bit set to ONE (1) = Unknown Link Version #, otherwise set to ZERO (0).

Bits7/5: Link Version # from link MOPS, binary encoded. Bit 7 is MSB and Bit 5 is LSB. The link version will be 1 for DO-260A and DO-282A avionics, and a value of 2 for DO-260B and DO-282B avionics.

Bit 4: 1090ES (ZERO (0) = report is NOT based on 1090 ES reception, ONE (1) = report is based on 1090ES reception).

Bit 3: UAT (ZERO (0) = report is NOT based on UAT reception, ONE (1) = report is based on UAT reception).

Bit 2: Non ADS-B Detection (ZERO (0) = report is based on ADS-B (e.g., 1090ES or UAT) detection, ONE (1) = report is based on non-ADS-B (e.g., radar) detection).

Bit 1: TIS-B Transmit Flag – (0 = Type A TIS-B Report, 1 = Type B TIS-B Report) set when the TIS-B Messages were intended to be transmitted. This bit is not applicable and is set to "0" in ADS-B Reports.

Notes:

1. *The information conveyed in this data item supports the case where a multilink-capable transceiver is operating with a single data source qualifier allocation.*

2. *An "Unknown" Link version number indicates an explicit Link Version Number has not yet been received for this aircraft/vehicle.*

3. *Bits 3 and 4 are mutually exclusive for ADS-B reports and either bit 3 or 4 will be set in any given ADS-B report. Bit 2 will never be set in an ADS-B report.*

4. *TIS-B reports may have multiple bits set for bits 2-4 dependent on the sensors supporting the TIS-B target.*

B.3.4 FRN 4: Time of Applicability

Definition: Time at which the target position is expected to be an accurate estimate of the true target state vector. For TIS-B targets, the TOA is estimated and provided by the tracker. It is the trackers estimate of the time that the Target was at the position contained in the Report.

Note: *ADS-B TOA is calculated based on TOMR as follows:*

For 1090ES Target Reports: The TOA for each received 1090ES ADS-B Message is determined by the ADS-B Service by either rounding the TOMR off to the nearest 1/128th second UTC value, or it is the nearest even or odd 200 ms UTC epoch, depending upon the type of 1090ES message.

For UAT Target Reports: The ADS-B Service determines TOA as one of the following based on the type of UAT Message: (1) the TOA is the start of the 1-second UTC epoch containing the TOMR, or (2) the TOA is the start of the 0.2-second UTC epoch containing the TOMR, or (3) the TOA is the TOMR minus 1 second.

For 1090-ES Test Target Reports: The TOA is set to the time that the Test Report is output by the 1090-ES Test Message State Machine within SBS.

For UAT Test Target Reports: The TOA is set to the time that the Test Report is output by the UAT Test Message State Machine within SBS.

Structure: Four byte fixed data item.

Byte 1								**Byte 2**							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
--Time of Applicability (Position)--								--Time of Applicability (Position)--							

Byte 3								**Byte 4**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--Time of Applicability (Position)--								Sign	--Time of Applicability (Velocity)--						

Encoding:

Bits 32/16: Time of Applicability (TOA) of Position in whole seconds elapsed since UTC midnight binary encoded.

Notes:

1. *The time of the day value is reset to 0 at every midnight. The time of the day is specified in UTC.*

2. *The Lsb for position ToA represents 1/128 of a second.*

Bits 15/9: TOA of Position in fractional seconds, is rounded DOWN nearest 1/128th second. In specifying a TOA at a 200 msec UTC epoch the rounding down is as follows:

- 200 msec is coded as 0.1953125 decimal (00011001 binary)
- 400 msec is coded as 0.3984375 decimal (00110011 binary)
- 600 msec is coded as 0.593750 decimal (01001100 binary)
- 800 msec is coded as 0.7968750 decimal (01100110 binary)

Bits 8/1: TOA of Velocity expressed relative to the TOA of Position

Bit 8: Sign bit, ZERO = Velocity TOA is before Position TOA
ONE = Velocity TOA is after Position TOA

Bits 7/1: Binary encoded relative time magnitude in 100ms increments for up to +/- 12.8 seconds offset to Position TOA

Notes:

1. *If the Sign bit contains a "1", this is an error condition and the velocity information should not be used. If the Sign bit is "0" and all other bits are "1", the Velocity or Velocity ToA is unavailable and the velocity information should not be used.*

2. *If the Velocity is not available in the report, the Velocity TOA Sign bit is set to ZERO (0) and Bits 7/1 are set to "1111111" binary.*

3. *For UAT Reports, the Velocity TOA is not applicable and will always be set to ZERO (0) because the velocity is provided in each message from the aircraft in lieu of separate messages as is experienced with 1090-ES.*

B.3.5 FRN 5: Target Address

Definition: Identifies a target through a 24 bit address associated with the target plus 3 bits of address qualifier

Structure: Four byte fixed length data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Target SV Type		Reserved bits		Duplicate Address Flag	Address Qualifier			Msb --24 bit Address--							
Byte 3								**Byte 4**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--24-bit Address--															Lsb

Encoding:

Bits 32/31: Target SV Type: defines the most stringent SV type for the target to identify the maximum update interval at which the target will be sent to automation systems and other end users. This field is set as follows:

Target SV Type		**Meaning**
Bit 32	Bit 31	
0	0	En Route Service Volume (update interval ≤ 6 seconds)
0	1	Terminal Service Volume (update interval ≤ 3 seconds)
1	0	En Route High Update SV (update interval ≤ 3 seconds)
1	1	Surface Service Volume (update interval 1 second average when Moving; ≤ 5.5 seconds when Stationary)

Note: *The Target SV Type is set to the most stringent SV within which the target resides. If a target is within an terminal service volume that overlaps an en route SV, then the Target SV type will be set to terminal and provided with an update interval of 3 seconds or better (95%).*

Bits 30/29: Reserved bits, always set to ZERO (0).

Bit 28: Duplicate Address Flag:
ZERO= target has unique address
ONE=target is involved in an address conflict

Note: *This bit will be set in a target report whenever the ICAO address of that target is being used by two or more targets and at least one target is reporting Link Version 1 or greater in a defined set of Service Volumes associated with an SBSS central ADS-B data processing function. For 1090ES Target Reports in a Type 1 Duplicate Address condition (i.e. targets are detected by a single radio channel), this flag will be an indication that certain link integrity parameters and Modes Status data will not be available as the 1090ES squitters that provide that data are not resolved to a single target. Once an ICAO address is determined to be a Type 1 Duplicate Address, this flag is set for all reports provided for that ICAO address unless the duplicate address condition is no longer present for a period of 60 seconds (i.e. flag is persistent for 60 seconds). This bit is also set when either two or more 1090 or two or more UAT targets with the same ICAO address are detected by multiple radio channels (duplicate address condition recognized, but target information is resolvable); when a duplicate address condition arises between a 1090 target(s) and a UAT target(s).*

Bits 27/25: Address Qualifier

ADDRESS QUALIFIER

Address Qualifier (binary)			**Address Type**
Bit 27	**Bit 26**	**Bit 25**	
0	0	0	ADS-B target with ICAO 24-bit address
0	0	1	ADS-B target with self-assigned temporary address
0	1	0	TIS-B target with ICAO 24-bit address
0	1	1	TIS-B target with track file identifier
1	0	0	Surface Vehicle
1	0	1	Fixed Beacon
1	1	0	(Reserved)
1	1	1	(Reserved)

Bits 24/1: 24 bit Address.

B.3.6 FRN 6: Integrity and Accuracy Parameters

Definition: This data item conveys the accuracy and integrity parameters reported by the ADS-B target.

Structure: Three byte data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
UTC	Msb --NIC-- Lsb				SIL Supplement	-SIL-		Msb --NAC_P-- Lsb					Reserved bit	Service in Test Mode	Reserved bit

Byte 3							
8	7	6	5	4	3	2	1
Validation		Msb NAC_V Lsb				NIC_{BARO}	

Encoding:

Bit 24: FOR ADS-B Target Reports:
ONE (1) = Avionics transmitting equipment is in the "UTC coupled" condition
ZERO (0) = Avionics transmitting equipment is in the "non-UTC coupled" condition.
(above applies both to 1090 and UAT Target Reports)

For UAT Test Target Reports:
1 = The GPS Timing source within the UAT Radio Station generating the Test Target Report is operational.
0 = The GPS Timing source within the UAT Radio Station generating the Test Target Report is non-operational or failed.

For 1090ES Test Target Reports:
1 = The GPS Timing source within the 1090-ES Radio Station generating the Test Target Report is operational.
0 = The GPS Timing source within the 1090-ES Radio Station generating the Test Target Report is non-operational or failed.

FOR TIS-B Reports:
Always set to ZERO (0), "non-UTC coupled"

Bits 23/20: Navigation Integrity Categories (NIC).

FOR ADS-B and TIS-B Reports:
The Navigation Integrity Category (NIC) is reported so that surveillance applications may determine whether the reported position has an acceptable level of integrity for the intended use. The value of the NIC parameter specifies an integrity containment radius, R_C.

NAVIGATION INTEGRITY CATEGORY (NIC)

NIC bits		***Horizontal Containment Bounds***
Msb Lsb	*decimal*	
0000	*0*	*R_C Unknown*
0001	*1*	*R_C < 37.04 km (20 NM)*
0010	*2*	*R_C < 14.816 km (8 NM)*
0011	*3*	*R_C < 7.408 km (4 NM)*
0100	*4*	*R_C < 3.704 km (2 NM)*
0101	*5*	*R_C < 1852 m (1 NM)*
0110	*6*	*R_C < 1111.2 m (0.6 NM)*
0111	*7*	*R_C < 370.4 m (0.2 NM)*
1000	*8*	*R_C < 185.2 m (0.1 NM)*
1001	*9*	*R_C < 75 m*
1010	*10*	*R_C < 25 m*
1011	*11*	*R_C < 7.5 m*
1100 - 1111	*12 - 16*	*Reserved for future use*

Bit 19: Source Integrity Level (SIL) – Supplement

SIL Supplement Bit Encoding

Coding	**Meaning**
0	Probability of exceeding NIC radius of containment is on a per hour basis
1	Probability of exceeding NIC radius of containment is on a per sample basis

Notes:

1. *"Per Hour" indicates the probability of the reported geometric position lying outside the NIC containment radius in any given hour without an alert or an alert longer than the allowable time-to-alert. The probability of exceeding the integrity radius of containment for GNSS position sources are based on a per hour basis, as the NIC will be derived from the GNSS Horizontal Protection Level (HPL) which is based on a probability of $1x10^{-7}$ per hour.*

2. "*Per Sample" indicates the probability of a reported geometric position lying outside the NIC containment radius for any given sample. The probability of exceeding the integrity radius of containment for non-GNSS position sources may be based on a per sample basis.*

3. *Always set to ONE (1) for TIS-B Reports.*

Bits 18/17: Source Integrity Level (SIL).

FOR ADS-B and TIS-B Reports:
The value of the SIL parameter specifies the probability of the true position lying outside the NIC-specified containment radius, R_C, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used. SIL is a static (unchanging) value that depends on the position sensor being used on the aircraft.

SOURCE INTEGRITY LEVEL (SIL)

SIL Bits		Probability of Exceeding the Horizontal Integrity Containment Radius R_C Reported in the NIC Subfield Without an Indication
Bit 18	**Bit 17**	
0	0	Not Available, Unknown, or $> 1 \times 10^{-3}$ per flight hour or per sample
0	1	$\leq 1 \times 10^{-3}$ per flight hour or per sample
1	0	$\leq 1 \times 10^{-5}$ per flight hour or per sample
1	1	$\leq 1 \times 10^{-7}$ per flight hour or per sample

Bits 16/12: Navigation Accuracy Categories for Position (NAC_P)
The Navigation Accuracy Category for Position (NAC_P) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use. The Estimated Position Uncertainty (EPU) is a 95% accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position being outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).

NAVIGATION ACCURACY CATEGORY for POSITION (NAC_P)

NACp Bits		95% Horizontal Accuracy Bounds (EPU)	Comment
Bit 16	Bits 15-12 Msb Lsb		
0	xxxx	NAC_P not available in this reporting interval	
1	0000	EPU ≥ 18.52 km (10 NM)	
1	0001	EPU < 18.52 km (10 NM)	RNP-10 accuracy
1	0010	EPU < 7.408 km (4 NM)	RNP-4 accuracy
1	0011	EPU < 3.704 km (2 NM)	RNP-2 accuracy
1	0100	EPU < 1852 m (1NM)	RNP-1 accuracy
1	0101	EPU < 926 m (0.5 NM)	RNP-0.5 accuracy
1	0110	EPU <555.6 m (0.3 NM)	RNP-0.3 accuracy
1	0111	EPU < 185.2 m (0.1 NM)	RNP-0.1 accuracy
1	1000	EPU <92.6 m (0.05 NM)	e.g., GPS (with SA)
1	1001	EPU < 30 m	e.g., GPS (SA off)
1	1010	EPU < 10 m	e.g., WAAS
1	1011	EPU < 3 m	e.g., LAAS
1	1100-1111	Reserved for future use.	

Bit 11: Reserved bit, always set to ZERO (0).
Bit 10: Service in Test Mode
ONE (1) = Service in Test Mode
ZERO (0) = Service not in Test Mode

Note: *Bit 10 is used as an indication to end user (i.e., ATC Automation) that the service is in a test condition and reports should not be used for Air Traffic purposes.*

Bit 9: Reserved bit, always set to ZERO (0)

Bits 8/7: Validation.

For ADS-B Reports:
The ADS-B service performs a reasonableness test, or validation, of reported ADS-B position data in some service volumes or composite traffic volumes. If the service volume or CTV does not offer the validation functionality, validation status will be reported as 'unknown.' If validation functionality is provided in the service volume or CTV, the validation field will be populated with the current validation status determined for this target. If validation is ordered but an independent position estimate is not available, then the validation status is reported as "unknown".

