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Surveillance and Broadcast Services Program

Traffic Information Service – Broadcast (TIS-B) /Flight Information Service - Broadcast (FIS-B) Essential Services Specification

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1 INTRODUCTION

1.1 Background

The Federal Aviation Administration (FAA)'s Surveillance and Broadcast Services Program plans to introduce Automatic Dependent Surveillance–Broadcast (ADS-B) technology based services into the NAS. Four distinct services are to be provided:

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

The service requirements are documented in two separate specifications: (1) ADS-B/ADS-R Services and (2) TIS-B/FIS-B Services.

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 ADS-R Service will be designed to the "Critical" level. However, that Service may, at the Government's option, be deployed at an "essential" level until such time as the ADS-R Service is required to provide a critical level of functionality.

The TIS-B/FIS-B Services will provide traffic, weather, and NAS Status information to equipped aircraft/vehicles, supporting airborne applications at the "Essential" level. ADS-B downlink information will be captured as part of providing the TIS-B Service and that information will also be made available to authorized airspace users.

The Essential and Critical level Services will provide data to FAA defined Service Delivery Points (SDP). The SDPs are the demarcation point between the Services and the systems which ultimately use the data on the ground. The Essential level Services will provide TIS-B, FIS-B, ADS-B, and Service Status Reports to authorized user systems and the SBS Monitor, via SDPs. The Critical level Services will provide ADS-B and Critical Service Status Reports to ATC Automation, other authorized user systems, and the SBS Monitor system, via SDPs.

The Service provider may provide data to user systems in addition to those specified by the FAA, but must comply with FAA Order 1200.22c, Data and Interface Equipment Used by Outside Interests, and have FAA approval.

Figure 1-1 provides an overview of the partitioning of these Services between the two specifications. Inter-operability between the Services provided in conformance with these two specifications is addressed in §1.4.3. Each Service is described in the following paragraphs.

Automatic Dependent Surveillance-Broadcast (ADS-B)

ADS-B equipped aircraft and vehicles broadcast their state vector (horizontal and vertical position, horizontal and vertical velocity) and other information over one of the link technologies approved for use in the NAS, Universal Access Transceiver (UAT) or 1090 MHz Extended Squitter (1090ES). These ADS-B Message broadcasts are intercepted by other aircraft in the vicinity and by the ADS-B ground infrastructure. Aircraft equipped with the proper equipment receive the ADS-B Messages and process and display the information for use in air-to-air applications. The ADS-B ground infrastructure processes

ADS-B Messages that are transmitted by aircraft/vehicles on each data link and formats them into a common ADS-B Report format. These ADS-B Reports are delivered to ATC for use in separation assurance and other services.

Automatic Dependent Surveillance-Rebroadcast (ADS-R)

The FAA's 2002 ADS-B Link Decision approved two data link technologies, UAT and 1090ES, for use in the NAS. As aircraft operating in the NAS or a vehicle operating in the movement area of an airport may equip with either UAT or 1090ES, the ground infrastructure will provide a Service to rebroadcast ADS-B data, which is received via one data link, on the other data link in some areas. This and the TIS-B Service will provide aircraft equipped with either UAT or 1090ES data link technologies a comprehensive air and airport surface picture. The ADS-R Service will eventually be provided at a level sufficient to support specified critical applications.

Traffic Information Service-Broadcast (TIS-B)

During NAS-wide deployment of ADS-B, aircraft will begin equipping with ADS-B avionics. Equipped aircraft will receive broadcast ADS-B Messages directly from other aircraft equipped with the same data link technology. Thus an aircraft equipped with a particular data link will have, in the absence of ground infrastructure, surveillance information only on like-equipped aircraft. The aircraft will lack surveillance information on other aircraft in the vicinity that are not ADS-B equipped and those that are equipped with the other data link technology. The Surveillance and Broadcast Services ground infrastructure will support air-to-air applications by broadcasting TIS-B Messages for targets detected and reported by radar, or other non-ADS-B surveillance systems, on both the UAT and 1090ES data links for reception by equipped aircraft. This, in conjunction with the ADS-R Service, will provide equipped aircraft the information needed for a comprehensive air and airport surface picture of traffic in their vicinity. The TIS-B Service will support only essential level applications.

Flight Information Service-Broadcast (FIS-B)

FIS-B provides the broadcast of weather and non-control, advisory information providing users valuable, near real-time aeronautical information, supporting safe and efficient operations. Broadcast of FIS is limited to the UAT link. FIS-B products include, but are not limited to: graphical and textual weather reports and forecasts, Special Use Airspace (SUA) information, NOTAMs, pilot reports (PIREPS), and other similar meteorological and aeronautical information. FIS-B products, from both government and/or commercial sources, will be broadcast to aircraft from the ground. In the future, aircraft equipped with the UAT data link may also broadcast FIS-B products using spare bits within the current ADS-B Messages.

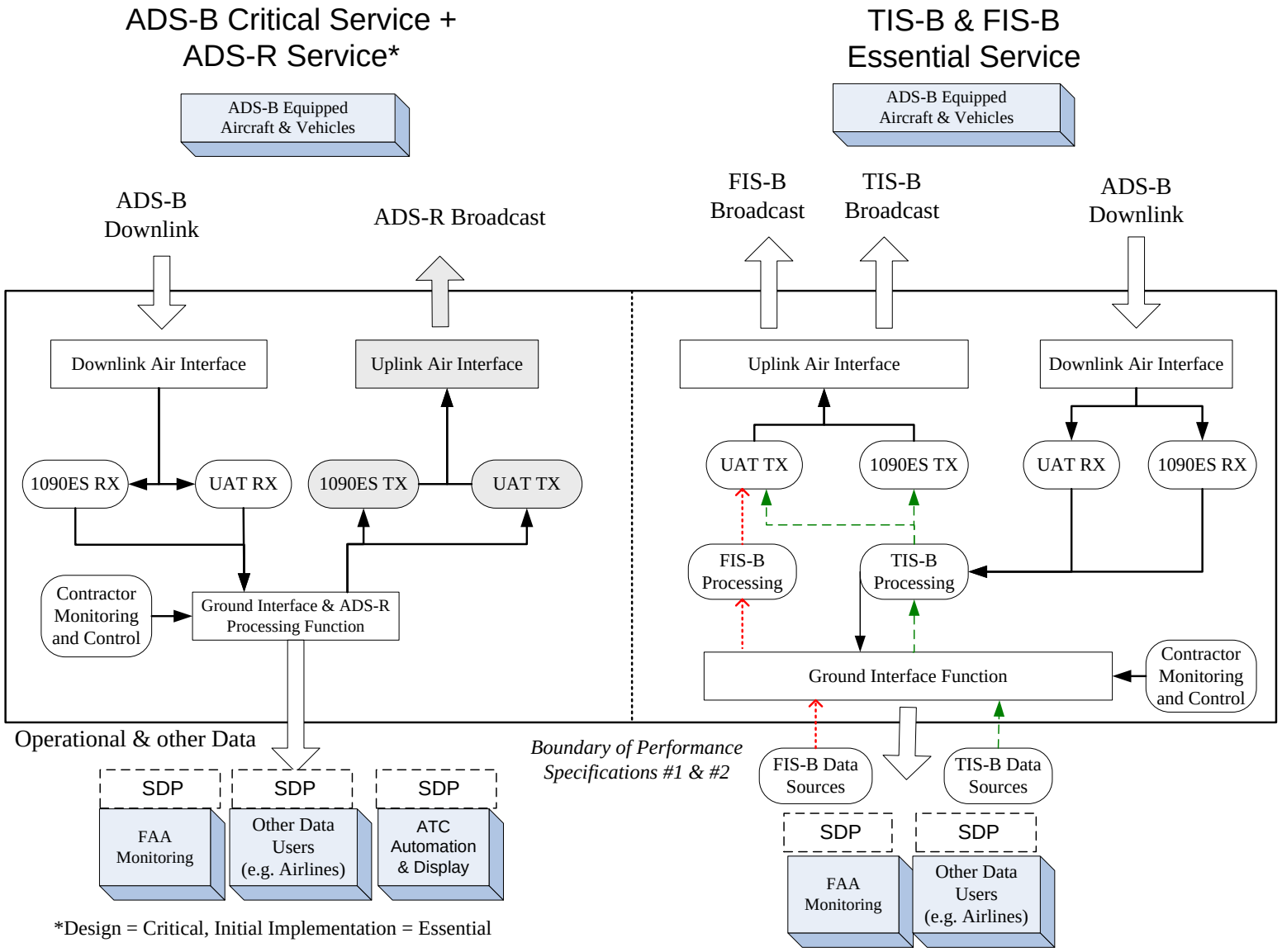


Figure 1-1. Surveillance and Broadcast Services Partitioning

1.2 Purpose

This document is to be used in the procurement of TIS-B and FIS-B (TIS-B/FIS-B) Services from a commercial service provider per the requirements in this document.

1.3 Scope

This essential services specification details the requirements for TIS-B and FIS-B Services the FAA will acquire under the Surveillance and Broadcast Services Program. The required functionality of the Services as well as the performance that must be provided is included herein. The external interfaces that the Services must provide are also specified.

1.4 Service Description

TIS-B/FIS-B Services will be deployed NAS-wide on the airport surface and in terminal and en route airspace. As these services will operate, in many cases, in the same airspace as ADS-B/ADS-R Services, the two will be transmitting in the same coverage volume. Section 1.4.3 discusses the related implications.

1.4.1 Functional Overview

The TIS-B/FIS-B Services will provide the NAS with real-time traffic, meteorological and NAS status information. The services should also support the overall NAS mission to provide users with a safe and economical mode of operation.

The functional requirements specified herein are grouped by the following three functions:

- Broadcast Services Processing
- Link Specific Processing
- Maintenance Processing

The functional grouping is not meant to imply a system architecture, but is used only to organize requirements and increase the document readability. Any solution which provides equivalent functionality will be considered compliant.

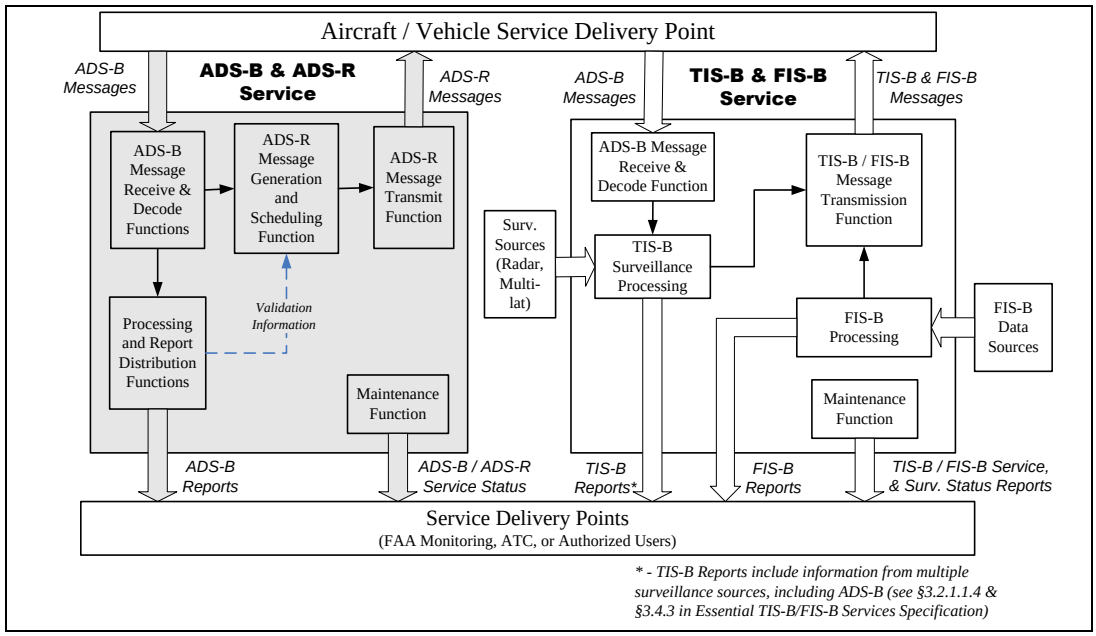


Figure 1-2. Broadcast Services Functional Overview

1.4.1.1 Broadcast Services Processing

Broadcast Services Processing comprises the application data processing necessary to generate TIS-B target data and FIS-B products for broadcast to aircraft/vehicles. Broadcast Services Processing receives sensor data from ground-base surveillance and ADS-B systems and generates TIS-B target data for transmission as TIS-B Messages by Link-Specific Processing. Additionally, Broadcast Services Processing receives and processes weather and NAS status data from external sources and generates applicable FIS-B products for transmission as FIS-B Messages by Link-Specific Processing.

1.4.1.2 Link Specific Processing

Link-Specific Processing comprises the ground-based transmit and receive functionality. Link-Specific Processing transmits TIS-B and FIS-B Messages as directed by the Broadcast Services Processing.

Link Specific Processing also receives ADS-B Messages from equipped aircraft/vehicles. The receive functionality decodes the messages and provides the ADS-B sensor data to the Broadcast Services Processing for use by the TIS-B Service.

1.4.1.3 Maintenance Processing

Maintenance Processing includes, but is not limited to, providing status on transmit/receive equipment and services to the FAA. The Maintenance Processing also includes the statistics on the quality of the data within the Service Volume.

1.4.2 External Interfaces

The TIS-B/FIS-B Services provides interfaces to the following external systems:

- Aircraft and Surface Vehicles (Aircraft/Vehicle),
- Ground-Based Surveillance Systems,
- Meteorological and Aeronautical Information Systems,
- SBS Monitoring System,
- Authorized Users.

Detailed interface requirements between these systems are contained in Interface Requirements Documents referenced in §3.4.

1.4.2.1 Aircraft/Vehicle

The interfaces to Aircraft/Vehicles are largely defined by the UAT and 1090ES data link MOPS. Any additional requirements for these interfaces are specified herein, thus Interface Requirements Documents (IRDs) are not needed for the Aircraft/Vehicle interface.

The TIS-B Service receives ADS-B Messages on the UAT and 1090ES links from Aircraft and Surface Vehicles to support the tracking of targets and filtering of TIS-B data to be broadcast. The Receive Function accepts and processes the incoming ADS-B Messages such as the aircraft's position, velocity, identification, and accuracy/integrity measures of position/velocity. ADS-B Messages are decoded based upon the MOPS Version number contained in the transmitted ADS-B Messages received from equipped aircraft or surface vehicles. UAT equipment complies with either RTCA DO-282A, MOPS Version number

1, or RTCA DO-282B, MOPS Version number 2. 1090ES equipment comply with either RTCA DO-260, MOPS Version number 0, RTCA DO-260A, MOPS Version number 1 or RTCA DO-260B, MOPS Version number 2. 282B260BTo meet specified Service Volume requirements, a network of ground sites (i.e., implementations of the ADS-B Message Receive Function) may be required to receive and decode the transmitted ADS-B Messages from the ADS-B equipped aircraft/vehicles.

1.4.2.2 Ground-Based Surveillance Systems

Ground based surveillance systems, as referred to in this document, represent FAA and Department of Defense (DOD) radar systems and FAA multilateration systems. These systems provide sensor data to the TIS-B Service. There are a variety of surveillance systems and their interfaces are equally as varied. The TIS-B Service uses only digital/digitized sensor data from these surveillance systems. The Service Provider may elect to digitize the analog data from surveillance sensors not providing a native digital output. The FAA will establish one or more SDPs to provide the sensor data to the service provider.

1.4.2.3 Meteorological and Aeronautical Information Systems

The raw data used by the FIS-B Service to generate products suitable for aeronautical users is obtained from meteorological and Aeronautical Information Systems (AIS). There are numerous sources of this data within the government and from commercial value-added suppliers that the FIS-B service provider may consider using. Meteorological data includes measured weather and atmospheric conditions. AIS data consists mainly of the status of National Airspace System (NAS) resources used by aircraft and airport surface vehicles. Notices to Airmen (NOTAMs) convey a large portion of AIS data, but there are other system status data, such as airport or airspace demand/capacity, that may be useful to aircraft operators.

1.4.2.4 SBS Monitor and Authorized Users

The SBS Monitor and authorized users are external recipients of TIS-B and FIS-B Reports and the Service Status Reports generated by the TIS-B/FIS-B Services. The SBS Monitor supports the FAA's responsibility to assure the services are provided with the expected quality and availability. Authorized users represent other government or commercial organization that the FAA has designated as necessary recipients of certain data sets. Additionally, the service provider may elect to provide some of these data sets to other entities, but these arrangements must be first approved by the FAA.

1.4.3 Inter-operability Between ADS-B/ADS-R and TIS-B/FIS-B Services

Any required spectrum coordination across the network of 1090ES and UAT transmitters will be accomplished procedurally through adaptation of the individual transmitters. The requirements necessary to achieve this adaptability are included in this specification.

1.5 Document Overview

The reference documents that are applicable to this specification are in §0. The functional and service performance requirements for the TIS-B/FIS-B Services are in §3. Section 0 contains the quality assurance information. A glossary of acronyms can be found in §5.

Appendix A contains traffic scenarios specifically tailored to the TIS-B track accuracy and reliability performance requirements in §3.3.2.10.

2 APPLICABLE DOCUMENTS

2.1 General Documents

The following documents form a part of this specification and are applicable to the extent specified here. In a case of conflict between the documents referenced here and the contents of this specification, the contents of this specification **shall** take precedence.

2.1.1 FAA Documents

SBS fPR	Final Program Requirements for Surveillance and Broadcast Services, Version 2.1, FAA, August 6, 2007
FAA-E-3011	Automatic Dependent Surveillance-Broadcast (ADS-B) / ADS-B Rebroadcast (ADS-R) Critical Services Specification, Version 2.8 dated April 20, 2011
FAA TSO C154C	Universal Access Transceiver (UAT) Automatic Dependent Surveillance - Broadcast (ADS-B) Equipment Operating on the Frequency of 978 MHz.
FAA TSO C166B	Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)
AC 00-62	U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular, Internet Communications of Aviation Weather and NOTAMs, November 1, 2002
AC 00-45E	U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular, Aviation Weather Services, December 1, 1999
FAA Order 8100.1	U.S. Department of Transportation, Federal Aviation Administration, Order, Air Transportation Operations Inspector's Handbook, Volume 3.

2.1.2 Military Documents

MIL-STD-810F	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, Version F, US DoD, January 1, 2000

2.1.3 NTIA Documents

NTIA Manual	Manual of Regulations and Procedures for Federal Radio Frequency Management, May 3003 Edition with January 2006 Revisions

2.1.4 RTCA and ICAO Industry Standards

DO-181C	Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, Revision C, RTCA, Inc.

DO-242A, Change 1	Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B), Revision A, RTCA, Inc. ***Note:*** *Any reference to RTCA/DO-242A in this specification must be interpreted as including Change 1.*
DO-260B	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Services-Broadcast (TIS-B), Revision B, RTCA, Inc. *260B*
DO-267A	Minimum Aviation Systems Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link, RTCA, Inc.
DO-282B	Minimum Operational Performance Standards for Universal Access Transceiver (UAT), Automatic Dependent Surveillance-Broadcast (ADS-B), Revision B, RTCA, Inc. *282B*
DO-286A	Minimum Aviation Systems Performance Standards (MASPS) for Traffic Information Services-Broadcast (TIS-B), Revision A, RTCA, Inc.
DO-317	Minimum Operational Performance Standards for Aircraft Surveillance Applications Systems (ASAS), April 14, 2009, RTCA Inc.
DO-358	Minimum Operational Performance Standards for Flight Information Services-Broadcast (FIS-B), RTCA, Inc.
DO-358A	DRAFT MOPS for FIS-B Rev A, RTCA, Inc.
ICAO Annex 10 To the Convention on International Civil Aviation	UAT and Mode S Extended Squitter Standards and Recommended Practices (SARPs)
ICAO Annex 3 To the Convention on International Civil Aviation	Meteorological Services
ICAO Annex 15 To the Convention on International Civil Aviation	Aeronautical Information Services

2.1.5 Reference and Guidance Material

Bourgeois, R., F. Castella, "System Integrity and Track Accuracy Methodology for Traffic Information Service – Broadcast (TIS-B)," The Johns Hopkins University Applied Physics Laboratory, 2004.

Chamlou, R., "TIS-B: Calculation of Navigation Accuracy Category for Position and Velocity Parameters," The MITRE Corporation, April 2004.

Strain, R., R. Chamlou, J. Giovino, "Operational and Functional Requirements for the Broadcast Services System Implementation," MP03W0000139R3, The MITRE Corporation, June 2006.

"Broadcast Services Ground Station Detailed Requirements Specification using the Universal Access Transceiver (UAT) and the 1090 MHz Extended Squitter (1090ES) ADS-B Data Links, Draft version 2.5," FAA, 2005.

2.2 Maintenance Documents

FAA Order 6000.15D	U.S. Department of Transportation, Federal Aviation Administration, Order, General Maintenance Handbook for NAS Facilities, July 23,2004
FAA Order 1100.157A	U.S. Department of Transportation, Federal Aviation Administration, Order, National Systems Engineering Divisions Maintenance Program Procedures, Operational Support, June 8, 1995
FAA Order 6032.1B	U.S. Department of Transportation, Federal Aviation Administration, Order, NAS Modification Program, September 18, 2002
FAA Order 7210.3T	U.S. Department of Transportation, Federal Aviation Administration, Order, Facility Operation and Administration, February 19, 2004

2.3 Interface Documents

2.3.1 Interface Requirements Documents

NAS-IR-82320001	Interface Requirements Document – En Route Communications Gateway (ECG)/Internet Protocol Local Area Network (IP LAN) User System, February 7, 2003
SUR.ET1.ST05.2000-STD-07-01	Eurocontrol Standard Document for Surveillance Data Exchange, Part 7: Category 010, Transmission of Monosensor Surface Movement Data, April 2005
SUR.ET1.ST05.2000-STD-08-01	Eurocontrol Standard Document for Surveillance Data Exchange, Part 8: Category 011, Transmission of A-SMGCS Data, April 2005
NAS-IR-82530001	Surveillance and Broadcast Services (SBS) Service Delivery Point (SDP) to ATC Automation and Service Monitoring User Subsystems Interface Requirements Document (IRD) Version 3.3.2 dated December 23, 2010.