VALIDATION

Validation Bits		**Meaning**
Bit 8	Bit 7	
0	0	Validation status unknown
0	1	Report determined to be invalid
1	0	Reserved
1	1	Report determined to be valid

For TIS-B Reports:
Always set to ALL ZEROs (00)

Bits 6/3: NAC_V is the 95% horizontal velocity accuracy

FOR ADS-B Reports:

NAVIGATION ACCURACY CATEGORY for VELOCITY (NAC_V)

NAC_V		
Bit 6	**Bits 5-3** MSB LSB	**Horizontal Velocity Error (95%)**
0	xxx	NAC_V not available in this reporting interval
1	000	Unknown or ≥ 10 m/s
1	001	< 10 m/s
1	010	< 3 m/s
1	011	< 1 m/s
1	100	< 0.3 m/s
1	101	(Reserved)
1	110	(Reserved)
1	111	(Reserved)

FOR TIS-B Reports:
The TIS-B service estimates the 95 percentile of the velocity accuracy for airborne TIS-B tracks and encodes this accuracy estimate into a NAC_V that is transmitted in TIS-B messages. For TIS-B in surface SVs the NAC_V is computed by ASDE-X and sent to SBS for uplink to aircraft.

Bits 2/1: $NIC_{BARO.}$ The NIC_{BARO} subfield provides a method of indicating a level of data integrity for aircraft installed with Gilham encoding barometric altitude sources. Because of the potential of an undetected error when using a Gilham encoded altitude source, a comparison will be performed with a second source and only if the two sources agree will the NIC_{BARO} subfield be set to a value of "1". For other barometric altitude sources (Synchro or DADS) the integrity of the data is indicated with a validity flag or SSM. No additional checks or comparisons are necessary. For these sources, the NIC_{BARO} subfield will be set to a value of "1" whenever the barometric altitude is valid.

FOR ADS-B Reports:
This field indicates whether or not the Barometric Pressure Altitude (defined in the RTCA DO-286 UAT MOPS as barometric altitude measured relative to a standard pressure of 1013.25 millibars (29.92 in.Hg.)) provided has been cross-checked against another source of pressure altitude.

NIC_{BARO}

Coding	Meaning
00	Barometric Pressure Altitude has NOT been cross checked
01	Barometric Pressure Altitude has been cross checked
11	Reserved

FOR TIS-B Reports:
Always set to ALL ZEROs (00)

B.3.7 FRN 7: Latitude and Longitude

Definition: Target latitude and longitude position.
Structure: Fixed 6 byte data item.

Byte 1								Byte 2							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
Msb --Latitude--															
Byte 3								**Byte 4**							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
--Latitude-- Lsb								Msb --Longitude--							
Byte 5								**Byte 6**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--Longitude--															Lsb

Encoding:
Bits 48/1: Latitude and Longitude.

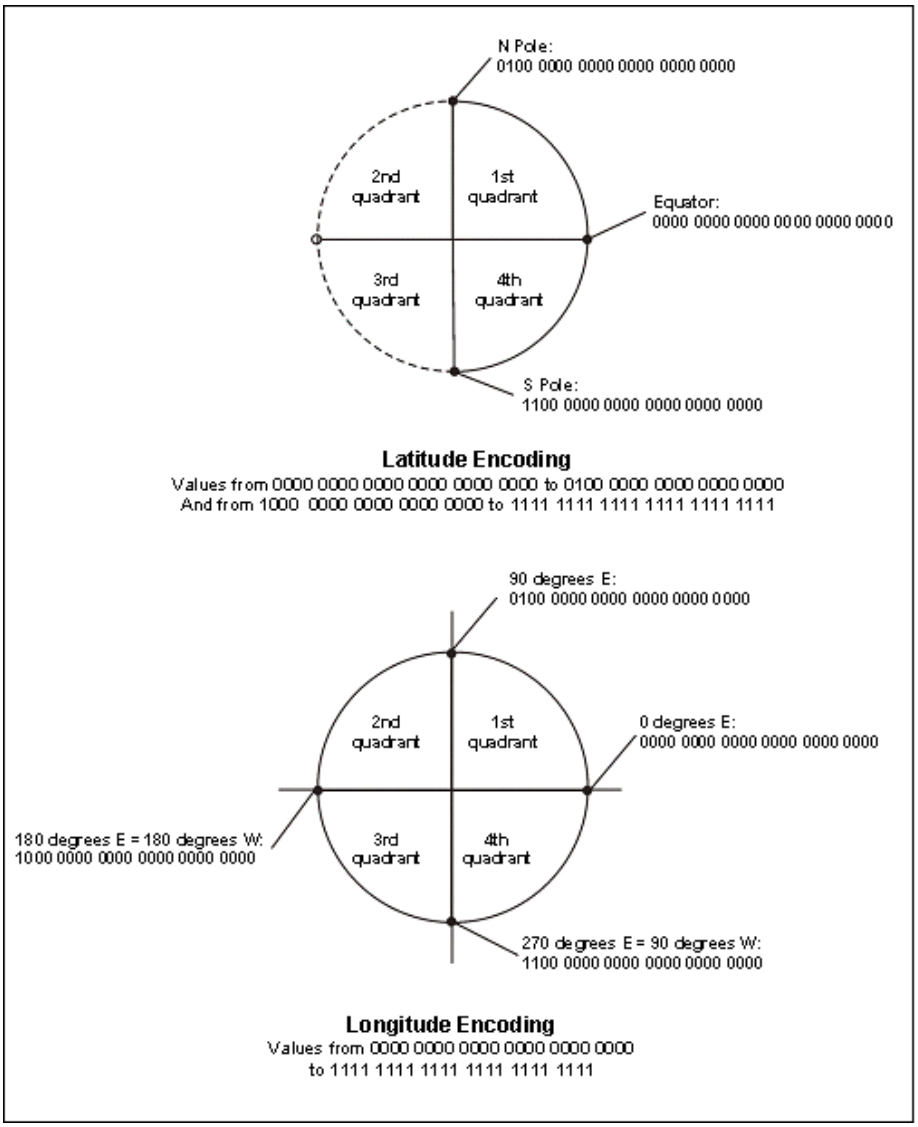
LATITUDE AND LONGITUDE

Quadrant	Latitude or Longitude bits (Msb … Lsb)	Meaning $INCR = Lsb = \frac{360}{2^{24}} = 0.00002146°$ Latitude	Meaning Longitude
1st quadrant	0000 0000 0000 0000 0000 0000	ZERO degrees (Equator)*	ZERO degrees (Prime Meridian)*
	0000 0000 0000 0000 0000 0001	*INCR* degrees North	*INCR* degrees East
	…	…	…
	0011 1111 1111 1111 1111 1111	(90-*INCR*) degrees North	(90-*INCR*) degrees East
2nd quadrant	0100 0000 0000 0000 0000 0000	90 degrees North (North Pole)	90 degrees East
	0100 0000 0000 0000 0000 0001	<Illegal Values>	(90+*INCR*) degrees East
	…	<Illegal Values>	…
	0111 1111 1111 1111 1111 1111	<Illegal Value>	(180-*INCR*) degrees East
3rd quadrant	1000 0000 0000 0000 0000 0000	<Illegal Value>	180 degrees East or West
	1000 0000 0000 0000 0000 0001	<Illegal Value>	(180-*INCR*) degrees West
	…	<Illegal Values>	…
	1011 1111 1111 1111 1111 1111	<Illegal Values>	(90+INCR) degrees West
4th quadrant	1100 0000 0000 0000 0000 0000	90 degrees South (South Pole)	90 degrees West
	1100 0000 0000 0000 0000 0001	(90-*INCR*) degrees South	(90-*INCR*) degrees West
	…	…	…
	1111 1111 1111 1111 1111 1111	*INCR* degrees South	*INCR* degrees West

** "Position Unavailable" is encoded as ALL ZEROs for Lat, Lon, NIC, and NAC_P simultaneously*

Note:

1. *This encoding is consistent with that of GPS/GNSS avionics providing Latitude/Longitude inputs to ADS-B (ARINC data labels 110, 111, 120,121). It is also illustrated in the figure below.*


N Pole:
0100 0000 0000 0000 0000 0000
2nd quadrant
1st quadrant
Equator:
0000 0000 0000 0000 0000 0000
3rd quadrant
4th quadrant
S Pole:
1100 0000 0000 0000 0000 0000
Latitude Encoding
Values from 0000 0000 0000 0000 0000 0000 to 0100 0000 0000 0000 0000
And from 1000 0000 0000 0000 0000 to 1111 1111 1111 1111 1111 1111
90 degrees E:
0100 0000 0000 0000 0000 0000
2nd quadrant
1st quadrant
0 degrees E:
0000 0000 0000 0000 0000 0000
180 degrees E = 180 degrees W:
1000 0000 0000 0000 0000 0000
3rd quadrant
4th quadrant
270 degrees E = 90 degrees W:
1100 0000 0000 0000 0000 0000
Longitude Encoding
Values from 0000 0000 0000 0000 0000 0000
to 1111 1111 1111 1111 1111 1111

B.3.8 FRN 8: Pressure Altitude

Definition: Barometric Aircraft altitude referenced to standard atmospheric pressure of 29.92 in. Hg. This is the uncorrected barometric pressure altitude.

Structure: Fixed two byte data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Resolution		Msb													Lsb
		--Pressure Altitude--													

Encoding:

Bit 16/15: Resolution of altitude encoding by the sensor source.

RESOLUTION

Resolution Bits Bit 16	Bit 15	Meaning
0	0	Resolution unknown
0	1	100 foot Resolution
1	0	25 foot Resolution
1	1	Reserved

Bits 14/1: Binary 2's complement encoding of altitude with 25 foot Lsb.

PRESSURE ALTITUDE

Pressure Altitude bits Msb Lsb	Meaning
10 0000 0000 0000	No pressure altitude information available
10 0000 0000 0001	-204775 feet
10 0000 0000 0010	-204750 feet
***	
11 1111 1111 1110	-50 feet
11 1111 1111 1111	-25 feet
00 0000 0000 0000	ZERO feet
00 0000 0000 0001	25 feet
00 0000 0000 0010	50 feet
***	
01 1111 1111 1110	204750 feet
01 1111 1111 1111	$\geq$204775 feet

Notes:

1. *Airborne ADS-B transmitters are restricted to a range of values for Pressure Altitude of -1000 feet to +101,325 feet.*

2. *The Resolution field is provided only to make a tracker aware of the resolution of the pressure altitude source. It has NO influence on the encoding of the Pressure Altitude field, i.e., the Pressure Altitude Lsb for FRN 8 is ALWAYS 25 feet*

B.3.9 FRN 9: Velocity (Airborne)

Definition: The Velocity reported by the aircraft indicated by the North/South and East/West Velocity (relative to true north) and the geometric vertical rate of change reported by the aircraft.

Structure: Fixed five byte data item.

Byte 1								Byte 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
Reserved	VV Src	SO	NS	Msb --N/S Velocity--											Lsb

Byte 3								Byte 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
EW	Msb --E/W Velocity--											Lsb	UD	Msb	

Byte 5							
8	7	6	5	4	3	2	1
--Vertical Rate--							Lsb

Encoding:

Bit 40: Reserved bit, always set to ZERO (0).

Bit 39: VV Src: Indicates the source of Vertical Velocity (ZERO (0) = GNSS; ONE (1) = Baro).

Bit 38: SO: Indicates the scale factor to be used for N/S and E/W Velocities (ZERO (0) = Subsonic 0.25 kt Lsb; ONE (1) = Supersonic—2 kt Lsb).

Bit 37: NS Indicates the direction of the N/S Velocity (ZERO (0) = North; ONE (1) = South).

Bits 36/25: N/S Velocity (Ground Referenced).

NORTH/SOUTH VELOCITY (Ground Referenced)

N/S Velocity bits Msb Lsb	**Meaning (when "SO"=ZERO)** (N/S Velocity in knots)	**Meaning (when "SO"=ONE)** (N/S Velocity in knots)
0000 0000 0000	No Information available	
0000 0000 0001	ZERO	
0000 0000 0010	0.25	2
0000 0000 0011	0.5	4
***	***	***
1111 1111 1110	1023.25	8186
1111 1111 1111	$\geq$ 1023.375	$\geq$ 8187

Note: *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the North/South Direction Bit.*

Bit 24: EW Indicates the direction of the E/W velocity
(ZERO (0) = East; ONE (1) = West).
Bits 23/12: E/W Velocity (Ground Referenced).

EAST/WEST VELOCITY (Ground Referenced)

E/W Velocity bits Msb Lsb	**Meaning (when "SO"=ZERO)** (E/W Velocity in knots)	**Meaning (when "SO"=ONE)** (E/W Velocity in knots)
0000 0000 0000	No Information Available	
0000 0000 0001	ZERO	
0000 0000 0010	0.25	2
0000 0000 0011	0.5	4
***	***	***
1111 1111 1110	1023.25	8186
1111 1111 1111	$\geq$ 1023.375	$\geq$ 8187

Note: *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the East/West Direction Bit.*

Bit 11: UD - Indicates vertical rate direction
(ZERO (0) = Up; ONE (1) = Down).
Bits 10/1: Vertical rate of change with 32 fpm Lsb.

VERTICAL RATE

Vertical Rate bits Msb Lsb	**Meaning** (VERTICAL RATE in feet / minute)
00 0000 0000	No Information Available
00 0000 0001	ZERO
00 0000 0010	32
00 0000 0011	64
***	***
11 1111 1110	32,672
11 1111 1111	$\geq$32,688

Note: *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the Vertical Rate Sign Bit.*

B.3.10 FRN 10: Velocity (Surface)

Definition: Velocity format reported when target is known to be ON GROUND.
Structure: Fixed four byte data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Trk/Hdg Valid	Trk/Hdg	True/Mag	Msb --Ground Track/Heading--									Lsb	Msb Ground Speed		

Byte 3								Byte 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Ground Speed							Lsb	A/V Length and Width Code				Reserved	Reserved bits		

Encoding:
Bit 32: Track/Heading Valid
(ZERO (0) = Ground Track/Heading data is NOT Valid;
ONE (1) = Ground Track/Heading data is Valid.)
Bit 31: Track/Heading bit
(ZERO (0) = Track; ONE (1) = Heading).
Bit 30: True/Magnetic bit
(ZERO (0) = True; ONE(1) = Magnetic).
Bits 29/20: Ground Track/Heading represented as a binary number.