2.3.2 FAA Interface Control Documents

NAS-IC-82320001-01	Interface Control Document – En Route Communications Gateway (ECG)/Internet Protocol (IP) Local Area Network (LAN) User System, July 30, 2003
ATCBI-6-SE13-002	Air Traffic Control Beacon Interrogator Replacement (ATCBI-6) Interface Control Document for the NAS Automation Systems Interface, Issue 3, 19 June 2006. ***Note:*** *The ATCBI-6 ICD applies to all en route radar feeds, including Mode S en route, ATCBI-6 (ARSR-1, ARSR-2, ARSR-3, FPS, Beacon Only), and ATCBI-6M (ARSR-4) facilities.*

NAS-IC-34032105	Interface Control Document - Airport Surveillance Radar Model 9 (ASR-9) /Standard Terminal Automation Replacement System (STARS), 14 June 2001.
A008-001-46	Interface Control Document [ASR-11] – Surveillance Data Translator (SDT) to ARTS-IIE (modified CD-2)
A008-007	Interface Control Document [ASR-11] – System Interface Unit (SIU) to ARTS-IIIE with Radar Gateways
NAS-IC-34180001, Rev H	Airport Surface Detection Equipment Model – X (ASDE-X) Data Distribution (DD) To End Users ICD, January 11, 2010
NAS-IC-34180001, Rev H Change Pages	Airport Surface Detection Equipment Model – X (ASDE-X) Data Distribution (DD) To End Users ICD Change Pages, June 21, 2012

2.4 Documentation Sources

2.4.1 FAA Documents

Copies of FAA specifications, standards, and publications may be obtained from the FAA Contracting Officer. Requests should clearly identify the desired material by number and state the intended use of the material.

2.4.2 Military and Federal Documents

Single copies of unclassified military and federal specifications, standards, and publications may be obtained by writing the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120 or by calling (215) 697 3321 Monday through Friday, 8:00 a.m. to 4:30 p.m. (EST).

2.4.3 National Telecommunications and Information Administration Documents

Copies of National Telecommunications and Information Administration (NTIA) materials may be obtained from NTIA, Department of Commerce, 14th Street and Constitution Avenue NW, Washington, DC 20230, by calling (202) 377-1832, or through the web site http://www.ntia.doc.gov .

2.4.4 RTCA, Inc. Documents

Copies of RTCA, Inc. documents may be obtained from RTCA, Incorporated, 1828 L Street NW, Suite 805, Washington, DC 20036, by calling (202) 833-9339, or through the web site http://www.rtca.org .

2.4.5 ICAO Documents

Copies of documents that are published by the International Civil Aviation Organization (ICAO) may be obtained from the ICAO Document Sales Unit, 999 University Street, Montreal, Quebec, Canada H3C 5H7, or by calling (514) 954-8022, or by sending an email to sales@icao.int , or by visiting the "Publications" link on the ICAO web site at: http://www.icao.int .

3 REQUIREMENTS

Two data links have been approved for use in the NAS. The requirements in this document support the use of one or both of those data links. If both data links are utilized in the Service design, then all requirements within this document apply to the TIS-B/FIS-B Services.

The TIS-B/FIS-B Service **shall [E3228]** meet all requirements in Section §3.2, §3.3, and §3.4 when the 1090ES and UAT data links are used in the Service design.

If the FIS-B Service is provided on a link other than UAT, then the Service **shall [E3229]** meet all requirements with the exception of the UAT link specific requirements**.**

When a single data link is used in the Service design for the TIS-B Service, the functional, performance, and interface requirements associated with providing the Service on that data link **shall [E3230]** be met.

3.1 Definitions

The definitions in this section are for informational purposes. Should any of these terms need to become a part of the contract between the Service Provider and the Government, they will be specifically incorporated in the contract.

3.1.1 Accelerated Flight

Accelerated flight as used in this specification means to be changing ground speed, turning, climbing or descending.

3.1.2 Access Control Mechanisms

Protection of system resources against unauthorized access; a process by which use of system resources is regulated according to a security policy and is permitted by only authorized entities according to that policy.

3.1.3 ADS-B Message

An ADS-B Message is an expression of the ADS-B target information in a data link specific format broadcast from aircraft/vehicles. ADS-B Messages are transmitted and received on either the UAT or 1090ES data links, per the formats defined in the Minimum Operational Performance Standards (MOPS) documents, RTCA/DO-282B and RTCA/DO-260B, respectively.

3.1.4 ADS-B Report

ADS-B information concerning a single target expressed in a data link independent format and exchanged between non-RF systems. An ADS-B Report is derived from one or more ADS-B Messages received on either the UAT or 1090ES data link. The ADS-B Report is provided in the CAT033 Report format detailed in NAS-IR-SBS SDP.

3.1.5 Application Protocol Data Unit (APDU)

The APDU encapsulates FIS-B product data that is data linked from the FIS-B Service to the aircraft. The APDU, as specified in the FIS-B MOPS, RTCA DO-358, represents a standard format for communicating the information necessary for receiving applications to process, store and display FIS-B products.

3.1.6 Client

Aircraft that are identified as being eligible to receive ADS-R and TIS-B services based on their ADS-B Out/In equipage and ADS-B reporting performance level.

3.1.7 Clutter Track

The sensor measurement for a target is far (i.e., >2 NM) from the true target position or the measurement is for non-existent targets. Primary radar is subject to ground reflections, road traffic, speckle or multipath that may cause clutter. Secondary radar is subject to multipath on interrogation/reply pulses resulting in beacon false targets or may cause beacon clutter.

3.1.8 Coverage Volume

A Coverage Volume is an airspace volume within which Broadcast Services are provided. Service is ordered on a Coverage Volume basis. A Coverage Volume contains one or more Service Volumes.

3.1.9 Domain

For purposes of this specification, there are three service domains: (1) airport surface, (2) terminal airspace, and (3) en route/off-shore airspace.

3.1.10 Dual Track

Each sensor produces one measurement per target, but the tracker produces more than one track for the target. This is indicated by multiple track IDs for the target under consideration.

3.1.11 FIS-B Service Latency

The FIS-B Service latency is measured from the time a product's source-data is received until the product is ready for transmission to the aircraft/vehicle.

3.1.12 FIS-B Source Data Approval

Approved aviation weather information means that aviation weather information provided by the National Weather Service (NWS), sources approved by the NWS, or those sources authorized for approval by the Administrator in FAA Order 8400.1, "Air Transportation Operations Inspector's Handbook," Volume 3, Chapters 6 and 7.

3.1.13 FIS-B Message

The expression of FIS-B product data in a data link specific format for broadcast. The FIS-B Service will transmit products in the UAT data link Ground Uplink Message format specified in RTCA/DO-282B. The message formats for FIS-B products comply with RTCA DO-358 and specific product definitions and available in this document.

3.1.14 FIS-B Service

The FIS-B service provides NAS users with adequate, accurate, reliable and timely data on weather phenomina occuring in the NAS and non-control aeronautical information regarding the status of NAS systems and resources.

3.1.15 PARROT

A fixed point target that is output from surveillance sensors, such as radar or wide area multilateration, that is used to assess the health of the sensor.

3.1.16 Product Transmission Interval

The amount of time within which a new or updated product transmission must be completed or the rate at which a product is rebroadcast between updates from the source data provider.

3.1.17 SBS Monitor

The SBS Monitor is a system that will monitor the performance of Surveillance and Broadcast Services. To the TIS-B/FIS-B Services, the SBS Monitor will be a Service Delivery Point.

3.1.18 Sensor Data

Sensor data is a term used in this specification to represent data from radars, multilateration systems and ADS-B systems used by the TIS-B Service to determine a target's state vector. Specifically, sensor data may include: radar plots, radar tracks, radar sector synchronization data, radar Real Time Quality Control (RTQC) data, ADS-B Reports, and multilateration plots and tracks. In contrast, sensor data doesn't include maintenance or status data from these systems.

3.1.19 Service Availability

Service Availability is defined as:

$$A = \frac{Uptime}{(Uptime + Downtime)}$$

Uptime is defined as the element of time during which the Service Provider's system is performing its required service functions. Downtime is the element of time during which the Service Provider's system is not performing its required service functions. The sum of Uptime and Downtime is the total time the service is planned to be provided by the service provider. It excludes time for testing and integration prior to the service being made available for operational use.

Note: In accordance with the FAA contract (DTFAWA-07-C-00067, Section H.7); the service provider is not liable for outages arising from causes beyond the control and without fault or negligence of the service provider. Examples of such causes include, but are not limited to, (1) acts of God or of the public enemy, (2) acts of the Government (United States or other government entities where ADS-B is located) in either its sovereign or contractual capacity, (3) fires, (4) floods, (5) epidemics, (6) quarantine restrictions, (7) strikes, (8) freight embargos and (9) unusually severe weather and (10) unscheduled, unplanned, or emergency requirements from commercial tower operators to power down transmitters where advance notification is not possible. In each instance the outage must be beyond the control and without fault or negligence of the service provider. Furthermore, in relation to the above availability calculation, the service provider shall not be liable for planned outages for equipment maintenance, equipment upgrades, and software upgrades. However, the service provider is responsible for timely action related to

all outages, regardless of cause, and will be liable for extended outages caused by inaction of the service provider.

3.1.20 Service Delivery Point

A Service Delivery Point (SDP) is the physical demarcation point between systems or services where specific information exchange takes place and where responsibility for the information transfers. Interface Requirements Documents and Interface Control Documents are used to specify the expectations and nature of the information exchanges, as well as protocols, formats and other related requirements.

3.1.21 Service Status Report

A periodic report containing equipment and service performance and system status information about the FIS-B/TIS-B Service provided by the Service Provider to the SBS Monitor. The Service Status Report is provided in the CAT023 format detailed in NAS-IR-SBS SDP.

3.1.22 Service Volume

An airspace volume within which a specific broadcast services application is supported and the associated performance requirements are achieved. A Service Volume lies within a Coverage Volume.

3.1.23 Split Track

The sensor produces more than one measurement per target. Primary radar can produce azimuth splits and range splits. Secondary radar can produce mis-columniations or aircraft transponder double-reply.

3.1.24 Swap Track

The identifying attributes for a target are incorrectly reported for that target. In the context of the TIS-B Service, these attributes may include: target address, 4096 identification code or track ID. The sensor may incorrectly report the 4096 identification code or ICAO address due to garble or de-interleaving problem, or the tracker may incorrectly associate attributes from one target to another target.