GROUND TRACK/HEADING

Ground Track /Heading bits Msb Lsb	**Meaning** $INCR = Lsb = \frac{360}{2^{10}} = 0.3515625°$
00 0000 0000	ZERO degrees
00 0000 0001	*INCR* degrees
***	
01 1111 1111	(180-*INCR*) degrees
10 0000 0000	180 degrees
10 0000 0001	(180+*INCR*) degrees
***	
11 1111 1111	(360-*INCR*) degrees

Bits 19/9: Binary encoding (linear) of Ground Speed with 0.125 kt Lsb.

GROUND SPEED

Ground Speed bits Msb Lsb	**Meaning**
000 0000 0000	Ground Speed Not Available
000 0000 0001	ZERO
000 0000 0010	0.125 kts
000 0000 0011	0.250 kts
***	***
111 1111 1110	255.625 kts
111 1111 1111	≥ 255.750 kts

Bits 8/5: A/V Length and Width Code.

A/V LENGTH AND WIDTH CODE

Length Code			**Width Code**	**Length Category (meters)**	**Width Category (meters)**
Bit 8	**Bit 7**	**Bit 6**	**Bit 5**		
0	0	0	0	No Data or Unknown	
			1	L < 15	W < 23
0	0	1	0	L < 25	W < 28.5
			1		W < 34
0	1	0	0	L < 35	W < 33
			1		W < 38
0	1	1	0	L < 45	W < 39.5
			1		W < 45
1	0	0	0	L < 55	W < 45
			1		W < 52
1	0	1	0	L < 65	W < 59.5
			1		W < 67
1	1	0	0	L < 75	W < 72.5
			1		W < 80
1	1	1	0	L < 85	W < 80
			1		W ≥ 80

Bit 4: Reserved bit, always set to ZERO (0).
Bits 3/1: Reserved bits, always set to ZERO (0).

Notes:

1. *Surface (polar) format is different from airborne format because the ability to discern a track angle from the Airborne (cartesian) format suffers at low speeds. Also use of polar format allows for a heading input if available. Heading (if available) can provide more reliable information on aircraft orientation on the surface when stationary or moving very slowly.*

2. *Aircraft are allowed to report velocity in this format when it is known for certain they are on the surface. It is also used by surface vehicles.*

3. *When a TIS-B report is received with speeds greater than or equal to 255.750 knots, set the field to Ground Speed Not Available.*

4. *ATC Automation is not required to use this information.*

B.3.11 FRN 11: Mode 3/A Code

Definition: Aircraft's Mode-3/A code reported by the aircraft.
Structure: Fixed two byte data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Reserved Bit	Reserved Bit	Reserved Bit	Mode-3/A Validity bit	Msb											Lsb
				Mode-3/A Code											

Encoding:
Bits 16/14: Reserved bits
Bit 13: Mode-3/A Validity bit.
ONE (1) = VALID_CODE and ZERO (0) = INVALID_CODE.
Bits 12/1: Mode-3/A Code.

Notes:

1. *The Mode 3/A Code is transmitted for both aircraft on-the-ground and airborne.*
2. *All ADS-B reports from SBSS that are from DO-260B (1090-ES Link Version 2) and DO-282B (UAT Link Version 2) aircraft will be provided with a Mode 3/A code. DO-260A (1090-ES Link Version 1) reports may not have a Mode 3/A at initial detection due to the time between 3/A code transmissions from these avionics. DO-282A (UAT Link Version 1) aircraft may not send a 3/A code due to operation in VFR mode. The SBS inserts a 1200 code for these UAT targets and sets the Validity bit to indicate INVALID_CODE.*
3. *Any Mode 3/A codes identified as invalid are either improperly formatted codes from a UAT avionics unit (DO-282A or B) or a 1200 code that was set by the SBS due to an aircraft not providing a Mode 3/A code as is possible in legacy DO-282A (UAT Link Version 1) avionics in VFR mode. All ADS-B reports from DO-260A that include this FRN and all ADS-B Reports from DO-260B will have the Validity flag set to ONE (1).*
4. *Invalid Mode 3/A codes can be configured on the interface to go to a different port than other ADS-B Reports.*
5. *In the future, if automation systems transition to alternate means of flight plan association, the 1090-ES equipped aircraft may inhibit their Mode 3/A transmission by programming a Code of 1000 (octal) into the ADS-B avionics. However, this will be prohibited procedurally by ATC until such time as new flight plan association requirements are defined and implemented within automation.*

B.3.12 FRN 12: Target Identification

Definition: Target Identification (in 8 characters) reported by the aircraft/vehicle. This is generally the radio call sign.

Structure: Six byte fixed length data item.

Byte 1								Byte 2							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
Msb (b6)		--Char 1--			Lsb (b1)	Msb (b6)		--Char 2--			Lsb (b1)	Msb (b6)		--Char 3--	

Byte 3								Byte 4							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
	Lsb (b1)	Msb (b6)		--Char 4--			Lsb (b1)	Msb (b6)		Char 5--			Lsb (b1)	Msb(b6)	

Byte 5								Byte 6							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--Char 6--			Lsb (b1)	Msb (b6)		--Char 7--			Lsb (b1)	Msb (b6)		--Char 8--			Lsb (b1)

Encoding:

Bits 48/1: Characters 1-8, coded as 6 bits per character.

CHARACTER ENCODING

Character *N* bits				b6	0	0	1	1
				b5	0	1	0	1
b4	b3	b2	b1					
0	0	0	0		UNA	P	sp	0
0	0	0	1		A	Q		1
0	0	1	0		B	R		2
0	0	1	1		C	S		3
0	1	0	0		D	T		4
0	1	0	1		E	U		5
0	1	1	0		F	V		6
0	1	1	1		G	W		7
1	0	0	0		H	X		8
1	0	0	1		I	Y		9
1	0	1	0		J	Z		
1	0	1	1		K	Illegal Values		
1	1	0	0		L			
1	1	0	1		M			
1	1	1	0		N			
1	1	1	1		O			

Notes:

1. *Character 1 is leftmost*

2. *Characters must be left justified using <space> fill if less than 8 characters are used*

3. *<UNA> = character information was reported by the aircraft as unavailable. This could appear in any character position.*

B.3.13 FRN 13: Emitter Category

Definition: The target's category code for the current position report.
Structure: Fixed one byte data item.

Byte 1							
8	7	6	5	4	3	2	1
Msb --Category Code--					Lsb	Reserved	

Encoding:
Bits 8/3: Category Code.

CATEGORY CODE

Category Code bits (decimal)	Category Code bits Msb Lsb	Meaning
0	00 0000	No ADS-B Emitter Category Information
1	00 0001	Light (< 15 500 lbs)
2	00 0010	Small (15 500 to 75 000 lbs)
3	00 0011	Large (>75 000 to 300 000 lbs)
4	00 0100	High Vortex Large
5	00 0101	Heavy (> 300 000 lbs)
6	00 0110	High Performance (> 5G acceleration)
7	00 0111	Rotorcraft
8	00 1000	No ADS-B Emitter Category Information
9	00 1001	Glider/sailplane
10	00 1010	Lighter than air
11	00 1011	Parachutist/sky diver
12	00 1100	Ultra light/hang glider/paraglider
13	00 1101	(Reserved)
14	00 1110	Unmanned aerial vehicle
15	00 1111	Space/trans-atmospheric vehicle
16	01 0000	No ADS-B Emitter Category Information
17	01 0001	Surface vehicle—emergency vehicle
18	01 0010	Surface vehicle—service vehicle
19	01 0011	Point Obstacle (includes tethered balloons)
20	01 0100	Cluster Obstacle
21	01 0101	Line Obstacle
22-63		(Reserved)

Bits 2/1: Reserved bits, always set to ZERO (0).

B.3.14 FRN 14: Target Status

Definition: Status information currently being reported by the target.
Structure: Fixed one byte data item.

Byte 1							
8	7	6	5	4	3	2	1
				Msb			Lsb
Reserved	IDENT	Surveillance Status		Emergency/Priority Status Code			

Encoding:
Bit 8: Reserved (set to ZERO (0))

Bit 7: ONE (1) indicates the avionics is in the IDENT condition;
ZERO (0) indicates the avionics is NOT in the IDENT condition.
Bits 6/5: Surveillance Status Codes

SURVEILLANCE STATUS CODES

Coding		Meaning
(Decimal)	(Binary) Msb Lsb	
0	00	No Condition Information
1	01	Permanent Alert Condition (Emergency)
2	10	Temporary Alert Condition (change in Mode A Identity Code other than emergency condition)
3	11	Special Position Identification (SPI) Condition

Notes:

1. *Surveillance Status Codes 1 and 2 take precedence over code 3.*

2. *The setting of the "Surveillance Status" is a transponder function and is appropriately specified in RTCA DO-181C, §2.2.16.2.7.*

3. *When not implemented in a Mode-S transponder based system, the ADS-B function will set the "Surveillance Status" to ZERO (0).*

4. *Redundancy exists in the way emergency information is encoded across bits 6/5 of FRN14, bits 4/1 of FRN 14, and the Mode 3/A code of FRN 11.*

5. *Alternative means of conveying IDENT information exist between bits 5/6 of FRN14, bit 7 of FRN14 and bit 2 of FRN16. In the event of a conflict between these indications, an automation system should assume an IDENT condition is active.*

Bits 4/1: Emergency/Priority Status Code.

EMERGENCY/PRIORITY STATUS CODES

Status Code bits		Meaning
(decimal)	Msb Lsb	
0	0000	No emergency/Not reported
1	0001	General emergency
2	0010	Lifeguard/medical emergency
3	0011	Minimum fuel
4	0100	No communications
5	0101	Unlawful interference (hijacking)
6	0110	Downed Aircraft
7-15	0111-1111	(Reserved for future definition)

B.3.15 FRN 15: Geometric Altitude

Definition: Aircraft altitude derived from GNSS, INS or ground-based measurement represented as Height Above Ellipsoid (HAE).

Structure: Fixed two byte data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb	--Geometric Altitude (HAE)--														Lsb

Encoding:

Bits16/1: Binary 2's complement encoding of altitude with 6.25 feet LSB.

ALTITUDE (GEOMETRIC)

Geometric Altitude bits Msb Lsb	Meaning
1000 0000 0000 0000	No geometric altitude information available
1000 0000 0000 0001	-204793.75 feet
1000 0000 0000 0100	-204775 feet
1000 0000 0000 1000	-204750 feet
***	
1111 1111 1111 1000	-50 feet
1111 1111 1111 1100	-25 feet
1111 1111 1111 1111	-6.25 feet
0000 0000 0000 0000	ZERO feet
0000 0000 0000 0001	6.25 feet
0000 0000 0000 0100	25 feet
0000 0000 0000 1000	50 feet
***	
0111 1111 1111 1000	204750 feet
0111 1111 1111 1100	204775 feet
0111 1111 1111 1111	≥204793.75 feet

Notes:

1. *Encoding consistent with Pressure Altitude item with the exception of two additional bits of precision which appear here.*

B.3.16 FRN 16: Modes and Codes

Definition: This FRN contains the ADS-B operational Modes and Capability Codes.
Structure: Fixed two byte data item.

Byte 1							
16	15	14	13	12	11	10	9
Reserved bits			Single Antenna	UAT IN	1090-ES IN	TCAS/ACAS Installed	Reserved

Byte 2							
8	7	6	5	4	3	2	1
Reserved bits						IDENT	TCAS RA

Encoding:

Bits 16/14: Reserved bits, always set to ZERO (0).

Bit 13: Single Antenna Flag: (ZERO (0) = aircraft has dual ADS-B transmit and/or receive antennas; ONE (1) = aircraft has a single ADS-B transmit/receive antenna)

Bit 12: UAT IN Capability: (ZERO (0) = aircraft does not have ADS-B IN on UAT, (ONE) 1 = aircraft has ADS-B IN avionics on UAT)

Bit 11: 1090-ES IN Capability: (ZERO (0) = aircraft does not have ADS-B IN on 1090-ES, (ONE) 1 = aircraft has ADS-B IN avionics on 1090-ES)

Bit 10: TCAS/ACAS Installed and Operational: ZERO (0) = NO; ONE (1) = YES

Bit 9: Reserved bit, always set to ZERO (0).

Bits 8/3: Reserved bits, always set to ZERO (0).

Bit 2: IDENT Switch Active Flag indicates whether the aircraft is sending a IDENT. ZERO (0) = NOT Active (> 20 seconds since activated by pilot); ONE (1) = Active (<= 20 seconds since activated by pilot)

Note: *Alternative means of conveying IDENT information exist between bits 5/6 of FRN 14, bit 7 of FRN 14 and bit 2 of FRN 16. In the event of a conflict between these 2 indications, an automation system should assume an IDENT condition is active.*

Bit 1: TCAS/ACAS Resolution Advisory Active Flag indicates whether the aircraft is under an RA. ZERO (0) = NO; ONE (1) = YES

B.3.17 FRN 17: TCAS RA Messages

Definition: Information on a TCAS Resolution Advisory that has been initiated by the aircraft's on-board TCAS system.

Notes:

1. *FRN 17 is only to be used for compliance monitoring of TCAS in the NAS. This FRN should not be used by any NAS ATC automation system.*
2. *For a further description of the fields in this FRN, see ICAO ANNEX 10.*

Structure: Fixed six byte data item.

Byte 1								Byte 2							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
Msb													Lsb	Msb	
Active Resolution Advisories (ARA)														RACS …	
Byte 3								**Byte 4**							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
	Lsb					Msb (b6)									
… RACS		RAT	MTE	TTI		Threat Identity Data (TID)….									
Byte 5								**Byte 6**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
															Lsb
…. Threat Identity Data (TID)															

Encoding:

Bits 48/35: Active Resolution Advisories (ARA) is a 14 bit field that indicates the characteristics of the RA, if any, generated by the TCAS associated with the transponder transmitting the RA information.