3.1.25 Steady State Flight

Steady state as it is used in this specification means constant speed, straight and level flight.

3.1.26 Surveillance Coverage Volume

The volume of airspace for which there is coverage from one or more non-ADS-B ground surveillance sensors.

3.1.27 Shall

When used in this specification, the word "**shall**" refers to an explicit requirement of a service function or of the entire service.

3.1.28 Should

When used in this specification, the word "should" refers to desired characteristic of service function or of the entire service.

3.1.29 State Vector

A State Vector refers to an aircraft/vehicle horizontal and vertical position and horizontal and vertical velocity. When used in reference to the TIS-B Service, a target's state vector is an estimate of position and velocity resulting from a tracking process.

3.1.30 Time of Applicability

The Time of Applicability for ADS-B, ADS-R and TIS-B reports is the time at which the reported values were valid.

3.1.31 TIS-B Latency

TIS-B latency is the difference between the time of measurement of the source position data and the time of transmission of the TIS-B Message.

3.1.32 TIS-B Message

The expression of TIS-B target information in a data link specific format for broadcast. The TIS-B Service will use the UAT and 1090ES data link message formats specified in RTCA/DO-282B and RTCA/DO-260B, respectively.

3.1.33 TIS-B Service

The TIS-B Service provides users equipped with an ADS-B system the ability to receive, process, and display state information on proximate traffic that cannot be adequately obtained air-to-air via ADS-B, but that can be tracked by alternative, ground-based surveillance systems.

3.1.34 Transmission Duty Cycle

The percentage of time the transmitter is keyed in proportion to total service time.

3.1.35 Transmission Rate

The number of message transmissions per unit of time as measured at the antenna.

3.1.36 UAT Application Data Field

The 424 byte, fixed-length content of an UAT Ground Uplink Message composed of one or more Information Frames. For the purposes of this specification, the Application Data field will consist of FIS-B products and TIS-B / ADS-R Service Status data; however, other uses are possible.

3.1.37 UAT Information Frame

Application Data subframes enabling various data content to be transported within each UAT Ground Uplink Message. For the purposes of this specification, the UAT Information Frame types include APDUs and TIS-B / ADS-R Service Status; however, other types are possible.

3.1.38 UAT Message Payload

A portion of the UAT Message that carries data (user information) that will be consumed by avionics application outside the UAT system.

3.1.39 UAT Optimum Sample Point

The point during the bit period at which the opening of the eye diagram is maximized (i.e., minimum separation between positive and negative frequency offsets at very high signal-to-noise ratios).

3.1.40 Update Interval

The time between the successful reception of reports / messages as measured at the receiving end-system.

3.1.41 Uplink Broadcast Service

Uplink Broadcast Service refers to the entire scope of services defined in this specification. The terminology is used when not appropriate to use the more specific TIS-B or FIS-B Service.

3.1.42 Will

When used in this specification, the word "will" provides information for a characteristic of a service function or of the entire service.

3.2 Functional Requirements

The TIS-B/FIS-B Services functional requirements are presented in the following sections.

3.2.1 Broadcast Services Processing

The Broadcast Services Processing represents the functionality necessary to transform TIS-B and FIS-B source data into products transmitted to aircraft/vehicles. This section contains the minimum functionality the services must contain to perform the data transformations.

3.2.1.1 TIS-B Service

TIS-B Service is only provided to aircraft that are clients. The TIS-B service identifies aircraft as clients based on the ADS-B Out and ADS-B In capabilities of an aircraft. The following requirements apply to determining whether an aircraft is set as a client for the provision of this service.

a. The TIS-B Service **shall [E5243]** identify an aircraft as a client for receiving TIS-B when the aircraft has ADS-B Out equipment that meets a defined performance threshold as follows:

    1. Link Version greater than or equal to a configured threshold (defaulted to 1), and
    2. NAC_P greater than or equal to a configured threshold (defaulted to 0), and
    3. NIC greater than or equal to a configured threshold (defaulted to 0), and
    4. SDA greater than or equal to a configured threshold (defaulted to 0), and
    5. SIL greater than or equal to a configured threshold (defaulted to 0), and
    6. NAC_V greater than or equal to a configured threshold (defaulted to 0).

b. The TIS-B Service **shall [E5244]** only set aircraft with ADS-B Link Version 2 as clients when these aircraft indicate ADS-B In capability on one or more datalinks.

c. The TIS-B service **shall [E5245]** drop an aircraft from client status if its ADS-B Out data falls below the performance thresholds of requirement 3.2.1.1a for a configured time period (defaulted to 60 seconds).

Other TIS-B Service functional requirements are organized into the following key areas:

- Surveillance Processing
- Target Suppression
- Service Status
- TIS-B Target Report Generation
- TIS-B Processing Specific to DO-260 and DO-260A Equipped Aircraft

Surveillance processing is further organized into requirements associated with surveillance sources and tracking targets. The surveillance sources section includes requirements on receiving sensor data and monitoring the sensor systems providing the data. In accordance with the TIS-B MASPS, surveillance targets used by the TIS-B service must be tracked. Tracking performance is paramount to the TIS-B Service performance.

3.2.1.1.1 TIS-B Surveillance Processing

TIS-B sensor data consists of surveillance measurements from FAA radars, multilateration systems and ADS-B receivers. These data are tracked and combined into a singular representation of each target and updated with each new measurement.

In order to meet the accuracy requirements of §3.3.2.10.2.1, the TIS-B Service may need to align input sensors. This may be accomplished either statically or dynamically. However, a static alignment process must be monitored to ensure alignment within a bias residual that ensure meeting the tracking accuracy requirements. The intent is to minimize measurement bias with respect to the standard for high-quality GNSS navigation systems used by ADS-B.

The TIS-B Service may use ADS-B Reports to aid in the correction of radar registration and bias errors.

3.2.1.1.1.1 Surveillance Sources

a. The TIS-B Service **shall [E001]** accept sensor data, sensor status and time of measurement (if available) from the following surveillance sources in accordance with the interface requirements in §3.4.1.

- Primary radar (search),
- Secondary radar (beacon),
- ADS-B receiver (1090ES and UAT),
- Multilateration system.

Notes:

1. *Sensor data may include: radar plots, radar tracks, radar sector synchronization data, radar Real Time Quality Control (RTQC) data, ADS-B Reports, and multilateration plots and tracks.*
2. *Sensor status from different surveillance systems may be explicitly provided (e.g., Radar Status Reports) or implied through the presence or absence of sensor data.*

b. The TIS-B Service **shall [E002]** only use sensor data from radars able to provide the data in a digital format (e.g., CD-2 or ASTERIX).

Note: *FAA and DOD analog radars must have a digitizer or equivalent means of converting their output to a digital format to be used by the TIS-B Service.*

c. The TIS-B Service **shall [E003]** monitor each surveillance source and only use sensor data from sources known to be in normal operation mode.

Note: *Radar and multilateration surveillance sources for TIS-B are outside the control of the service provider, whereas ADS-B surveillance will be within service provider control. The health and status of the sources need to be monitored and continually assessed to ensure incorrect target data is not used. Radar Status Reports from some sensors may contain explicit data indicating its operating mode, but in many cases the sensor health will need to be determined by the TIS-B Service.*

d. The TIS-B Service **shall** [**E5220**] determine a reference location for each PARROT report from each sensor (Radar and/or WAM) being utilized in providing this service.

e. The TIS-B Service **shall** [**E5221**] compare the reference location of each PARROT from each sensor to the respective reported PARROT location each time a PARROT report is received from a sensor.

f. The TIS-B Service **shall** [**E5222**] "fail" a sensor (Radar and / or WAM) if the reported location of a PARROT from the sensor is outside an adapted tolerance (Default = 0.25NM) from the reference location for the same PARROT.

g. The TIS-B service **shall** [**E5223**] inhibit the use of a sensor in providing the service while the sensor is identified as "failed" from the PARROT location comparison test.

h. The TIS-B Service **shall [E004]** receive ADS-B data from all aircraft/vehicles transmitting on the UAT and 1090ES ADS-B data links within the Service Volume, consistent with the performance requirements specified in §3.3.2.11.

Note: *This requirement previously referenced 3.3.2.9.3 but was changed to reference 3.3.2.11 (per the FAA contract letter ADS-B 0007 dated November 5, 2007.*

i. The TIS-B Service **shall [E005]** monitor all surveillance sources used and report all conditions impacting the availability of sensor data in the TIS-B Service to the SBS Monitor.

Notes:

1. *The status of surveillance sources is conveyed via the Maintenance Processing as one of the Maintenance Data Sets per §3.2.3.*
2. *The interface requirements for these data are in §3.4.2.*

Note: *It is not necessary to also provide the sensor context for the same ADS-B receivers which are reported on using the ADS-B equipment context reports (per the FAA contract letter ADS-B 0007 dated November 5, 2007).*

3.2.1.1.1.2 Target Tracking

a. The TIS-B Service **shall [E006]** generate and update a single track state vector for each aircraft/vehicle with correlated sensor data received from any of the following surveillance sources:

- Both primary and secondary radars (i.e., radar reinforced),
- Secondary radar only,

- Primary radar only (for track updates only),
- Multilateration systems,
- ADS-B.

Note: *The above requirement applies across all Service Volume boundaries.*

b. The TIS-B Service **shall [E007]** derive an estimate of the time the sensor data was measured if it is not provided explicitly by the sensor.

Note: *The estimated measurement time for sensor data is the Time of Applicability for the target state vector and will be the time basis from which the Transmit Function will perform position extrapolation. There are no requirements on the measurement time accuracy, but estimation errors will be reflected in position accuracy for which there are requirements §3.3.2.10.2.*

c. The TIS-B Service **shall [E008]** transmit a TIS-B Message only when the target's state vector is updated with new sensor data.

Note: *The state vector elements describe the target's three dimensional position and velocity at any given time. As measurements are received, the target track state vector elements are updated.*

d. The TIS-B Service **shall [E009] not** use ADS-B data containing horizontal position, NAC_P, NIC and SIL all set to ZERO.

Note: *ADS-B Messages with all these elements set to ZERO indicate the ADS-B data is invalid and is generally observed from ADS-B avionics during startup.*

3.2.1.1.1.3 Target Address and Address Qualifier

a. The TIS-B Service **shall [E010]** assign a unique and unambiguous target address to each target represented in a TIS-B Message.

Notes:

1. *The unique address may come from the 24-bit ICAO address included in ADS-B Messages or be self-assigned by the TIS-B Service.*
2. *Target addresses, once assigned, must remain with the target for the life of the track since the address is one way the user avionics use to associate updates with a particular target.*
3. *The above requirement applies across all Service Volume boundaries.*

b. The TIS-B Service **shall [E011]** use the 24-bit ICAO address associated with targets for which this address is available provided a Track ID is not already assigned to the track when the ICAO address becomes available.

c. The TIS-B Service **shall [E012]** provide the means for the aircraft/vehicle to differentiate TIS-B data from ADS-B data.