The bits in ARA have meanings determined by the value of the MTE subfield and, for vertical RAs, the value of bit 48 of ARA field.

ARA bit 48 is defined as follows:

Coding	Meaning
0	There is more than one threat and the RA is intended to provide separation below some threat(s) and above some other threat(s) or no RA has been generated (when MTE = 0)
1	Either there is only one threat or the RA is intended to provide separation in the same direction for all threats

When ARA bit 48 = 1 and MTE = 0 or 1, bits 47-42 have the following meanings:

Bit	Coding	Meaning
47	0	RA is preventive
	1	RA is corrective
46	0	Upward sense RA has been generated
	1	Downward sense RA has been generated
45	0	RA is not increased rate
	1	RA is increased rate
44	0	RA is not a sense reversal
	1	RA is a sense reversal
43	0	RA is not altitude crossing
	1	RA is altitude crossing
42	0	RA is vertical speed limit
	1	RA is positive
41-35	Set to 0	Reserved for ACAS III

When ARA bit 48 = 0 and MTE = 1, bits 47-42 have the following meanings:

Bit	Coding	Meaning
47	0	RA does not require a correction in the upward sense
	1	RA requires a correction in the upward sense
46	0	RA does not require a positive climb
	1	RA requires a positive climb
45	0	RA does not require a correction in the downward sense
	1	RA requires a correction in the downward sense
44	0	RA does not require a positive descend
	1	RA requires a positive descend
43	0	RA does not require a crossing
	1	RA requires a crossing
42	0	RA is not a sense reversal
	1	RA is a sense reversal
41-35	Set to 0	Reserved for ACAS III

Bits 34/31: Resolution Advisory Complement (RACs record) indicates all the currently active RACs, if any, received from other ACAS aircraft. If set to ZERO (0), then the respective bit has no meaning.

RACS RECORD

Bit	Meaning of Resolution Advisory Complement when Bit is set to ONE (1)
34	Do not pass below
33	Do not pass above
32	Do not turn left
31	Do not turn right

Bit 30: RA Terminated Indicator (RAT)

RAT

Coding	Meaning
0	TCAS is currently generating the RA indicated in the ARA field
1	The RA indicated by the ARA field has been terminated

Bit 29: Multiple Threat Encounter (MTE)

MTE

Coding	Meaning
0	One threat is being processed by the resolution logic (when ARA bit 48 = 1); or no threat is being processed by the resolution logic (when ARA bit 48 = 0)
1	Two or more simultaneous threats are being processed by the resolution logic

Bits 28/27: Threat Type Indicator (TTI)

TTI

Coding		Meaning
(Decimal)	(Binary) Msb Lsb	
0	00	No identity data in TID
1	01	TID contains a Mode S transponder address
2	10	TID contains altitude, range and bearing data
3	11	Not assigned

Bits 26/1: Threat Identity Data (TID) is a 26-bit field that contains the Mode S address of the threat or the altitude, range, and bearing if the threat is not Mode S equipped. If two or more threats are simultaneously processed by the ACAS resolution logic, TID contains the identity or position data for the most recently declared threat.

If TTI = ONE (1), TID is as follows:

Bits 26/3: Contains the 24 bit ICAO Address for the threat aircraft
Bits 2/1: set to ZERO (0)

If TTI = TWO (2), TID is as follows:

Bits 26/14: Contains the Mode 3/A Code for the target that includes the octal code (ABCD) and a binary Mode 3/A X bit. This field is encoded as follows:

MODE 3/A CODE IN TID

Coding													
TID Bit	26	25	24	23	22	21	20	19	18	17	16	15	14
Mode C Code Bit	C1	A1	C2	A2	C4	A4	X	B1	D1	B2	D2	B4	D4

Bits 13/7: Contains the most recent TCAS range estimate to the threat which is encoded as follows:

THREAT RANGE

Coding	
n	Estimated range (NM)
0	No range estimate available
1	Less than 0.05
2-126	(n-1)/10 ±0.05
127	Greater than 12.55

Bits 6/1: Contains the most recent TCAS bearing estimate to the threat which is encoded as follows:

THREAT BEARING

Coding	
n	Estimated bearing (degrees)
0	No bearing estimate available
1-60	Between 6(n-1) and 6n
61-63	Not assigned

B.3.18 FRN 18: Time of Message Reception (TOMR)

Definition: The time at which the ADS-B message was received by the Service expressed as fractional seconds from the UTC second.

Structure: Fixed four byte data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Sign	Msb --Time of Message Reception--														
Byte 3								**Byte 4**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
--Time of Message Reception--															Lsb

Encoding:

Bit 32: TOMR Sign bit is set to ZERO (0) if the TOMR is a positive value, or to ONE (1) if the TOMR is a negative value.

Bits 31/1: Time of Message Reception encoded as nanoseconds elapsed after the UTC 1 second time mark.

TIME OF MESSAGE RECEPTION

Time of Message Reception bits Msb Lsb	**Meaning** $INCR = Lsb = \frac{2\,\text{sec}}{2^{31}} = 0.93132\,\text{nanosecond}$
000 0000 0000 0000 0000 0000 0000 0000	Message received on the UTC second
000 0000 0000 0000 0000 0000 0000 0001	Message received on the UTC second plus *INCR*
…	**…**
111 1111 1111 1111 1111 1111 1111 1111	Message received on the UTC second plus (2- *INCR*)

Notes:

1. *FRN #4 (Time of Applicability) defines the whole second part to which this fractional second measurement applies. The ToA cannot be a negative value.*

2. *This data item will have to be derived within the Service based on protocols specific to a particular ADS-B data link.*

B.3.19 FRN 19: GPS Antenna Offset

Definition: This defines the offset from the aircraft's ADS-B Position Reference Point to the GPS antenna that is utilized by the GPS positioning source that measures the ADS-B position for the aircraft. It defines the lateral distance of the GPS Antenna from the longitudinal axis (Roll) axis of the aircraft and the longitudinal distance of the GPS Antenna from the NOSE of the aircraft.

The ADS-B Position Reference Point is defined as the center of a rectangle around the aircraft that has length equal to the aircraft length and width equal to the aircraft width as identified in the length and width code of FRN 10.

Structure: Fixed 1 byte data item.

Byte 1							
8	7	6	5	4	3	2	1
Msb Lateral Lsb			Msb Longitudinal Lsb				

Bits 8/6: Lateral Offset of GPS antenna used by positioning source

GPS ANTENNA LATERAL OFFSET

Bit 8	Bit 7	Bit 6	Meaning
0 = left 1 = right	Encoding		Upper Bound of the GPS Antenna Offset Along Lateral (Pitch) Axis Left or Right of Longitudinal (Roll) Axis in meters
0	0	0	NO DATA
	0	1	2 meters to left
	1	0	4 meters to left
	1	1	6 meters to left
1	0	0	0
	0	1	2 meters to right
	1	0	4 meters to right
	1	1	6 meters to right

Bits 5/1: Longitudinal Offset of GPS antenna used by positioning source encoded as the Upper Bound of the GPS Antenna Offset Along the Longitudinal (Roll) Axis Aft From Aircraft Nose

GPS ANTENNA LONGITUDUNAL OFFSET

Coding Msb **(binary)** Lsb	**Meaning**
0 0000	Zero (0) or NO DATA
0 0001	Position Offset Applied by Sensor
0 0010	2 meters
0 0011	4 meters
…	…
1 1110	58 meters
1 1111	60 meters

Note: *Maximum distance aft from aircraft nose is 60 meters or 196.85 feet.*

B.3.20 FRN 20: Target State Data

Definition: This FRN provides Target State information broadcast by ADS-B.
Structure: Fixed five byte data item.

Byte 1								Byte 2							
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25
SAT	Msb Selected Altitude										Lsb	Msb Barometric Pressure Setting …			

Byte 3								Byte 4							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
…Barometric Pressure Setting				Lsb	Heading Status	Msb Selected Heading								Lsb	ST

Byte 5							
8	7	6	5	4	3	2	1
AP	VNAV	ALT	APP	LNAV	Reserved		

Bit 40: Selected Altitude Type: A value of ZERO (0) indicates that the altitude is derived from the Mode Control Panel / Flight Control Unit (MCP / FCU) or equivalent equipment. A value of ONE (1) indicates that the altitude is derived from the Flight Management System (FMS).

Bits 39/29: Selected Altitude for the ADS-B Transmitting Subsystem.

SELECTED ALTITUDE

Coding		Meaning
Msb **(Binary)** Lsb	**(Decimal)**	
000 0000 0000	0	NO Data or INVALID Data
000 0000 0001	1	0 feet
000 0000 0010	2	32 feet
000 0000 0011	3	64 feet
*** **** ****	***	*** **** ****
*** **** ****	***	*** **** ****
*** **** ****	***	*** **** ****
111 1111 1110	2046	65440 feet
111 1111 1111	2047	65472 feet

Bits 28/20: Barometric Pressure Setting field contains the Barometric Pressure Setting data that has been adjusted by subtracting 800 millibars from the data received from the aircraft's Barometric Pressure sensor.

BAROMETRIC PRESSURE SETTING (minus 800 millibars)

Coding		Meaning
Msb **(Binary)** Lsb	**(Decimal)**	
0 0000 0000	0	NO Data or INVALID Data
0 0000 0001	1	0 millibars
0 0000 0010	2	0.8 millibars
0 0000 0011	3	1.6 millibars
* **** ****	***	*** **** ****
* **** ****	***	*** **** ****
* **** ****	***	*** **** ****
1 1111 1110	510	407.2 millibars
1 1111 1111	511	408.0 millibars

Bit 19: Selected Heading Status is set to ONE (1) if the contents of the Selected Heading sign and magnitude subfields are VALID, or set to ZERO (0) otherwise.

Bits 18/10: Selected Heading for the ADS-B Transmitting Subsystem.

SELECTED HEADING

Coding Msb **(Binary)** Lsb	**Meaning when Status = ONE (Valid)**
0 0000 0000	0.000 degrees
0 0000 0001	0.703125 degrees (360/512)
0 0000 0010	1.406250 degrees
**** ****	**** **** ****
**** ****	**** **** ****
0 1111 1111	179. 296875 degrees
1 0000 0000	180.0 (or –180.0) degrees
1 0000 0001	180.703125 (or –179.296875) degrees
1 0000 0010	181.406250 (or –178.593750) degrees
**** ****	**** **** ****
**** ****	**** **** ****
1 1000 0000	270.000 (or –90.0000) degrees
1 1000 0001	270.703125 (or –89.296875) degrees
1 1000 0010	271.406250 (or –88.593750) degrees
**** ****	**** **** ****
**** ****	**** **** ****
1 1111 1110	358.593750 (or –1.4062500) degrees
1 1111 1111	359.296875 (or –0.7031250) degrees

Bits 9/4: Mode Indicators for target

MODE INDICATORS

Bit #	Encoding
9	ST is the Status of MCP/FCU Mode Bits that is set to ONE (1) when any of the Mode Indicator Fields are valid, otherwise it is set to ZERO (0).
8	Autopilot Engaged (AP) field is set to ONE (1) when the MCP/FCU source indicates that the Autopilot function is engaged, otherwise it is set to ZERO (0).
7	VNAV Mode Engaged (VNAV) field is set to ONE (1) when the MCP/FCU source indicates that the VNAV function is engaged, otherwise it is set to ZERO (0).
6	Altitude Hold Mode (ALT) field is set to ONE (1) when the MCP/FCU source indicates that the Altitude Hold function is engaged, otherwise it is set to ZERO (0).
5	Approach Mode (APP) field is set to ONE (1) when the MCP/FCU source indicates that the Approach Mode function is engaged, otherwise it is set to ZERO (0).
4	LNAV Flag indicates whether or not the Lateral Navigation Mode is active for the aircraft. A value of ONE (1) indicates that LNAV mode is active. A value of ZERO (0) indicates that LNAV mode is not active.

Bits 3/1: Reserved bits, always set to ZERO (0).

B.3.21 FRN 21: ADS-B Data Quality Parameters

Definition: The ADS-B Data Quality field contains parameters concerning the quality of the data provided in various FRNs.

Structure: Two byte fixed length

Byte 1							
16	15	14	13	12	11	10	9
Enhanced Validation		--GVA--		NIC6 Supplement		--SDA--	

Byte 2							
8	7	6	5	4	3	2	1
Reserved bit	UAT Uplink Feedback			Reserved bit	-- SQL --		

Bits 16/15: Enhanced Validation. The ADS-B service performs an enhanced validation of reported ADS-B position data for targets close-in to radars to confirm the target is supporting required positional performance. Enhanced Validation indicates the target has been validated to within an adaptable Enhanced Validation Threshold (defaulted to 0.2NM which equates to a NIC 7) of the actual target position.

ENHANCED VALIDATION

Coding		**Meaning**
Bit 16	Bit 15	
0	0	Report is not within Enhanced Validation airspace or validation is not offered in the SV or CTV
0	1	Report is in Enhanced Validation airspace and determined to be Invalid to the Enhanced Validation Threshold
1	0	Report is in Enhanced Validation airspace but is in an unknown status in reference to the Enhanced Validation Threshold
1	1	Report is in Enhanced Validation airspace and determined to be Valid to the Enhanced Validation Threshold

Bits 14/13: Geometric Vertical Accuracy (GVA) is set based upon the Vertical Figure of Merit (VFOM) (95%) from the GNSS position source used to encode the geometric altitude field

GEOMETRIC VERTICAL ACCURACY

Coding		**Meaning**
(Decimal)	(Binary) Msb Lsb	
0	00	Unknown or > 150 meters
1	01	≤ 150 meters
2	10	≤ 45 meters
3	11	Reserved

Note: *The GVA field defines the accuracy range for the Geometric Altitude reported by FRN 15. This field is for use by SBS Compliance Monitoring. It is not needed for ATC automation.*

Bits 12/11: NIC 6 Supplement Bits are configured to indicate if a 1090-ES aircraft determined to have a NIC 6 has a containment radius that is different than the default value of 0.6NM for NIC 6.