Note: *The UAT and 1090ES use different approaches to differentiate TIS-B and ADS-B data. The UAT uses an address qualifier while 1090ES uses different message identifiers.*

d. The TIS-B Service **shall [E013]** preserve the anonymity of targets as designated in their ADS-B data or by FAA directive.

Note: *ADS-B data may contain self-assigned 24-bit addresses and associated address qualifier, which is to be preserved. An FAA policy directive may also indicate a specific target address or 4096 identification code that will be the basis for suppressing target data (see §3.2.1.1.2)*

e. The TIS-B service **shall [E5202]** maintain the same Track ID for each target as the target traverses terminal and surface SVs.

f. If a 24-bit ICAO address is not available at the start of the track, the TIS-B service **shall [E5203]** assign a unique Track ID in each TIS-B message and maintain this ID for the life of the track.

Note: *If a 24-bit address becomes available for the track after transmission of the first TIS-B message for the target, the service does not change the Track ID from that already assigned.*

g. The TIS-B service **shall [E5204]** coordinate Track ID assignments by associating surface and terminal tracks in transition regions to maintain continuity in the unique Track ID broadcast in the TIS-B Messages for each target.

Note: *In reference to items (a) through (g), the TIS-B 24-bit address that is broadcast in the TIS-B Messages for a target needs to be consistent during surface to terminal SV transitions and within a surface or terminal SV so that avionics do not have display dual tracks. Since the service is using separate trackers for targets in Terminal SVs and those in Surface SVs, Track ID coordination is necessary to ensure consistency in the 24-bit address transmitted for the target as it crosses terminal and surface SVs.*

3.2.1.1.1.4 Target State Vector

3.2.1.1.1.4.1 Horizontal Position

a. The TIS-B Service **shall [E014]** reference a target's horizontal position (i.e., latitude and longitude) to the WGS-84 datum.

b. The TIS-B Service **shall [E015]** compute a NAC_P, as defined in DO-242A Table 2-3, for each target at each track state vector update.

Notes:

1. *Cross-range radar position estimates, limited by azimuth angle measurements, are typically less accurate than the along-range measurement. The 95% horizontal error containment bound is thus elliptical with the major axis oriented in the cross-range direction. Since current message formats limit NAC_P to a single radial parameter, the transmitted TIS-B value will be circle with the same radius as this semi-major axis to assure the bound applies for any horizontal aspect angle.*

2. *For the Enhanced Visual Acquisition and Airport Surface Situational Awareness applications, NAC_P is limited to the horizontal position information. NAC_P for a TIS-B target will be based on the surveillance sources used to derive the target position rather than navigation sources used to supply ADS-B position. Therefore, the derivation of NAC_P for TIS-B will likely be different from that for ADS-B. For example, the NAC_P value must include the uncertainty in converting slant range measurements to horizontal position estimates.*

3. *Technical guidance on algorithms for computing NAC_P may be found in works by Chamlou and Bourgeois/Castella.*

c. The TIS-B Service **shall [E016]** assure that a target's track state vector and NAC_P correspond to a common Time of Applicability.

Note: *Unless explicitly provided, the Time of Applicability should be an estimate of when the measurement was made.*

The requirements in items (d) through (i) apply to targets in Terminal and En Route Service Volumes

d. The TIS-B Service **shall [E5205]** compute a Position Containment Radius for each target at each track update based upon the error covariance matrix calculated by the TIS-B Tracker.

e. The TIS-B Service **shall [E5206]** determine the Position Containment Radius (PCR) using a configurable probability (with possible values 10^{-1}, 10^{-3}, 10^{-5}, or 10^{-7}; Defaulted to 10^{-5}) that the true target position lies within this radius about the reported TIS-B position based upon measured performance data of the error distribution.

f. The TIS-B Service **shall [E5207]** set the NIC field in the TIS-B position message by converting the PCR to a NIC value as follows:

NIC Coding	Position Containment Radius (PCR)
0	PCR ≥ 37040m or unknown
1	14816m ≤ PCR < 37040m
2	7408m ≤ PCR < 14816m
3	3704m ≤ PCR < 7408m
4	1852m ≤ PCR < 3704m
5	1111.2m ≤ PCR < 1852m
6	370.4m ≤ PCR < 1111.2m
7	185.2 ≤ PCR < 370.4m
8	75m ≤ PCR < 185.2m
9	25m ≤ PCR < 75m
10	7.5m ≤ PCR < 25m
11	0m ≤ PCR < 7.5m
12 -15	Reserved

g. The TIS-B Service **shall [E5208]** set the SIL within the TIS-B Messages as follows:

SIL Coding	Adapted Probability The Target Position Lies Outside The PCR
0	10^{-1}
1	10^{-3}
2	10^{-5}
3	10^{-7}

h. If a TIS-B track is supported only by primary radar for a period of 40 seconds, the TIS-B Service **shall [E5209]** set the SIL for this track to Zero (0), regardless of the adapted SIL value, for the duration that the track only has sensor support from primary radar.

i. The TIS-B Service **shall [E5210]** set the SIL Supplement bit to ONE (1) in UAT TIS-B Messages to indicate that the SIL is on a per sample basis.

j. The TIS-B Service **shall [E5211]** set the SDA to 2 within UAT TIS-B messages.

Notes: *An SDA of ≤ $1x10^{-5}$ (Major) is assumed for the TIS-B service based on the following:*

1. *TIS-B tracks are created from surveillance data inputs from various FAA radar systems that have fault detection capabilities. Radar sensors are taken out of service when a fault is detected.*
2. *Radar sensors use fixed point targets to ensure system performance is within specified tolerance. When these targets are detected at an incorrect position, the radar is taken out of service.*
3. *The TIS-B multisensor tracker is designed to a software assurance level of 3 which supports a "Major" failure classification.*

For ASDE-X provided surface tracks for TIS-B in surface Service Volumes, the ASDE-X system will provide NAC_P, NIC, and SIL to SBS. The ASDE-X provided data fields for these parameters are identified in the June 21, 2012 Change pages to NAS NAS-IC-34180001 Rev H. The requirements in items (k) through (o) apply for the TIS-B Service in using these surface tracks.

k. The TIS-B Service **shall [E5212]** set the NAC_P in the TIS-B Message to the ASDE-X reported NAC_P for the track.

l. The TIS-B Service **shall [E5213]** set the NIC in the TIS-B Message to the ASDE-X reported NIC for the track.

m. The TIS-B Service **shall [E5214]** set the SIL to the ASDE-X reported SIL value for the track.

n. The TIS-B Service **shall [E5215]** set the SIL Supplement bit to ONE (1) in UAT TIS-B Messages to indicate that the SIL is on a per sample basis.

o. The TIS-B Service **shall [E5216]** set the SDA to 2 in the UAT TIS-B Message uplinks for ASDE-X tracks.

Notes: *An SDA of ≤ 1x10-5 (Major) is assumed for the TIS-B service based on the following:*

1. *The ASDE-X system monitors the surveillance sensors feeding its fusion tracker. Sensors that do not meet a defined performance level are taken out of service.*
2. *The ASDE-X SMR and Multilateration sensors use fixed point targets to ensure system performance is within specified tolerance. When these targets are detected at an incorrect position, the sensor is taken out of service.*
3. *The ASDE-X system, including its multisensor tracker, is used by FAA ATC and also for TIS-B service in surface SVs. This system is periodically certified by FAA Tech Ops and the service history has shown that it supports a failure classification of "Major".*

3.2.1.1.1.4.2 Pressure Altitude

a. The TIS-B Service **shall [E019]** reference a target's barometric pressure altitude to standard temperature and pressure.

b. The TIS-B Service **shall [E020]** always set the NIC_{BARO} to ZERO.

Note: *Barometric altitude integrity reporting (i.e., NIC_{BARO}) is not required for the expected situational awareness applications enabled by TIS-B.*

c. For surface Service Volumes, the TIS-B Service shall **[E5237]** set the Barometric Altitude for the track to the ASDE-X reported Uncorrected Barometric Altitude identified in the June 21, 2012 Change Pages to NAS NAS-IC-34180001 Rev H.

3.2.1.1.1.4.3 Horizontal Velocity

a. The TIS-B Service **shall [E021]** provide velocity information for each target.

b. The TIS-B Service **shall [E022]** determine the velocity accuracy (95^{TH} percentile) for airborne targets based on the measured track accuracy performance for the sensor type(s) supporting the TIS-B track.

c. The TIS-B Service **shall [E5224]** set the NAC_V for airborne targets based on the 95% velocity accuracy determined for each TIS-B track.

d. For targets in Surface Service Volumes, the TIS-B Service **shall [E5241]** set the NAC_V to the value reported by the ASDE-X.

e. The TIS-B Service **shall [E5225]** report the NAC_V in the uplinked TIS-B messages per Tables 3-2 (1090-ES TIS-B) and 3-3 (UAT TIS-B)

Note: *Velocity accuracy reporting (i.e., NAC_V) is necessary for some ADS-B In applications per the recently published ADS-B In MOPS contained in RTCA/DO-317A.*

3.2.1.1.1.4.4 Vertical Rate

a. The TIS-B Service **shall [E023]** provide vertical rate information for each target.

For ASDE-X provided surface tracks for TIS-B in surface Service Volumes, the ASDE-X system will provide Vertical Rate, Vertical Rate Direction, and Vertical Source to SBS. The ASDE-X provided data fields for these parameters are identified in the June 21, 2012 Change pages to NAS NAS-IC-34180001 Rev H. The requirements in items (b) through (d) apply for the TIS-B Service in using these surface tracks.

b. The TIS-B Service **shall [E5238]** set the Vertical Rate in the TIS-B Message to the ASDE-X reported Vertical Rate for the track.

c. The TIS-B Service **shall [E5239]** set the Vertical Rate Direction in the TIS-B Message to the ASDE-X reported Vertical Rate for the track.

d. The TIS-B Service **shall [E5240]** set the Vertical Rate Source to the ASDE-X reported Vertical Rate Source for the track.

3.2.1.1.1.4.5 Direction – Ground Track

a. The TIS-B Service **shall [E024]** provide the direction a target is moving.

b. If a target is stationary, the TIS-B Service **shall [E025]** provide heading information, if available, or an indication that there is no directional information available.

c. The TIS-B Service **shall [E026]** indicate whether the target direction is referenced to true or magnetic north.

Note: *RTCA/DO-242A specifies heading as the reported directional information. However, the sources of TIS-B may not provide target heading, but do provide the direction the target is moving over the ground (i.e., ground track).*

3.2.1.1.1.5 Target Air/Ground State

a. The TIS-B Service **shall [E027]** report the air/ground state of each target if the air/ground state can be definitively determined, otherwise report as "airborne."