NIC 6 Supplement Bits		**Meaning**
Bit 12	Bit 11	
0	0	NIC 6 Rc is default 0.6NM
0	1	NIC 6 Rc is 0.5NM
1	0	NIC 6 Rc is 0.3NM
1	1	Reserved

Note: *The NIC Supplement field is used to indicate differing performance for a containment radius than is encoded in the NIC 6. This is for use with airborne applications and not required for ATC automation.*

Bits 10/9: System Design Assurance (SDA) Level defines the failure condition that the ADS-B avionics or TIS-B surveillance sources are designed to support.

SYSTEM DESIGN ASSURANCE (SDA) LEVEL

SDA Bits		Probability of Undetected Fault causing transmission of False or Misleading Information	Supported Failure Condition	S/W and H/W Design Assurance Level
Bit 10	Bit 9			
0	0	Not Available, Unknown, or $> 1 \times 10^{-3}$ per flight hour	Unknown or No Safety Effect	N/A
0	1	$\leq 1 \times 10^{-3}$ per flight hour	Minor	D
1	0	$\leq 1 \times 10^{-5}$ per flight hour	Major	C
1	1	$\leq 1 \times 10^{-7}$ per flight hour	Severe Major/Hazardous	B

Notes:

1. *Software Design Assurance per RTCA DO-178B (EUROCAE ED-12B). Airborne Electronic Hardware Design Assurance per RTCA DO-254 (EUROCAE ED-80). The Design Assurance Levels indicate that the hardware and software design supports the identified failure condition for purposes of safety hazard assessments. The assurance levels are defined in the above standards to directly reflect the supported failure condition such that "D" = Minor, "C" = Major, "B" = Severe Major/Hazardous.*
2. *For DO-260, DO-260A, and DO-282A equipped aircraft, (Link Versions 0 and 1), the SDA is to be set to ZERO (0) because it is not sent by these aircraft.*
3. *ATC automation needs to filter targets based upon the reported SDA. Targets with an SDA of 2 or 3 are acceptable for use in providing separation Services. Targets with an SDA of 0 or 1 are not to be used for air traffic separation by ATC automation systems.*

Bit 8: Reserved bit, always set to ZERO (0)

Bits 7/5: UAT Uplink Feedback field is a 3-bit field that reports on the number of successful Ground Uplink Messages that were successfully received on a particular Data Channel in the previous 32 seconds.

UAT UPLINK FEEDBACK

Feedback Code	Score
111	32
110	31
101	29 to 30
100	26 to 28
011	22 to 25
010	14 to 21
001	1 to 13
000	0

Notes:

1. *The Score is the number of successful Ground Uplink Messages received on a particular Data Channel out of a possible 32.*
2. *This field is used for SBS Monitoring and is not applicable to ATC automation.*

Bit 4: Reserved bit, always set to ZERO (0)

Bits 3/1: Signal Quality Level is an estimate of the received power level of the position message that generated the ADS-B report.

SIGNAL QUALITY LEVEL

Encoding Msb Lsb	**1090-ES Report**	**UAT Report**
000	SA <= -90 dBm	SA <= -96 dBm
001	-90 dBm < SA <= -87 dBm	-96 dBm < SA <= -93 dBm
010	-87 dBm < SA <= -84 dBm	-93 dBm < SA <= -90 dBm
011	-84 dBm < SA <= -81 dBm	-90 dBm < SA <= -87 dBm
100	-81 dBm < SA <= -78 dBm	-87 dBm < SA <= -84 dBm
101	-78 dBm < SA <= -72 dBm	-84 dBm < SA <= -78 dBm
110	-72 dBm < SA <= -66 dBm	-78 dBm < SA <= -72 dBm
111	-66 dBm < SA	-72 dBm < SA

Note: *The SQL field is utilized for SBS avionics compliance monitoring. It should not be used by ATC automation.*

B.3.22 FRN 22: Data Source Qualifier

Definition: Identification of the data source supplying status data

Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Reserved			Msb Equipment Type				Lsb

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb Location Identifier							Lsb	Msb Instance			Lsb				

Encoding:

Bit 24/22: Reserved bits, always set to binary 111.

Bits 21/17: Type of Equipment

Bits 16/5: Location Identifier: binary coded integer corresponding to a "facility" (similar to FAA LID). Unique assignment for each radio station.

Bits 4/1: Equipment instance as a defined integer value for redundant system implementations and sectorization (up to 16); this field is populated based on the Equipment Type

Note: *The Data Source Qualifier field is applied as follows:*

Report Type	***Description***
ADS-B Report	*Radio receiver that received the triggering ADS-B Message.*
Test Target	*Radio receiver that originated the test message.*
TIS-B Report Type A (echo of sensor update)	*Sensor (including radio receiver) that triggered the report.*
TIS-B Report Type B (copy of Tx Report)	*Radio transmitter that transmitted the report.*

B.3.23 FRN 23: Report Identifier

Definition: Arbitrary persistent number used for traceability. This FRN is for Service Provider use only.

Structure: Three bytes fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb --Report Identifier--								-- Report Identifier--							

Byte 3							
8	7	6	5	4	3	2	1
-- Report Identifier-- Lsb							

Encoding:

Bit 24/1: Three byte integer value assigned to report (0 → 16777215).

B.3.24 FRN 24: Time of Origination

Definition: Time at which the radar data for a TIS-B report was received at the FAA SDP.

Structure: Three byte fixed data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
--Time of Origination --								--Time of Origination--							

Byte 3							
8	7	6	5	4	3	2	1
--Time of Origination--							

Encoding:

Bits 24/8: Time of Origination in whole seconds elapsed since UTC midnight binary encoded.

Bits 7/1: Time of Origination in fractional seconds.

Notes:

1. *The time of the day value is reset to 0 at every midnight. The time of the day is specified in UTC.*

2. *The LSB for time of origination represents 1/128 of a second.*

Appendix C – SBS SDP ADS-R ACK/NACK Format

C.1 Message Structure

This message is established as a fixed set of frames where the Field Reference Number (FRN) establishes the order of the items in this message. This is not an ASTERIX message, but there is an FSPEC for this message.

The minimum length of the FSPEC is one octet, which allows the composition of Records consisting of any combination of Data Fields with FRNs from one up to and including seven. When Data Fields with FRNs greater that seven have to be transmitted, the FSPEC extension mechanisms are used. This is achieved by assigning a special meaning to the LSB of the FSPEC octet. The LSB, called the Field Extension (FX) bit, when set to one, signals the continuation of the FSPEC field with at least one further octet, until finally an octet is provided with the FX bit set to zero. An example of the first seven FRNs of an FSPEC for an ADS-R ACK/NACK Report is shown below.

SBS SDP ADS-R ACK/NACK							
F1	***F2***	***F3***	***F4***	***F5***	***F6***	***F7***	***FX***

C.2 User Application Profile for the SBS SDP ADS-R ACK/NACK Report

Table C-1: SBS SDP ADS-R ACK/NACK (v3) User Application Profile and Construction

FRN	Data Item	Length in Bytes (when present)	Criteria for Inclusion: A=Always; O=Optional; x=Never
1	Service Volume Identifier	2	A
2	Version Number	1	A
3	Data Source Qualifier	3	A
4	Report Identifier	3	A
5	ACK Status	1	A
6	Time of Message Arrival (TOMA)	4	A
7	Latency	2	O (only for ACK)
8	Target ICAO Address	3	A

C.3 Format and Encoding of SBS SDP ADS-R ACK/NACK

C.3.1 FRN 1: Service Volume Identifier

Note: *See the SBS Service Volume Definition spreadsheet for the Service Volume Identifier assigned to each Service Volume.*

Definition: Identification of the Service Volume or Composite Traffic Volume supplying the data.

Structure: Two byte fixed length data item.

Byte 1								**Byte 2**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb							Lsb	Msb							Lsb
—SAC--								--SIC--							

Encoding:
SAC - The SAC consists of a two-digit hexadecimal encoded data number as defined in the ASTERIX Standard. SAC codes hexadecimal A0-C3 and DA-DF are reserved for the US. The SAC codes are assigned as follows:

Bits 16/13: Service Area

- Eastern Service Area: 0xA
- Western Service Area: 0xB
- Composite Traffic Volume: 0xC [Does not apply to ADS-R]
- Central Service Area: 0xD

Bits 12/9: Domain

- CTV feeding an En Route SDP: 0x1 [Does not apply to ADS-R]
- CTV feeding a Terminal SDP: 0x2 [Does not apply to ADS-R]
- CTV feeding a User Defined SDP: 0x3 [Does not apply to ADS-R]
- En Route Class A: 0xA
- Terminal Class B: 0xB
- Terminal Class C: 0xC
- Terminal Class D: 0xD
- Terminal Other: 0xE
- Surface: 0xF

Bits 8/1: The SIC is a unique numerical identifier for service volumes or composite traffic volumes of each Domain – up to 255 individual codes can be assigned.

Notes:

1. *See the SBS Service Volume Definition Document (SVDD) spreadsheet for the Service Volume Identifier assigned to each Service Volume. Examples are as follows:*

- *Phoenix Terminal is SVID #1 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB01*

- *LAX Terminal is SVID #2 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB02*

- *ZAB (Albuquerque) is SVID #154 in the SVDD spreadsheet. This is in the Western Service Area and En Route Class A airspace. The SAC/SIC code would be: BA9A. It is the first En Route SV in the SVDD that falls in the Western Service Area.*

2. *ADS-R Service is provided on an SV basis (and not on a CTV basis); therefore, there is no SIC/SAC encoding instruction related to CTVs for this ADS-R ACK/NACK Report.*

C.3.2 FRN 2: Version Number

Definition: Version of this SBS SDP ADS-R ACK/NACK format.
Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Reserved bit	Reserved bit	Version Status	Msb — Version Number — Lsb				

Encoding:
Bits 8/7: Reserved bits set to ZERO (0).

Bit 6: ZERO (0) = Version is for operational use;
ONE (1) = Version is for experimental use only.

Bits 5/1: SBS SDP ACK/NACK Version Number encoded as binary numeral in the range of 1 to 31 (Value of ZERO (0) represents "unknown" version regardless of "Version Status".)

SBS SDP ACK/NACK messages conforming to this document will be encoded with the value THREE (3) in the Version Number field (Bits 5/1).

C.3.3 FRN 3: Data Source Qualifier

Definition: Identification of the radio channel originating the ACK/NACK message.
Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Reserved			Msb — Equipment Type — Lsb				

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb — Location Identifier — Lsb												Msb — Instance — Lsb			

Encoding:
Bits 24/22: Reserved bits, always set to binary 111.

Bits 21/17: Type of Equipment

Bits 16/5: Location Identifier: binary coded integer corresponding to a "facility" (similar to FAA LID).

Bits 4/1: Instance: binary coded equipment instance number.

C.3.4 FRN 4: Report Identifier

Definition: Arbitrary persistent number used for traceability. This FRN is for Service Provider use only.

Structure: Three bytes fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb	--Report Identifier--														

Byte 3							
8	7	6	5	4	3	2	1
-- Report Identifier--							Lsb

Encoding:
Bit 24/1: Three byte integer value assigned to report (0 → 16777215).

C.3.5 FRN 5: ACK Status

Definition: Indicates ACK/NACK status and NACK reason code.
Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
ACK/ NACK	NACK Reason Code			Reserved			

Encoding:
Bit 8: ACK/NACK: NACK (0), ACK (1)

Bit 7/5: NACK Reason Code

NACK Reason Code Bit 7 Bit 6 Bit 5	Meaning
000	Unknown
001	Graceful Degradation
011	Could not meet Latency
All others	Reserved

Bit 4/1: Reserved.

C.3.6 FRN 6: Time of Message Arrival (TOMA)

Definition: UTC time at which the trigger message for the ACK/NACK was received by the Radio.

Structure: Fixed four byte data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Msb Whole Seconds Elapsed since UTC midnight															
Byte 3								**Byte 4**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Lsb	Msb Fractional Seconds Elapsed After Whole Seconds											Lsb	Reserved		

Encoding:

Bits 32/16: TOMA in whole seconds elapsed since UTC midnight (binary encoded).

Bits 15/4: TOMA in fractional seconds elapsed after whole seconds (LSB represents 1/4096s (~250 μseconds))

Bits 3/1: Reserved. Set to 000.

Note: *The time of the day value is reset to 0 at every midnight. The time of the day is specified in UTC.*

C.3.7 FRN 7: Latency

Definition: Reported latency - Elapsed time from the TOMA to the schedule time of transmission (TOT) of applicable set of ADS-R Messages

Structure: Two byte fixed length data item.

Byte 1				**Byte 2**											
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOT and TOMA Difference				Msb	Latency fractional seconds										Lsb

Encoding:
For ACK Message:

Bit 16/13: Whole seconds difference between TOT and TOMA

Bits 12/1: Latency fractional seconds elapsed since Latency whole seconds. LSB represents 1/4096 sec (~250 μsec)

Field not used For NACK Report.

C.3.8 FRN 8: Target Address

Definition: Identifies a target through a 24 bit address associated with the target.

Structure: Three byte fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb 24 bit Address															

Byte 3							
8	7	6	5	4	3	2	1
— 24 bit Address							Lsb

Encoding:
Bits 24/1: 24 bit Address

Appendix D – FAA Category 010 Format

D.1 Message Structure

The ASTERIX CAT010 Report is an Application Element in the BSDU. ASTERIX based Application Elements contain the ASTERIX CAT and LEN fields and one or more ASTERIX records (FSPEC and the specified Field Reference Numbers (FRN)) of the same Category (CAT) (See SUR.ET1.ST05.2000-STD-01-01, Figure 2).

The Field Reference Number (FRN) establishes the order of the items in the FSPEC, and along with the Category code, serves to uniquely identify each data item. The FSPEC is the first byte(s) of the Report and indicates which FRNs are present in the Report (1=FRN is included, 0=FRN is not included). Within each data item, byte 1 is transmitted first. "FX" is the Field Extension bit. A one in this bit indicates that the field extends into the next byte. As there are up to 28 FRNs identified for the WAM target report, four bytes are required for the FSPEC depending on the information to be reported.