Note: *There are various approaches to determining whether a target is on the surface or airborne. The approach the TIS-B Service uses in determining the air/ground state should be consistent with the approach recommended in DO-242A for ADS-B targets to avoid conflicting indications.*

3.2.1.1.2 TIS-B Target Suppression

The TIS-B Service must be capable of suppressing specific data associated with a target as well as complete messages based on criteria established for a Service Volume. Target data suppression generally supports security objectives or to provide target anonymity. Target suppression will generally be done on a three dimensional geographic basis to support service volume, airspace management or uplink bandwidth objectives.

a. The TIS-B target suppression criteria **shall [E028]** be configurable.

b. The TIS-B Service **shall [E029]** be capable of suppressing a TIS-B target based on either 4096 identification code or target address.

c. The TIS-B Service **shall [E030]** be capable of suppressing TIS-B targets inclusive to a prescribed airspace volume or surface area.

d. The TIS-B Service **shall [E031]** be capable of suppressing TIS-B targets exclusive to a prescribed airspace volume or surface area.

Note: *The suppression of targets relative to prescribed airspace volumes will be necessary to allocate targets for transmission or to prevent the transmission of targets in certain airspace (e.g., above FL240 or within the Washington, DC Flight Restricted Zone). It is anticipated these volumes will be defined be using 2-D and 3-D geometric shapes.*

Note: *For exclusive TIS-B volumes, the TIS-B service filters all targets outside of the defined TIS-B exclusion region for any Service Volumes that overlap the exclusion region (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*

e. The TIS-B Service **shall [E032]** suppress TIS-B targets for which ADS-B Messages have been received and correlated with non-ADS-B surveillance data when the ADS-B data in at least one of a configured number of consecutive messages (defaulted to 10) meets a defined performance threshold as follows:

1. NAC_P greater than or equal to a configured threshold (defaulted to 5), and
2. NIC greater than or equal to a configured threshold (defaulted to 0), and
3. SDA greater than or equal to a configured threshold (defaulted to 1), and
4. SIL greater than or equal to a configured threshold (defaulted to 0), and
5. NAC_V greater than or equal to a configured threshold (defaulted to 0).

Notes:

1. *The SDA threshold only applies to ADS-B Version 2 because Version 1 and Version 0 ADS-B avionics do not report SDA .*

f. For ADS-B Out aircraft that do not meet the performance thresholds in requirement 3.2.1.1.2e, the TIS-B Service **shall [E5246]** only suppress TIS-B Messages when the TIS-B computed NAC_P is less than or equal to a configured threshold (defaulted to 4).

Notes:

1. *When an aircraft provides poor performing ADS-B data and a TIS-B radar track is available that meets a defined performance minimum, the TIS-B messages for that track are to be uplinked to applicable client aircraft.*
2. *In Service Volumes where ADS-R Service is available, the TIS-B Service should not provide target data derived from ADS-B since the target data Time of Applicability may be different in corresponding ADS-R and TIS-B messages.*

g. The TIS-B Service **shall [E033]** suppress a target's 4096 identification code in all TIS-B Messages.

Note*: For 1090ES, a separate message is used for the 4096 code and this is to be omitted from the transmit sequence (this includes omission of the 1090 test messages). For UAT, the 4096 code is multiplexed with Call Sign/Flight ID. When transmitting a UAT target, the Call Sign/Flight ID message only, without 4096 code, (i.e., full rate) is to be transmitted (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*

h. The TIS-B Service **shall [E3191]** suppress targets corresponding to radar reflectors and parrot emitters.

Note: *ATC uses radar reflectors and parrot emitters to monitor radar performance. These will result in TIS-B targets and should not be transmitted by the TIS-B Service.*

i. The TIS-B Service **shall [E3192]** suppress targets corresponding to ADS-B reports with an Address Qualifier indicating the target is a Fixed ADS-B Beacon.

j. The TIS-B Service **shall [E034]** suppress a TIS-B target scheduled to be transmitted on the same data link from which a corresponding ADS-B Message on the same target has been received when the ADS-B data meets the performance thresholds identified in 3.2.1.1.2e.

Note: *The TIS-B Service will associate ADS-B targets with measurements from other surveillance systems on corresponding targets to generate TIS-B Messages on dissimilar data links. As shown in the following table, UAT-only ADS-B targets will have a corresponding TIS-B Message transmitted by the TIS-B Service on 1090ES and vice versa. Though this is similar to ADS-B Rebroadcast, the performance requirements are not as stringent. This capability enables aircraft with different ADS-B systems operating in the Service Volume, but outside of coverage from radar or multilateration systems, to see each other. A "yes" indication in the table indicates that the ADS-B data meets the configured performance thresholds in requirement 3.2.1.1.2e.*

TIS-B Message Uplinked	*Source Contributing to TIS-B Track*		
	1090 ES ADS-B	*UAT ADS-B*	*Radar/MLAT*
1090, UAT	*no*	*no*	*yes*
1090-only	*no*	*yes*	*Optional*
UAT-only	*yes*	*no*	*Optional*
No Uplink	*yes*	*yes*	*Optional*
No Uplink	*no*	*no*	*no*

k. The TIS-B Service **shall [E3240]** suppress a TIS-B target scheduled to be transmitted to ADS-B targets that are reporting Receive Capability equal to "NO" in Version TWO (2) Messages per DO-282B or DO-260B.

Note: *The TIS-B Service does not provide TIS-B Service to ADS-B targets equipped to only transmit (i.e., ADS-B OUT). DO-282B and DO-260B have new message fields to indicate whether the ADS-B target is ADS-B OUT only or also ADS-B IN capable. ADS-B targets that ADS-B IN capable only is not an acceptable configuration to receive TIS-B Service. This requirement does not apply to Version One (1) UAT or 1090ES equipped targets.*

3.2.1.1.2.1 TIS-B Suppression for Surface Service Volumes

Surface service volumes are often densely populated with aircraft, thereby requiring significant spectrum bandwidth to support the TIS-B performance requirements for ADS-B applications. Reducing the number of TIS-B transmission on the surface can mitigate the spectrum bandwidth needs in these dense target environments. One means of reducing TIS-B transmissions is to eliminate broadcasts for aircraft which do not require sight of each other. Some airports are designed with multiple distinct movement areas within which aircraft operating on one movement area do not need to be seen by aircraft on a separate movement area. Therefore, the TIS-B service can suppress broadcasts that are intended for aircraft operating in different sections of the airport surface. The following suppression requirements apply only for aircraft on the surface movement area within a surface service volume.

a. The TIS-B Service **shall [E5226]** provide non-broadcast region pairs for surface service volumes within which TIS-B broadcasts are inhibited.

b. When in a non-broadcast region pair, the TIS-B Service **shall [E5227]** not rebroadcast data from a target in one region to another target in a paired non-broadcast region.

c. The TIS-B Service **shall [E5228]** permit a minimum of 10 sets of non-broadcast region pairs per surface service volume.

d. Non-broadcast regions **shall [E5229]** be adaptable to be enabled or disabled within a surface service volume.

Note: *Alternate implementations of this TIS-B target suppression functionality are permissible upon agreement of the FAA that the alternate implementation meets the intent of these requirements to reduce spectrum usage in dense surface environments.*

3.2.1.1.3 TIS-B / ADS-R Service Status

TIS-B / ADS-R Service Status provides users with a near real-time indication of the availability of a complete surveillance picture in their immediate operating area. The

service status informs ADS-B In equipped aircraft that they are within an operational service volume and receiving both TIS-B and ADS-R service. If targets are dual equipped with both UAT and 1090-ES receivers, the TIS-B / ADS-R Service Status provides an indication that the target is in a service volume and receiving TIS-B services. The ADS-R service does not apply to targets equipped with both UAT and 1090-ES ADS-B In.

The TIS-B / ADS-R Service Status on the 1090-ES link is provided through a series of 1090-ES messages with the 24-bit ICAO address of targets receiving these services. Up to three (3) 24-bit addresses can be contained in each TIS-B / ADS-R Service Status Message on 1090-ES. Multiple messages are transmitted to provide service status to all appropriately equipped aircraft. The 1090-ES messages include an "In-Service / Out-of-Service" bit for each 24-bit address. The "In-Service indication is sent to client aircraft when they are within the Service Volume and receiving these services. The "Out-of-Service" indication is only sent for a brief period if a client is receiving service, but a failure in the system or radars supporting the service prevents providing reliable service to that client.

The TIS-B / ADS-R Service Status indication on the UAT data link requires the use of both the TIS-B and FIS-B Services to process and communicate the relevant data. The TIS-B Service determines which aircraft/vehicle has service available and transfers this data to the FIS-B Service, which formats and transmits the data in UAT Ground Uplink Messages. For the UAT link, it is important that the target address and address qualifier provided in the TIS-B / ADS-R Service Status is the same as what is provided by the ADS-B aircraft/vehicle. Regardless of whether an ADS-B equipped aircraft/vehicle is eligible to receive TIS-B / ADS-R Service Status, TIS-B target data is still provided to all ADS-B targets operating in the Service Volume.

a. The TIS-B / ADS-R Service Status **shall [E035]** indicate whether the TIS-B and ADS-R Services are currently available to each UAT ADS-B equipped aircraft/vehicle operating in the Service Volume in accordance with §3.4.4.6.

b. The TIS-B / ADS-R Service Status **shall [E5217]** indicate whether the TIS-B and ADS-R Services are currently available to each 1090-ES ADS-B equipped aircraft/vehicle operating in the Service Volume in accordance with the service status management message format defined in §3.2.2.1.3.3.

Notes on (a) and (b):

1. *The TIS-B service will not provide information on traffic that is not visible to the ground surveillance system. Furthermore, the TIS-B Service depends on the user transmitting ADS-B to confirm their presence in the Service Volume.*

2. *If an aircraft is equipped with both UAT and 1090-ES receive capability, the service status is based upon the availability of TIS-B Service to these aircraft because ADS-R is not needed by the aircraft to obtain a complete traffic picture.*

c. When TIS-B service is not offered in a Service Volume, the TIS-B / ADS-R Service Status **shall** [**E5218**] not be provided to any clients in that Service Volume.

d. When TIS-B and ADS-R services were being provided to a client with 1090-ES ADS-B In equipage and either service can no longer be provided to that client due to a radar or system failure, the TIS-B / ADS-R Service Status **shall** [**E5219**] report "not receiving service" to these clients at least once every 20 seconds (95%) for a time period of 60 seconds.

e. The TIS-B / ADS-R Service Status **shall [E036]** be available to ADS-B In equipped aircraft/vehicles operating throughout the Service Volume.

f. The TIS-B / ADS-R Service **shall [E040**] maintain a list of target addresses (including the corresponding address qualifiers) for ADS-B In equipped aircraft/vehicles that correlate with sensor data from either radar or multilateration systems.

Note: *Both radar/multilateration surveillance coverage and ADS-B RF coverage are necessary to prevent providing a aircraft/vehicle, operating in only ADS-B RF coverage, with a false indication that there is no proximate traffic.*

g. The TIS-B / ADS-R Service Status data **shall [E038] not** include addresses for suppressed TIS-B targets inclusive to an airspace volume or surface area (see §3.2.1.1.2).