WAM Target Report Construction Example

Time ⟶

FSPEC	FRN 1 Data Source Identifier	FRN 2 Version Number	FRN 3 Target Report Descriptor	FRN 4 Time of Applicability	FRN 5 Position in WGS-84	FRN 11 Track Status	FRN 12 Mode 3/A Code	FRN 22 Standard Deviation of Position	FRN 23 Report Identifier

F1	F2	F3	F4	F5	F6	F7	FX	F8	F9	F10	F11	F12	F13	F14	FX	F15	F16	F17	F18	F19	F20	F21	FX	F22	F23	F24	F25	F26	F27	F28	FX
1	1	1	1	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0

D.2 WAM Category 010 Report Type Definition

WAM Category 010 Reports transmitted to end users will be formatted as defined in the following sections. The Category 010 data items that will be used to specify the WAM Report are listed in Table D-1. This table also indicates the sub-fields within each data item.

Table D-1: WAM CAT010 Report Definition

FRN	Data Item	Field	Description
1	Data Source Identifier	SAC	System Area Code
		SIC	System Identification Code (0-255)
2	Version Number	STAT	Version Status
		VERSION	FAA CAT010 Version Number
3	Target Report Descriptor	TYP	Data Type (ATCRBS, Mode-S, 1090ES, UAT)
		ACI	Altitude Correction Indicator
		GBS	Transponder Ground bit Setting
		CRT	Corrupted Replies Indicator
		FX1	Field extension bit (Set to 1 if SIM, TST, RAB, or SPI are set to 1)
		SIM	Simulated Target Report Indicator
		TST	Test Target Report Indicator
		RAB	Reference Transmitter Report Indicator
		LOP	Set to 0 (undetermined)
		TOT	Set to 0 (undetermined)
		FX2	Field extension bit (Set to 1 if SPI = 1)
		SPI	Absence of SPI bit = 0; SPI present = 1
		FX3	Field extension bit, Set to 0
4	Time of Applicability	TIME	Report position time of applicability (UTC) ($1/128^{th}$ sec resolution)
5	Position in WGS-84 Coordinates	LAT/LON	Track Report latitude/longitude
9	Calculated Track Velocity in Cartesian Coordinates	VX,VY	Track velocity (0.25m/s resolution)
10	Track Number	TRACK NUMBER	Track number – assigned such that oldest released track numbers are reused first
11	Track Status	CNF	Confirmed Track Indicator
		TRE	Set to 0 (dropped tracks not reported)

FRN	Data Item	Field	Description
		CST	Set to 0 (no extrapolation)
		MAH	Set to 0 (no maneuver determination)
		TCC	Set to 1 (slant range correction applied)
		STH	Smoothed Position Indicator
		FX1	Field extension bit (Set to 0)
12	Mode 3/A Code in Octal Representation	V	Validation Indicator
		G	Garble Indicator (Not Applicable)
		L	Code Coast Indicator
		A4-D1	Mode 3/A code
13	Target Address	TARGET ADDRESS	24 bit target address or Mode S code
17	Flight Level in Binary Representation	RES	Resolution of flight level encoding
		V	Validation Indicator
		G	Garble Indicator (Not Applicable)
		FLIGHT LEVEL	Flight level in 25 foot increments (not barometric pressure corrected)
18	Corrected Flight Level	C	Indication of altitude source
		Altitude	Altitude in 25 foot increments
22	Standard Deviation of Position	σ_x	Standard Deviation of X component, LSB = 1m
		σ_y	Standard Deviation of Y component, LSB = 1m
		σ_{xy}	Covariance in two's complement form LSB = 1m (elliptical covariance)
23	Report Identifier	Report ID	Arbitrary persistent number used for traceability.
26	Data Source Qualifier	Equipment Type	Type of equipment data is sourced from
		Location ID	Provides a unique identifier for a source facility
		Instance	Instance defined in terms of equipment type

Table D-2: WAM CAT010 User Application Profile and Construction

FRN	Data Item	Length in Bytes (when present)	Criteria for Inclusion: A=Always; O=Optional; x=Never*
1	Data Source Identifier	2	A
2	Version Number	1	A
3	Target Report Descriptor	1+	A
4	Time of Applicability	3	A
5	Position in WGS-84 Coordinates	8	A
6	Measured Position in Polar Coordinates	N/A	x
7	Position in Cartesian Co-ordinates	N/A	x
8	Calculated Track Velocity in Polar Coordinates	N/A	x
9	Calculated Track Velocity in Cartesian Coordinates	4	A
10	Track Number	2	A
11	Track Status	1	A
12	Mode 3/A Code in Octal Representation	2	A
13	Target Address	3	O
14	Target Identification	N/A	x
15	Mode-S MB Data	N/A	x
16	Vehicle Fleet Identification	N/A	x
17	Flight Level in Binary Representation	3	A
18	Corrected Flight Level	2	A
19	Target Size and Orientation	N/A	x
20	System Status	N/A	x
21	Pre-programmed Message	N/A	x
22	Standard Deviation of Position	4	A
23	Report Identifier	3	A
24	Amplitude of Primary Plot	N/A	x
25	Calculated Acceleration	N/A	x
26	Data Source Qualifier	3	A

** For consistency with standard EUROCONTROL ASTERIX definitions, all FRNs associated with the CAT010 report are included in the table above. Each FRN marked as N/A is an FRN that is not used in the FAA SBS definition of CAT010; they are never included in the CAT010 and always indicated as "not present" (VALUE = ZERO) in the CAT010 FSPEC.*

D.3 Format and Encoding of WAM CAT010 Data Items

D.3.1 FRN 1: Data Source Identifier

Note: See the SBS Service Volume Definition spreadsheet for the Service Volume Identifier assigned to each Service Volume.

Definition: Identification of the Service Volume that is providing data to the SDP.

Structure: Two-byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
msb	SAC						lsb	msb	SIC						lsb

Encoding:

SAC - The SAC consists of a two-digit hexadecimal encoded data number as defined in the ASTERIX Standard. SAC codes hexadecimal A0-C3 and DA-DF are reserved for the US. The SAC codes are assigned as follows:

Bits 16/13: Service Area

- Eastern Service Area: 0xA
- Western Service Area: 0xB
- Central Service Area: 0xD

Bits 12/9: Domain

- En Route Class A: 0xA
- Terminal Class B: 0xB
- Terminal Class C: 0xC
- Terminal Class D: 0xD
- Terminal Other: 0xE
- Surface: 0xF

Bits 8/1: The SIC is a unique numerical identifier for service volumes of each Domain – up to 255 individual codes can be assigned.

Note: Example is as follows:

Montrose Terminal is SV ID #338 in the SVDD. This is in the Western Service Area and Other airspace. The SAC/SIC code would be: BE01.

D.3.2 FRN 2: Version Number

Definition: Version of this FAA CAT010 format.

Structure: One-byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
0	0	STAT	VERSION				

Encoding:

Bits 8/7: Spare bits always set to 0

Bit 6: STAT:

0 = Operational use
1 = Experimental use only

Bits 5/1 FAA CAT010 Version Number encoded as a binary numeral in the range of 1 to 31

Notes:

1. *A value of Zero (0) represents "Unknown" version regardless of Version Status (STAT).*
2. *FAA Category 010 messages conforming to this document will be encoded with the value of 3 in the VERSION field (Bits 5/1)*

D.3.3 FRN 3: Target Report Descriptor

Definition: Type and characteristics of the target report in the message.

Structure: Variable length data item comprising a first part of one-byte followed by one-byte extents as necessary.

Base Message

Byte 1							
8	7	6	5	4	3	2	1
TYP			ACI		GBS	CRT	FX1

Encoding:

Bits 8/6 TYP:

000 = SSR Multilateration (ATCRBS)
001 = Mode-S Multilateration
010 = ADS-B 1090 ES Multilateration
011 = Primary Surveillance Radar (PSR) (N/A)
100 = Magnetic Loop System (N/A)
101 = HF Multilateration (N/A)
110 = ADS-B UAT Multilateration
111 = Other Types (N/A)

Bit 5/4: ACI:

00 = No altitude used in horizontal position
01 = Corrected altitude used in horizontal position calculation
10 = Uncorrected altitude used in horizontal position calculation
11 = Undefined (N/A)

Bit 3: GBS:

0 = Target not on the ground
1 = Target is on the ground

Bit 2: CRT:

0 = No corrupted replies used in multilaterated position
1 = Corrupted replies used in Multilateration

Bit 1: FX1:

0 = If {(RAB=0) AND (SPI=0) AND (TST=0) AND (SIM=0)}
Otherwise set to 1.

If FX1 is set to 1, then message will include the optional first extent

First Extent

Structure of Optional First Extent:

Byte 2							
8	7	6	5	4	3	2	1
SIM	TST	RAB	LOP		TOT		FX2

Encoding:

Bit 8: SIM:

0 = Actual Target Report
1 = Simulated Target Report (playback)

Bit 7: TST:

0 = Default (not a Test Target Report)
1 = Test Target Report

Bit 6: RAB:

0 = Target Report
1 = Report from field monitor or fixed transponder

Bits 5/4: LOP:

00 = Undetermined (always set to 00)
01 = Loop start (N/A)
10 = Loop finish (N/A)
11 = Undefined

Bits 3/2: TOT:

00 = Undetermined (always set to 00)
01 = Aircraft (N/A)
10 = Ground vehicle (N/A)
11 = Helicopter (N/A)

Bit 1: FX2:

0 = If {(SPI=0)}
Otherwise set to 1

If FX2 is set to 1, then message will include the optional second extent.

Second Extent

Structure of Optional Second Extent:

Byte 3							
8	7	6	5	4	3	2	1
SPI	0	0	0	0	0	0	FX3

Bit 8: SPI:

0 = Absence of SPI bit in transponder message
1 = Special Position Identification (SPI present in message)

Bits 7/2: Spare bits always set to 0.

Bits 1: FX3:

0 = End of the Data Item (always set to 0)

D.3.4 FRN 4: Time of Applicability

Definition: Time of applicability of the target report message.

Structure: Three byte fixed length data item. The Lsb represents 1/128th of a second.

Byte 1							
24	23	22	21	20	19	18	17
Time							

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Of Applicability															

Encoding:

Bits 24/1 Seconds elapsed since UTC midnight binary encoded. Lsb = 1/128th of a second.

D.3.5 FRN 5: Position in WGS-84 Coordinates

Definition: Position of the target in WGS-84 Coordinates.

Structure: Eight-byte fixed length data item.

Byte 1								Byte 2							
64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49
Latitude in WGS-84															

Byte 3								Byte 4							
48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33
Latitude in WGS-84															

Byte 5								Byte 6							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Longitude in WGS-84															

Byte 7								Byte 8							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Longitude in WGS-84															

Encoding:

Bits 64/33 Latitude in WGS-84 in two's complement
Range -90 <= latitude <= 90 deg.
LSB = $180/2^{31}$ degrees

Bits 32/1 Longitude in WGS-84 in two's complement
Range -180 <= longitude <= 180 deg.
LSB = $180/2^{31}$ degrees

Note: Latitude (+ = N; - = S), Longitude (+ = E; - = W)

D.3.6 FRN 9: Calculated Velocity in Cartesian Coordinates

Definition: Calculated track velocity expressed in Cartesian Coordinates, in two's complement representation.

Structure: Four-byte fixed length data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Vx															

Byte 3								Byte 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Vy															

Encoding:

Bits 32/17 Velocity X, LSB = 0.25 m/s, maximum value = ±8192 m/s

Bits 16/1 Velocity Y, LSB = 0.25 m/s, maximum value = ±8192 m/s

D.3.7 FRN 10: Track Number

Definition: An integer value representing a unique reference to a track record within a particular track file entry from the WAM Service.

Structure: Two-byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Track Number															

Encoding:

Bits 16-1: Track number assigned by WAM Service for track-aided plot such that the oldest released track numbers are reused first.

D.3.8 FRN 11: Track Status

Definition: Status of track.

Structure: Variable length data item comprising up to two bytes of data as necessary.

Base Message

Byte 1							
8	7	6	5	4	3	2	1
CNF	TRE	CST		MAH	TCC	STH	FX1

Encoding:

Bit 8 CNF:

0 = Confirmed Track
1 = Track in initialization phase

Bit 7: TRE:

0 = Default (always set to 0)
1 = Last report for a track (N/A)

Note: WAM Tracker does not report lost tracks; therefore TRE is always set to 0.

Bits 6/5: CST:

00 = No extrapolation (always set to 00)
01 = Predictable extrapolation due to sensor refresh (N/A)
10 = Predictable extrapolation in masked area (N/A)
11 = Extrapolation due to unpredictable absence of detection (N/A)

Bit 4: MAH:

0 = Default (always set to 0)
1 = Horizontal maneuver (N/A)

Bit 3: TCC:

0 = Tracking performed in "sensor plane", i.e. neither slant range correction nor projection applied.
1 = Slant range correction and a suitable projection technique used to track in 2D reference plane, tangential to the earth model at the sensor site coordinates.

Bit 2: STH:

0 = Measured position
1 = Smoothed position

Bit 1: FX1: Always set to 0

D.3.9 FRN 12: Mode 3/A Code in Octal Representation

Definition: Mode 3/A code converted into octal representation.

Structure: Two-byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
V	G	L	0	Mode 3/A Code											

Encoding:

Bit 16: V:
0 = Code validated
1 = Code not validated

Notes:

1. *A valid Mode 3/A Code indicates that the track has received a valid Mode 3/A Code update within the adapted Mode 3/A Validity Time.*
2. *If the Mode 3/A code is never received from the aircraft, a Mode 3/A Code of all zeros will be sent and the V bit will be set to "code not validated".*

Bit 15 G:
0 = Default (Not Garbled)
1 = Garbled Code

Bit 14 L:
0 = Mode 3/A code obtained from a transponder reply that occurs within the adapted Mode 3/A Validity time.
1 = Mode 3/A code contained in FRN has not been updated within the configured Validity time.