Note: *Targets operating in an airspace volume or surface area for which all TIS-B targets are suppressed are not considered to be receiving TIS-B Service as they will not have target data for proximate aircraft.*

Note: *Service Status is not provided to targets that are on the target filter list, within exclusion regions, or outside the service volume. This is to signal the aircraft that they should (or should not) expect TIS-B / ADS-R visibility to proximate targets (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

h. The TIS-B Service **shall [E041]** generate TIS-B / ADS-R Service Status data at a configurable interval to achieve the update interval identified in §3.3.2.4 for each eligible target.

i. The TIS-B / ADS-R Service Status data **shall [E3231] not** include target addresses for which the same address has been received in the Service Volume from multiple targets.

Note: *A target's address is not included in the TIS-B / ADS-R Service Status if duplicate addresses have been received to avoid potentially falsely indicating service availability to any of the targets that may be outside the TIS-B and ADS- R Service Volume. TIS-B Service is still to be provided to these ADS-B aircraft regardless of whether their address is/is not included in the Service Status data.*

3.2.1.1.4 TIS-B Target Report Generation

The TIS-B Service will provide target data to the SBS Monitor and potentially other FAA authorized users via one or more specified SDPs. The reported data must contain the same data broadcast to aircraft/vehicles, with the exception that position data will not be extrapolated.

a. The TIS-B Service **shall [E042]** send to designated SDPs a TIS-B Report for each TIS-B target within the Service Volume whenever the target is updated with new sensor data at an update interval not to exceed once per second.

Notes:

1. *The interface requirement for these data is in §3.4.3.*
2. *The reporting rate and filtering criteria for authorized users may be specified in coordination with those users and can be independent of the criteria for reports being sent to the SBS Monitor.*

3. *When the TIS-B Service is deployed in a Service Volume without the ADS-B Service, a TIS-B report is sent to SBS Monitor SDP whenever the target is updated with new surveillance data (i.e., whenever it is updated as a result of new sensor data OR new ADS-B data) (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*

4. *When the TIS-B Service is combined with the ADS-B Service, ADS-B reports are not to be included in the TIS-B track reports sent to the SDP since ADS-B reports are sent to the SDP by the ADS-B Service (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*

3.2.1.1.5 TIS-B Processing Specific to DO-260 and DO-260A Equipped Aircraft

The processing of 1090ES ADS-B Reports from aircraft equipped with legacy DO-260 certified avionics requires special consideration by the TIS-B Service. The TIS-B Messages for transmitted to DO-260A and DO-260B aircraft are the same with the exception of the Movement field. The TIS-B Service needs to accept DO-260 Messages from aircraft (per §3.2.2.1.1) and, in addition to meeting the related requirements in §3.2.1.1.2, meet the following requirements specific to DO-260 and DO-260A aircraft reporting ADS-B.

a. DO-260 aircraft **shall [E3232] not** be considered clients by the TIS-B Service and are ineligible for the reception of TIS-B Messages.

b. The TIS-B Service **shall [E3233] not** transmit TIS-B messages for DO-260 aircraft on the 1090ES datalink.

c. Reserved.

   ***Note**: Requirement E3234 was replaced by new requirements to accommodate Version B on the 1090ES MOPS.*

d. The TIS-B Service **shall** [**E3241**] use only 1090ES Version ZERO (0) Messages in the provision of TIS-B over the UAT data link when the ADS-R Service is configured to transmit 1090ES Version ONE (1) and TWO (2).

e. The TIS-B Service **shall** [**E3242**] use 1090ES Version ZERO (0) and ONE (1) Messages in the provision of TIS-B over the UAT data link when the ADS-R Service is configured to transmit 1090ES Version TWO (2).

f. By way of service adaptation, DO-260A aircraft **shall [E3243] not** be considered clients by the TIS-B Service and are ineligible for the reception of TIS-B Messages.

   ***Note**: With the introduction of DO-260B equipage requirements, the FAA will eventually require all traffic eligible for TIS-B to be DO-260B equipped. This change will require the TIS-B Service to transition from serving DO-260A as clients to only DO-260B as clients.*

3.2.1.2 FIS-B

This section contains the functional requirements for the FIS-B Service. The FIS-B Service and associated products support the Weather and NAS Status Information Situational Awareness Application. FIS-B products are characterized as either meteorological or aeronautical information.

The FIS-B Service receives weather and NAS status source data from government and commercial sources and provides products using the UAT data link in FIS-B Messages (i.e., UAT Ground Uplink Messages) to aircraft/vehicles.

The service provider is required to provide the Basic Meteorological and Aeronautical Products identified in §3.2.1.2.3 and §3.2.1.2.4, respectively. The provision of the Optional FIS-B Products (§3.2.1.2.5) is considered a system enhancement that may be exercised by the FAA in the future. These products will reflect the conditions in the NAS airspace to include: CONUS, and OCONUS areas of Alaska, Hawaii, U.S. Virgin Islands and Puerto Rico as available for these latter locations.

3.2.1.2.1 Meteorological and Aeronautical Information Sources

The service provider will receive raw data from viable sources and create the required FIS-B products that are transmitted to the aircraft/vehicle. These sources may include, but are not limited to, FAA, National Weather Service (NWS), or commercial data providers.

a. The FIS-B Service **shall [E043]** ingest all meteorological and aeronautical information necessary to provide the products defined in §3.2.1.2.3 and §3.2.1.2.4 from government or commercial services.

b. All FIS data source providers used by the service provider for the purpose of generating products **shall [E044]** be approved by the FAA.

c. If the service provider uses FIS data sources available via the public internet, the source data provider **shall [E045]** be approved by the FAA.

d. All commercial FIS product sources proposed by the service provider **shall [E229]** be subject to approval by the FAA.

Note: *See §3.1.12 for definition of the FIS-B source data approval process.*

3.2.1.2.2 FIS-B Service Management

a. Changes made to the FIS-B product filtering criteria **shall [E210]** be performed without taking the FIS-B Service Offline, in the absence of an FAA approved service outage.

b. Changes made to a suite of FIS-B products being provided **shall [E211]** be performed without taking the FIS-B Service Offline, in the absence of an FAA approved service outage.

c. Changes made to the allocation of FIS-B product to transmitters **shall [E212]** be performed without taking the FIS-B Service Offline, in the absence of an FAA approved service outage.

d. The meteorological products **shall [E213]** represent the most recently available atmospheric conditions throughout the NAS airspace and at designated airports.

Note: *This requirement is to ensure that the most recent source data available to the service provider is broadcast as soon as it becomes available.*

e. The aeronautical information products **shall [E214]** represent the most recently available status of NAS operational resources throughout the NAS airspace and at designated airports.

Note: *This requirement is to ensure that the most recent source data available to the service provider is broadcast as soon as it becomes available.*

f. The FIS-B Service **shall [E046]** be capable of providing a geographic subset of FIS-B products to the Transmit Function.

Note: *This subset may be geographically filtered for proximity to the ground station location.*

g. The geographic scope of each FIS-B product **shall [E047]** be configurable by the service provider on a Service Volume basis.

Notes:

1. *Each product is sized to accommodate operational objectives and/or communication bandwidth constraints. The resolution of products may vary by UAT transmitter with some stations providing more product content than others. For example, some transmitters may provide METARs for large airports, while others may provide METARs for all other airports.*
2. *The geographic scope of each product may also vary by UAT transmitter with some stations having limited scope for low altitude operations and other stations having larger scope and able to be received for longer ranges (without co-channel interference) at high altitude.*

3.2.1.2.3 Basic Meteorological Products

a. The FIS-B Service **shall [E048]** provide users with the following basic meteorological products:

- Airman's Meteorological Information (AIRMET),
- Aviation Routine Weather Report (METAR) and Unscheduled Specials (SPECI)
- Multi-Radar Multi Sensor (MRMS) Next Generation Radar (NEXRAD) precipitation reflectivity (CONUS and Regional),
- Pilot Reports (PIREPS) (urgent and routine),
- Significant Meteorological Information (SIGMET) (including Convective SIGMET),
- Terminal Area Forecast (TAF) and unscheduled Amendments (AMEND),
- Winds and Temperatures Aloft

b. The FIS-B Service **shall [E5230]** provide users with the following expanded set of basic meteorological products:

- Lightning strikes,
- Turbulence,
- Icing, Current/Forecast Potential (CIP/FIP),
- Cloud tops,
- Graphical AIRMET (G-AIRMET),
- Center Weather Advisory (CWA).

Note: *The formats for the expanded set of basic meteorological products will be jointly defined and agreed to by the FAA and SBS vendor.*

3.2.1.2.4 Basic Aeronautical Information Products

a. The FIS-B Service **shall [E049]** provide users with the following basic aeronautical information products:

- Distant (D) and Flight Data Center (FDC) Notices to Airmen (NOTAMs) important to flight safety or currently not documented in the FAA NOTAM Bulletin,
- TFR NOTAMs
- TRA NOTAMs
- TMOA NOTAMs
- Status of Special Use Airspace (SUA),
- TIS-B / ADS-R Service Status.

b. The aeronautical information provided **shall [E050]** conform to applicable aeronautical information found in FAA approved Flight Information Publications.

c. The FIS-B Service **shall [E5271] not** be required to uplink NOTAMs which have an Effective Date, Issuance Date, or are first received by FIS-B more than a configurable number of days in the past (with a default value of 30 days).

Note: *Flight Information Publications include, but are not limited to: "Aeronautical Information Manual (AIM);" AC 00-45E, "Aviation Weather Services;" ICAO Annex 3, "Meteorological Services;" and ICAO Annex 15, "Aeronautical Information Services."*

3.2.1.2.5 Optional FIS-B Products

Optional products are defined as those products beyond the basic meteorological and aeronautical information products defined above. Optional products may be added to the basic product suite. Implementation timing of these or any additional products desired by the service provider will depend on external factors, including:

- FAA approval process for addition of FIS-B products.
- FAA operational approval process for the display and use of FIS-B products.
- UAT bandwidth availability for additional products without impacting basic products.
- Refinement of bandwidth management techniques based on system operating experience.
- User demand and market penetration.
- Availability of suitable product source data.
- Coordination of product definitions with FAA and industry.

a. The optional FIS-B products **shall [E052 SE]** be subject to approval by the FAA prior to implementation by the service provider.

Notes:

1. *The Aeronautical Radio Navigation Spectrum (ARNS) within which UAT operates is regulated by the FAA and therefore all data transmitted on UAT must first be approved by the FAA.*
2. *Optional products will not be classified as experimental products.*

b. The addition of optional FIS-B products **shall [E053 SE] not** degrade the performance of the basic meteorological or aeronautical information products defined in §3.2.1.2.3 and §3.2.1.2.4, respectively.

The following products, in addition to others not listed here, may be considered by the service provider as optional products:

- Echo tops,
- Severe Weather Forecast Alerts (AWW) and Severe Weather Watch Bulletin (WW),
- Ceilings,
- Digital Automated Terminal Information Service (D-ATIS),
- Terminal Weather Information for Pilots (TWIP),
- 1 Minute AWOS.