Bit 13 Spare bit always set to 0

Bits 12/1 Mode 3/A Code in octal representation, A4 – D1 or 4 octal digits

Notes:

1. *A4-D1 format is $A_4A_2A_1B_4B_2B_1C_4C_2C_1D_4D_2D_1$ (as specified by DO-181D) and in this order from bit 12 to 1.*
2. *If a valid Mode 3/A code was never received from the aircraft, a Mode 3/A Code of all zeros will be sent.*

D.3.10 FRN 13: Target Address

Definition: Target 24-bit address assigned uniquely to each target.

Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Target							

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Address															

Encoding:

Bits 24/1: Target Address: 24-bit Target address [A23 to A0] or Mode S code

D.3.11 FRN 17: Flight Level in Binary Representation

Definition: Flight level (Mode C) converted into binary two's complement representation.

Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Flight Level Age						RES	

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
V	G	Flight Level													

Encoding:

Bits 24/19: Flight Level Age - Seconds elapsed since the receipt of the Mode-C value contained in the flight level field. The LSB of this field is 100ms. The age is measured from the time of receipt of the ADS-B or reply message containing the Mode-C value to the time of applicability of the report containing that value.

Notes:

1. *The age value is rounded to the nearest 100ms*
2. *The age value is set to zero (000000) for certification targets*
3. *The age value is set to all ones (111111) if the value is ≥ 6.3 seconds.*
4. *The age field is not applicable if the Validation Bit (Bit 16) is set to One (1)*

Bit 18/17: RES: Resolution of flight level encoding by the sensor.

RESOLUTION

Resolution Bits		Meaning
Bit 18	Bit 17	
0	0	Resolution unknown
0	1	100 foot Resolution
1	0	25 foot Resolution
1	1	Reserved

Note: *Resolution field is provided only to make a tracker aware of the resolution of the flight level (pressure altitude) source. It has NO influence on the encoding of the Flight Level field, i.e., the Flight Level Lsb for FRN 17 is always 25 feet*

Bit 16: V:

0 = Code validated
1 = Not validated

Notes:

1. *A valid Mode C Code indicates that the track has received a valid Mode C Code within the Mode C Age Limit.*
2. *For ATCRBS Mode C replies with the D1 bit set or with C bits having values of 0, 5, or 7, the system will assign a 1 to this field to indicate that the Mode C is Not validated*
3. *For Cert Targets the delivered Mode C code will be configurable.*

Bit 15 G:

0 = Default (Not garbled)
1 = Garbled code

Note: Always set to zero

Bits 14/1 Flight Level in 25 foot increments (1/4 FL) (barometric correction not applied)

Notes:

1. *If a valid Flight Level was never received or has not been received for an adaptable amount of time, a flight level of all zeros and a validation status of "not validated" will be sent.*
2. *This field will be set to -99,900 ft. for ATCRBS targets with Mode C replies with the D1 bit set or C bits having values of 0, 5, or 7. A value of -99,900 ft signifies an invalid Gillham gray code was received in the Mode-C field.*
3. *For RTCA/DO-260B and RTCA/DO-282B MOPS compliant aircraft, the barometric altitude information contained within the airborne position message may be utilized for determination of flight level.*

D.3.12 FRN 18: Corrected Flight Level

Definition: This data item reflects the best height source available for slant range calculation and will normally contain corrected Altitude AMSL – derived from correcting the reported Mode C based on current atmospheric conditions. Encoded into binary two's compliment representation.

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
C		Altitude													

Encoding:

Bits 16/15 C:

00 = Corrected Mode C Altitude

01 = Uncorrected Mode C (same as reported Mode-C)

10 = 3D Multilaterated Position Altitude

11 = No Altitude information available

Bits 14/1 Altitude in 25 foot increments (1/4 FL)

Notes:

1. *This field may contain a corrected Mode C altitude or multilaterated height as determined by the WAM Service. Therefore it should not be utilized by the automation system. FRN 17 will always contain the uncorrected Mode C altitude and should be utilized by automation.*

D.3.13 FRN 22: Standard Deviation of Position

Definition: Standard deviation of position.

Structure: Four byte fixed length data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
σ_x								σ_y							

Byte 3								Byte 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Reserved		σ_{xy}													

Encoding:

Bits 32/25: σ_x – Standard deviation of X component, LSB = 1m

Bits 24/17: σ_y – Standard deviation of Y component, LSB = 1m

Note: σ_x, σ_y is set to maximum value if exceeded

Bits 16/15 Reserved

Bits 16/1 σ_{xy} – Elliptical covariance in two's complement form, LSB = 1m

Note: This field contains the square root of the absolute value of the cross covariance term. The original sign is then applied to the square root term and is included in this field.

D.3.14 FRN 23: Report Identifier

Definition: Arbitrary persistent number used for traceability. This FRN is for Service Provider use only.

Structure: Three bytes fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Report							

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Identifier															

Encoding:

Bit 24/1: Three byte integer value assigned to report (0 → 16777215).

D.3.15 FRN 26: Data Source Qualifier

Definition: Identification of the data source supplying target data.

Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Reserved			Equipment Type				

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Location ID												Instance			

Encoding:

Bits 24/22: Reserved bits always set to binary 111.

Bits 21/17: Equipment Type: value will indicate the type of equipment that generated the data. For the WAM Service, this value will be set to binary 11101 to indicate MLAT Server.

Bits 16/5: Location ID: binary coded integer that provides a unique identifier for a facility comparable to a FAA LID.

Bits 4/1: Instance: binary coded equipment instance number that is defined in context with the equipment type. For the WAM Service this field will not be utilized and will be set to binary 0000.

Appendix E FAA Category 019 Format

E.1 Message Structure

The ASTERIX CAT019 Report is an Application Element in the BSDU. ASTERIX based Application Elements contain the ASTERIX CAT and LEN fields and one or more ASTERIX records (FSPEC and the specified Field Reference Numbers (FRN)) of the same Category (CAT) (See SUR.ET1.ST05.2000-STD-01-01, Figure 2).

The Field Reference Number (FRN) establishes the order of the items in the FSPEC, and along with the Category code, serves to uniquely identify each data item. The FSPEC is the first byte(s) of the Report and indicates which FRNs are present in the Report (1=FRN is included, 0=FRN is not included). Within each data item, byte 1 is transmitted first. "FX" is the Field Extension bit. A one in this bit indicates that the field extends into the next byte. As there are up 14 FRNs identified for the WAM Service Status Report, two bytes are required for the FSPEC depending on the information to be reported.

WAM Service Status Report Construction Example

Time →

FSPEC	**FRN 1** Data Source Identifier	**FRN 2** Version Number	**FRN 3** Time of Status Message	**FRN 4** System Status	**FRN 5** Track Processor Detailed Status	**FRN 6** Remote Sensor Detailed Status	**FRN 7** RefTran Detailed Status	**FRN 12** Data Source Qualifier

F1	F2	F3	F4	F5	F6	F7	FX	F8	F9	F10	F11	F12	F13	F14	FX
1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0

E.2 WAM Category 019 Report Type Definition

WAM Category 019 Reports transmitted to end users will be formatted as defined in the following section. One FAA CAT 019 Service Status report will be sent per update interval for each WAM Service Volume. The Category 019 data items that will be used to specify the WAM Service Status Report are listed in Table E-1. This table also indicates the sub-fields within each data item.

Table E-1: WAM CAT019 Report Definition

FRN	Data Item	Field	Description
1	Data Source Identifier	SAC	System Area Code
		SIC	System Identification Code (0-255)
2	Version Number	STAT	Version Status
		VERSION	FAA CAT019 Version Number
3	Time of Status Message	TIME	Absolute time stamping expressed as UTC. ($1/128^{th}$ sec resolution)
4	System Status	NOGO	Operational Status of the Service per Service Volume
		OVL	Overload Indication
		TSV	Time Source Validity
		TTF	Test Target Failure
		ACA	Altitude Correction Application Status
		CRS	Critical Radio Set
5	Track Processor Detailed Status	TP STATUS	Status of Target Processors
6	Remote Sensor Detailed Status	REP	Repetition Factor
		Location Identifier	Unique assignment for each remote sensor
		RS TYPE	Remote Sensor Type
		RS STATUS	Status of Remote Sensor
7	Reference Transponder Detailed Status	REFTRAN STATUS	Status of Reference Transmitters 1-n
		FX	Field Extension
12	Data Source Qualifier	Equipment Type	Type of equipment status data is sourced from
		Location ID	Provides a unique identifier for a source facility
		Instance	Defined in terms of equipment type

Table E-2: WAM CAT019 User Application Profile and Construction

FRN	Data Item	Length in Bytes (when present)	Criteria for Inclusion: A=Always; O=Optional; x=Never*
1	Data Source Identifier	2	A
2	Version Number	1	A
3	Time of Status Message	3	A
4	System Status	1	A
5	Track Processor Detailed Status	1	A
6	Remote Sensor Detailed Status	4+	A
7	Reference Transponder Detailed Status	1+	O
8	Position of MLT System Reference	N/A	x
9	Height of MLT System Reference Point	N/A	x
10	WGS-84 Undulation	N/A	x
11	Spare	N/A	x
12	Data Source Qualifier	3	A

** For consistency with standard EUROCONTROL ASTERIX definitions, all FRNs associated with the CAT019 report are included in the table above. Each FRN marked as N/A is an FRN that is not used in the FAA SBS definition of CAT019; they are never included in the CAT019 and always indicated as "not present" (VALUE = ZERO) in the CAT019 FSPEC.*

E.3 Format and Encoding of WAM CAT019 Data Items

E.3.1 FRN 1: Data Source Identifier

Note: See the SBS Service Volume Definition spreadsheet for the Service Volume Identifier assigned to each Service Volume.

Definition: Identification of the Service Volume that is providing data to the SDP.

Structure: Two-byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
msb	SAC						lsb	msb	SIC						lsb

Encoding:

SAC - The SAC consists of a two-digit hexadecimal encoded data number as defined in the ASTERIX Standard. SAC codes hexadecimal A0-C3 and DA-DF are reserved for the US. The SAC codes are assigned as follows:

Bits 16/13: Service Area
- Eastern Service Area: 0xA
- Western Service Area: 0xB
- Central Service Area: 0xD

Bits 12/9: Domain
- En Route Class A: 0xA
- Terminal Class B: 0xB
- Terminal Class C: 0xC
- Terminal Class D: 0xD
- Terminal Other: 0xE
- Surface: 0xF

Bits 8/1: The SIC is a unique numerical identifier for service volumes of each Domain – up to 255 individual codes can be assigned.

Note: Example is as follows:

Montrose Terminal is SV ID #338 in the SVDD. This is in the Western Service Area and Other airspace. The SAC/SIC code would be: BE01.

E.3.2 FRN 2: Version Number

Definition: Version of this FAA CAT019 format.

Structure: One-byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
0	0	STAT	VERSION				

Encoding:

Bits 8/7: Spare bits always set to 0

Bit 6: STAT:

0 = Operational use
1 = Experimental use only

Bits 5/1 FAA CAT019 Version Number encoded as a binary numeral in the range of 1 to 31

Notes:

1. *A value of Zero (0) represents "Unknown" version regardless of Version Status (STAT).*
2. *FAA Category 019 messages conforming to this document will be encoded with the value of 3 in the VERSION field (Bits 5/1)*

E.3.3 FRN 3: Time of Status Message

Definition: The time the information contained within the status message was recorded expressed as UTC.

Structure: Three byte fixed length data item. The LSB represents 1/128th of a second.

Byte 1							
24	23	22	21	20	19	18	17
Time							

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Of Status Message															

Encoding:

Bits 24/1 Seconds elapsed since UTC midnight binary encoded, Lsb = 1/128th of a second.

E.3.4 FRN 4: System Status

Definition: Information concerning the status of the WAM Service on a per Service Volume basis.

Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
NOGO		OVL	TSV	TTF		ACA	CRS

Encoding:

Bits 8/7 Operational Status (NOGO):

00 = Operational (No Faults)
01 = Degraded (Faults present however service still meets all performance requirements)
10 = NOGO (Critically Faulted, service may no longer meets all performance requirements within a portion or throughout the service volume.)
11 = Test (Service in Test or maintenance mode)

Bit 6 Overload Indicator (OVL)

0 = No Overload
1 = Overload Condition

Note: Defined as exceeding max target load.

Bit 5 Time Source Validity (TSV)

0 = Valid
1 = Invalid

Note: Time Source Validity indicates whether WAM Server is UTC synchronized via NTP.

Bit 4/3 Test Target (TTF)

00 = Test Targets Operative *(All Certification Targets are available)*
01 = Test Targets Failure *(At least one Certification Target is absent)*
10 = Test Targets Failure (*All certification Targets are absent*)
11 = Not Defined

Bit 2 Altitude Correction Application Status (ACA)

0 = Altitude Correction Operative
1 = Altitude Correction Failure

Bit 1 Critical Radio Set (CRS)

0 = Number/combination of operational radios support surveillance service in specified service volume. No critical radio sets faulted

1 = Number/combination of faulted radios meets/exceeds the configured settings which define when the service can no longer meet performance requirements in a specified service volume. Any critical radio set is faulted.

E.3.5 FRN 5: Tracking Processor Detailed Status

Definition: Information concerning the configuration and status of the WAM Target Processors.

Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
TP1 Status			0	TP2 Status			0

Encoding:

Bits 8/6 TP1 Status

- Bits 8/7
  - 11 = Good
  - 10 = Faulted
  - 00 = Not Present
  - 01 = Not Defined
- Bit 6
  - 0 = Standby
  - 1 = Operational

Bit 5 Spare bit always set to zero

Bits 4/2 TP2 Status

- Bits 4/3
  - 11 = Good
  - 10 = Faulted
  - 00 = Not Present
  - 01 = Not Defined
- Bit 2
  - 0 = Standby
  - 1 = Operational

Bit 1 Spare bit always set to zero

E.3.6 FRN 6: Remote Sensor Detailed Status

Definition: Information concerning the configuration and status of the WAM remote sensors.

Structure: Repetitive data item starting with a one byte Field Repetition Indicator (REP) followed by at least one report comprising a status of a single remote sensor.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
REP								Location Identifier							

Byte 3								Byte 4							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Location Identifier				RS Type				RS Status						0	0

Encoding:

Bits 32/25 REP: Repetition Factor

Bits 24/13 Location Identifier: binary coded integer corresponding to a "facility" (similar to FAA LID). Unique assignment for each remote sensor.

Bits 12/9 Remote Sensor Type

- Bit 12 1 = 978 MHz receiver present, otherwise set to zero
- Bit 11 1 = 1090 MHz receiver present, otherwise set to zero
- Bit 10 1 = 1030 MHz transmitter present, otherwise set to zero
- Bit 9 1 = 1090MHz transmitter present, otherwise set to zero

Bits 8/3 Remote Sensor Status

- Bit 8 Receiver Status
  1 = Good
  0 = Faulted
- Bit 7 Transmitter Status
  1 = Good
  0 = Faulted
- Bit 6 RS State
  1 = Online
  0 = Offline
- Bit 5 Alarm
  1 = Receiver and Transmitter status is Good and RS State is Online
  0 = Receiver or Transmitter status is Faulted or RS State is Offline
- Bit 4: Timing Status
  1 = UTC coupled;
  0 = non-UTC coupled (i.e., coasting)
- Bit 3: Integrity Monitor
  1 = Radio available for inclusion in solutions;

0 = Radio excluded from all solutions

Bits 2/1 Spare bits set to zero

E.3.7 FRN 7: Reference Transponder Detailed Status

Definition: Information concerning the status of the configuration and status of the WAM reference Transmitters.

Structure: Variable length data item depending on the total number of reference transmitters within a service volume.

Byte 1							
8	7	6	5	4	3	2	1
Ref Tran 1		0	0	Ref Tran 2		0	FX

Encoding:

Bits 8/7 Ref Tran 1 Status

11 = Good
10 = Faulted
01 = Warning
00 = Not Installed

Bits 6/5 Spare bits set to zero

Bits 4/3 Ref Tran 2 Status

11 = Good
10 = Faulted
01 = Warning
00 = Not Installed

Bit 2 Spare bit set to zero

Bit 1 FX

0 = End of Data Item
1 = Extension into the first extent

First Extent:

Byte 2							
8	7	6	5	4	3	2	1
Ref Tran 3		0	0	Ref Tran 4		0	FX

Encoding:

Bits 8/7 Ref Tran 3 Status

11 = Good
10 = Faulted
01 = Warning
00 = Not Installed

Bits 6/5 Spare bits set to zero

Bits 4/3 Ref Tran 4 Status

11 = Good
10 = Faulted
01 = Warning
00 = Not Installed

Bit 2 Spare bit set to zero

Bit 1 FX

0 = End of Data Item
1 = Extension into the next extent

Note: Ref Tran status bytes are repeated until status is provided for all available Reference Transmitters. Ref Tran status bytes are repeated until bit 1 (FX) is set to zero.

E.3.8 FRN 12: Data Source Qualifier

Definition: Identification of the data source supplying status data.

Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Reserved			Equipment Type				

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Location ID												Instance			

Encoding:

Bits 24/22: Reserved bits always set to binary 111.

Bits 21/17: Equipment Type: value will indicate the type of equipment that generated the data. For WAM this value will be set to binary 11101 to indicate MLAT Server.

Bits 16/5: Location ID: binary coded integer that provides a unique identifier for a facility comparable to a FAA LID.

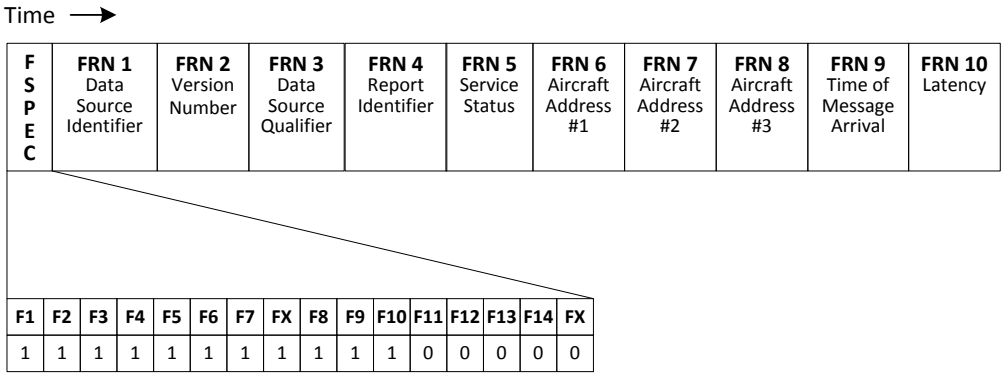
Bits 4/1: Instance: binary coded equipment instance number that is defined in context with the equipment type. For the WAM Service this field will not be utilized and will be set to binary 0000.

Appendix F – 1090-ES TIS-B/ADS-R Service Status Format

F.1 Message Structure

This report applies to TIS-B/ADS-R Service status messages that are uplinked on 1090-ES. This message is established as a fixed set of frames where the Field Reference Number (FRN) establishes the order of the items in this message. This is not an ASTERIX message, but there is an FSPEC for this message.

The minimum length of the FSPEC is one octet, which allows the composition of Records consisting of any combination of Data Fields with FRNs from one up to and including seven. When Data Fields with FRNs greater that seven have to be transmitted, the FSPEC extension mechanisms are used. This is achieved by assigning a special meaning to the LSB of the FSPEC octet. The LSB, called the Field Extension (FX) bit, when set to one, signals the continuation of the FSPEC field with at least one further octet, until finally an octet is provided with the FX bit set to zero. An example of the FRNs of an FSPEC for this Report is shown below.



F.2 User Application Profile for 1090-ES TIS-B/ADS-R Service Status Reports

Table F-1: TIS-B/ADS-R Service Status Report User Application Profile and Construction

FRN	Data Item	Length in Bytes (when present)	Criteria for Inclusion: A=Always; O=Optional; x=Never
1	Service Volume Identifier	2	A
2	Version Number	1	A
3	Data Source Qualifier	3	A
4	Report Identifier	3	A
5	Service Status	1	A
6	Aircraft Address #1	3	A
7	Aircraft Address #2	3	A
8	Aircraft Address #3	3	A
9	Time of Message Arrival (TOMA)	4	A
10	Latency	2	A

F.3 Format and Encoding of TIS-B/ADS-R Service Status Report

F.3.1 FRN 1: Service Volume Identifier

Note: *See the SBS Service Volume Definition spreadsheet for the Service Volume Identifier assigned to each Service Volume.*

Definition: Identification of the Service Volume or Composite Traffic Volume supplying the data.

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb							Lsb	Msb							Lsb
—SAC--								--SIC--							

Encoding:
SAC - The SAC consists of a two-digit hexadecimal encoded data number as defined in the ASTERIX Standard. SAC codes hexadecimal A0-C3 and DA-DF are reserved for the US. The SAC codes are assigned as follows:

Bits 16/13: Service Area

- Eastern Service Area: 0xA
- Western Service Area: 0xB
- Composite Traffic Volume: 0xC [Does not apply to ADS-R]
- Central Service Area: 0xD

Bits 12/9: Domain

- CTV feeding an En Route SDP: 0x1 [Does not apply to ADS-R]
- CTV feeding a Terminal SDP: 0x2 [Does not apply to ADS-R]
- CTV feeding a User Defined SDP: 0x3 [Does not apply to ADS-R]
- En Route Class A: 0xA
- Terminal Class B: 0xB
- Terminal Class C: 0xC
- Terminal Class D: 0xD
- Terminal Other: 0xE
- Surface: 0xF

Bits 8/1: The SIC is a unique numerical identifier for service volumes or composite traffic volumes of each Domain – up to 255 individual codes can be assigned.

Notes:

3. *See the SBS Service Volume Definition Document (SVDD) spreadsheet for the Service Volume Identifier assigned to each Service Volume. Examples are as follows:*

   - *Phoenix Terminal is SVID #1 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB01*

   - *LAX Terminal is SVID #2 in the SVDD spreadsheet. This is in the Western Service Area and Class B airspace. The SAC/SIC code would be: BB02*

   - *ZAB (Albuquerque) is SVID #154 in the SVDD spreadsheet. This is in the Western Service Area and En Route Class A airspace. The SAC/SIC code would be: BA9A. It is the first En Route SV in the SVDD that falls in the Western Service Area.*

4. *ADS-R Service is provided on an SV basis (and not on a CTV basis); therefore, there is no SIC/SAC encoding instruction related to CTVs for this Report.*

F.3.2 FRN 2: Version Number

Definition: Version of this TIS-B/ADS-R Service Status Report format.
Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Reserved bit	Reserved bit	Version Status	Msb — Version Number — Lsb				

Encoding:
Bits 8/7: Reserved bits set to ZERO (0).

Bit 6: ZERO (0) = Version is for operational use;
ONE (1) = Version is for experimental use only.

Bits 5/1: TIS-B/ADS-R Service Status Report Version Number encoded as binary numeral in the range of 1 to 31 (Value of ZERO (0) represents "unknown" version regardless of "Version Status".)

TIS-B/ADS-R Service Status Report messages conforming to this document will be encoded with the value THREE (3) in the Version Number field (Bits 5/1).

F.3.3 FRN 3: Data Source Qualifier

Definition: Identification of the radio channel originating the TIS-B/ADS-R Service Status Message.
Structure: Three byte fixed length data item.

Byte 1							
24	23	22	21	20	19	18	17
Reserved			Msb — Equipment Type — Lsb				

Byte 2								Byte 3							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Msb — Location Identifier — Lsb												Msb — Instance — Lsb			

Encoding:
Bits 24/22: Reserved bits, always set to binary 111.

Bits 21/17: Type of Equipment

Bits 16/5: Location Identifier: binary coded integer corresponding to a "facility" (similar to FAA LID).

Bits 4/1: Instance: binary coded equipment instance number.

F.3.4 FRN 4: Report Identifier

Definition: Arbitrary persistent number used for traceability. This FRN is for Service Provider use only.

Structure: Three bytes fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb --Report Identifier--															

Byte 3							
8	7	6	5	4	3	2	1
-- Report Identifier-- Lsb							

Encoding:
Bit 24/1: Three byte integer value assigned to report (0 → 16777215).

F.3.5 FRN 5: Service Status

Definition: Indicates TIS-B/ADS-R Service Status to each respective aircraft to which this report applies.

Structure: One byte fixed length data item.

Byte 1							
8	7	6	5	4	3	2	1
Reserved					Address #3 Service Status	Address #2 Service Status	Address #1 Service Status

Encoding:

Bit 8/4: Reserved (set to ZERO)

Bit 3: Service Status for aircraft Address #3, where:
ZERO (0) = Out of Service or leaving Service Area
ONE (1) = TIS-B and ADS-R traffic services are being provide to this aircraft address.

Bit 2: Service Status for aircraft Address #2, where:
ZERO (0) = Out of Service or leaving Service Area
ONE (1) = TIS-B and ADS-R traffic services are being provide to this aircraft address.

Bit 1: Service Status for aircraft Address #1, where:
ZERO (0) = Out of Service or leaving Service Area
ONE (1) = TIS-B and ADS-R traffic services are being provide to this aircraft address.

F.3.6 FRN 6: Aircraft Address #1

Definition: Identifies the 24 bit address of the aircraft for which the first service status bit of this report applies.

Structure: Three byte fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb 24 bit Address															

Byte 3							
8	7	6	5	4	3	2	1
— 24 bit Address							Lsb

Encoding:
Bits 24/1: 24 bit Address of aircraft #1 to which this report applies.

F.3.7 FRN 7: Aircraft Address #2

Definition: Identifies the 24 bit address of the aircraft for which the second service status bit of this report applies.

Structure: Three byte fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb	24 bit Address														

Byte 3							
8	7	6	5	4	3	2	1
— 24 bit Address							Lsb

Encoding:
Bits 24/1: 24 bit Address aircraft #2 to which this report applies.

F.3.8 FRN 8: Aircraft Address #3

Definition: Identifies the 24 bit address of the aircraft for which the third service status bit of this report applies.

Structure: Three byte fixed length data item.

Byte 1								Byte 2							
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
Msb	24 bit Address														

Byte 3							
8	7	6	5	4	3	2	1
— 24 bit Address							Lsb

Encoding:
Bits 24/1: 24 bit Address of aircraft #3 to which this report applies.

F.3.9 FRN 9: Time of Message Arrival (TOMA)

Definition: UTC time at which the trigger message for the TIS-B/ADS-R Service Status Message that generated this Report was received by the Radio.

Structure: Fixed four byte data item.

Byte 1								Byte 2							
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17
Msb Whole Seconds Elapsed since UTC midnight															
Byte 3								**Byte 4**							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Lsb	Msb Fractional Seconds Elapsed After Whole Seconds											Lsb	Reserved		

Encoding:

Bits 32/16: TOMA in whole seconds elapsed since UTC midnight (binary encoded).

Bits 15/4: TOMA in fractional seconds elapsed after whole seconds (LSB represents 1/4096s (~250 µseconds))

Bits 3/1: Reserved. Set to 000.

Note: *The time of the day value is reset to 0 at every midnight. The time of the day is specified in UTC.*

F.3.10 FRN 10: Latency

Definition: Reported latency - Elapsed time from the TOMA to the scheduled time of transmission (TOT) of the applicable TIS-B/ADS-R Service Status Message

Structure: Two byte fixed length data item.

Byte 1								Byte 2							
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOT and TOMA Difference				Msb Latency fractional seconds											Lsb

Encoding:

Bit 16/13: Whole seconds difference between TOT and TOMA

Bits 12/1: Latency fractional seconds elapsed since Latency whole seconds. LSB represents 1/4096 sec (~250 μsec)