3.2.1.2.6 FIS-B Product Characteristics

The FIS-B MOPS, DO-358A allow for a standard approach to product encoding, categorizing, communication and presentation. This allows avionics application vendors and service providers to use standard formatting and product identification. The Service Provider's FIS-B products must be agreed to by the FAA or contained in the FIS-B MOPS, RTCA DO-358A.

Many FIS-B products can have both textual and graphical representations or the graphical depiction can be derived from the text. Per the MOPS, the avionics must be able to associate the textual content with the graphical content. This enables pilots to reference the text from a graphically display of the information. The Service Provider's FIS-B product development approach should take this into consideration.

The FIS-B products should be consistent in content and extent with FIS information available to Flight Watch/Dispatch and/or Air Traffic Specialists. This will enable pilots to communicate more effectively with these individuals when assessing flight deviations.

a. Each FIS-B product **shall [E054]** be compliant with the FIS-B MOPS, RTCA DO-358A.

b. The FIS-B Service **shall [E248]** continue to provide pre-existing products as defined in the original version of DO-358.

Note: *The Basic products include the following pre-existing products: METAR/SPECI, TAF/AMEND, Winds/Temperature Aloft, Regional MRMS NEXRAD.*

c. FIS-B products **shall [E056]** conform to the product definitions in the FIS-B MOPS, RTCA DO-358.

Note: *This requirement applies to existing products in the FIS-B MOPS.*

d. FIS-B products defined by the service provider **shall [E057]** be registered and maintained in the FIS-B MOPS, RTCA DO-358.

3.2.1.2.6.1 AIRMET

a. The FIS-B Service **shall [E067]** receive AIRMET text reports.

b. The FIS-B Service **shall [E068]** format each AIRMET report for uplink broadcast in accordance with §3.4.4.5.2.3.

c. The FIS-B Service **shall [E5252]** ensure that AIRMET graphical and text records can be unambiguously associated by avionics.

***Note**: One possible method to ensure the correct association of graphical and textual AIRMETs is through assigning mutually exclusive report ID block numbers to each processor that assigns these block numbers.*

3.2.1.2.6.2 METAR/SPECI

a. The FIS-B Service **shall [E061]** receive METAR/SPECI text reports.

b. The FIS-B Service **shall [E062]** format each METAR/SPECI report for uplink broadcast in accordance with §3.4.4.5.2.1.

c. The FIS-B service **shall [E5248]** uplink METARs from all United States stations that are identified with an initial "K", "P", or "T" character in the station ID.

d. The FIS-B service **shall [E5249]** periodically add United States METAR stations to the FIS-B uplink database as these become available to the FIS-B Service provider.

3.2.1.2.6.3 MRMS NEXRAD Precipitation Reflectivity (CONUS and Regional)

This product is generally derived from one or more available products from the National Weather Service Next Generation Radar (WSR-88D). The Service Provider has the latitude to propose the specific MRMS NEXRAD product or products from which the MRMS NEXRAD Precipitation Reflectivity products is derived as long as: (1) it complies with the FIS-B MOPS and (2) the regional derivative is backward compatible with the existing NEXRAD reflectivity product provided by the FAA to users of UAT FIS-B pre-existing this specification. The quality and usability of the resulting MRMS NEXRAD product should meet or exceed existing norms (e.g., filtering of false returns).

a. The FIS-B Service **shall [E058]** receive and process MRMS precipitation reflectivity data.

b. The FIS-B Service **shall [E3193]** utilize MRMS's Quality Controlled Reflectivity Product which reduces non-weather echoes such as ground clutter, anomalous propagation and interference from the Precipitation Reflectivity Products while not removing actual reflective precipitation.

c. The FIS-B Service **shall [E3194]** utilize mosaics with a spatial resolution equal to or better than the specified FIS-B MRMS NEXRAD Precipitation Reflectivity Products.

***Note:** The reflectivity products provided by MRMS come in a variety of spatial resolutions and coverage range limits. This requirement looks to ensure that the NEXRAD products provided by the FIS-B Service are derived from better data. For example, 2 NM x 2 NM resolution, 124 NM range data is used to generate a FIS-B Service product with an 8 NM x 8 NM resolution and not the reverse.*

d. The FIS-B Service **shall [E059]** provide a Regional MRMS NEXRAD Precipitation Reflectivity Product with a spatial resolution equal to or better than 1.2 NM (2.2 Km) and formatted for uplink broadcast in accordance with §3.4.4.5.2.2.

***Note:** The regional MRMS NEXRAD product is intended to be available wherever WSR-88D radar coverage exists in the NAS.*

e. The FIS-B Service **shall [E060]** provide a conterminous U.S. (CONUS) MRMS NEXRAD Precipitation Reflectivity Product with a spatial resolution equal to or better than 5.7 NM (10.6 Km) and formatted for uplink broadcast in accordance with §3.4.4.5.2.2.

f. The FIS-B system **shall [E5253]** establish MRMS NEXRAD uplinks based on data available on the hour and every subsequent 2 minutes throughout the hour (i.e. :02, :04, :06, …:58).

Note:*These are the MRMS* NEXRAD Mosaic Creation *times that are encoded in the APDU.*

g. The Regional MRMS NEXRAD uplink for an *update* **shall [E5254]** be completed within 2 minutes (95%) after the MRMS NEXRAD Update Epoch time for which the update is based.

h. The CONUS MRMS NEXRAD uplink for an *update* **shall [E5256]** be completed within 4 minutes (95%) after the MRMS NEXRAD Update Epoch time for which the update is based.

i. The timeout for MRMS NEXRAD imagery **shall [E5270]** be configurable from 5 to 20 minutes (defaulted to 5 minutes) in 1 minute increments such that the timeout can be set to comply with the maximum permitted age defined in the DO-358 FIS-B Minimum Operational Performance Standards.

3.2.1.2.6.4 NOTAM-D/FDC (includes Temporary Flight Restrictions [TFRs], TRAs, TMOAs)

a. The FIS-B Service **shall [E073]** receive NOTAM-D/FDC text reports.

b. The FIS-B Service **shall [E3195]** receive TFR text and graphic reports.

c. The FIS-B Service **shall [E074]** format each NOTAM-D/FDC and TFR report for uplink broadcast in accordance with §3.4.4.5.2.3.

d. The FIS-B Services **shall [E5280]** receive Temporary Restricted Area (TRA) text and graphic reports.

e. The FIS-B Services **shall [E5281]** receive Temporary Military Operations Area (TMOA) text and graphic reports.

f. The FIS-B Service **shall [E5282]** format each TRA report for uplink broadcast in accordance with §3.4.4.5.2.3.

g. The FIS-B Service **shall [E5283]** format each TMOA report for uplink broadcast in accordance with §3.4.4.5.2.3.

3.2.1.2.6.5 PIREP

a. The FIS-B Service **shall [E065]** receive PIREP text reports.

b. The FIS-B Service **shall [E066]** format each PIREP report for uplink broadcast in accordance with §3.4.4.5.2.1.

3.2.1.2.6.6 SIGMET (including Convective SIGMET)

a. The FIS-B Service **shall [E069]** receive SIGMET text reports.

b. The FIS-B Service **shall [E070]** format each SIGMET report for uplink broadcast in accordance with §3.4.4.5.2.3.

c. The FIS-B Service **shall [E5257]** ensure that SIGMET graphical and text records can be unambiguously associated by avionics

***Note**: One possible method to ensure the correct association of graphical and textual SIGMETs is through assigning mutually exclusive report ID block numbers to each processor that assigns these block numbers.*

3.2.1.2.6.7 SUA

a. The FIS-B Service **shall [E3196]** receive Status of Special Use Airspace text reports.

b. The FIS-B Service **shall [E3197]** format the Status of Special Use Airspace data for uplink broadcast in accordance with §3.4.4.5.2.3.

3.2.1.2.6.8 TAF/AMEND

a. The FIS-B Service **shall [E063]** receive TAF/AMEND text reports.

b. The FIS-B Service **shall [E064]** format each TAF/AMEND report for uplink broadcast in accordance with §3.4.4.5.2.1.

c. The FIS-B service **shall [E5250]** uplink TAFs from all United States stations that are identified with an initial "K", "P", or "T" character in the station ID.

d. The FIS-B service **shall [E5251]** periodically add United States TAF stations to the FIS-B uplink database as these become available to the FIS-B Service provider.

3.2.1.2.6.9 TIS-B / ADS-R Service Status for the UAT data link

a. The FIS-B Service **shall [E075]** receive TIS-B and ADS-R Status data from the TIS-B and ADS-R Services.

b. The FIS-B Service **shall [E076]** format the TIS-B / ADS-R Service Status data for uplink broadcast in accordance with §3.4.4.6.

3.2.1.2.6.10 Winds and Temperatures Aloft

a. The FIS-B Service **shall [E071]** receive Winds and Temperatures Aloft text reports.

b. The FIS-B Service **shall [E072]** format each Winds and Temperatures Aloft report for uplink broadcast in accordance with §3.4.4.5.2.1.

3.2.1.2.6.11 Graphical AIRMET (G-AIRMET)

a. The FIS-B Service **shall [E5284]** receive G-AIRMET text and graphical reports.

b. The FIS-B Service **shall [E5285]** format each G-AIRMET report for uplink broadcast in accordance with §3.4.4.5.2.3.

c. The FIS-B Service **shall [E5286]** ensure that G-AIRMET graphical and text records can be unambiguously associated by avionics.

3.2.1.2.6.12 Center Weather Advisories (CWA)

a. The FIS-B Service **shall [E5287]** receive CWA text and graphical reports.

d. The FIS-B Service **shall [E5288]** format each CWA report for uplink broadcast in accordance with §3.4.4.5.2.3.

e. The FIS-B Service **shall [E5289]** ensure that CWA graphical and text records can be unambiguously associated by avionics.

3.2.1.2.6.13 Lightning

a. The FIS-B Service **shall [E5290]** receive an FAA approved Lightning graphical product.

b. The FIS-B Service **shall [E5291]** format the Lightning graphical product for uplink broadcast in accordance with §3.4.4.5.2.2.

3.2.1.2.6.14 Turbulence

a. The FIS-B Service **shall [E5292]** receive an FAA approved Turbulence graphical product.

b. The FIS-B Service **shall [E5293]** format the Turbulence graphical product for uplink broadcast in accordance with §3.4.4.5.2.2.

3.2.1.2.6.15 Icing, Forecast Potential (FIP)

a. The FIS-B Service **shall [E5294]** receive an FAA approved Icing, Forecast Potential (FIP) graphical product.

b. The FIS-B Service **shall [E5295]** format the Icing, Forecast Potential (FIP) graphical product for uplink broadcast in accordance with §3.4.4.5.2.2.

3.2.1.2.6.16 Cloud Tops

a. The FIS-B Service **shall [E5296]** receive an FAA approved Cloud Tops graphical product.

b. The FIS-B Service **shall [E5297]** format the Cloud Tops graphical product for uplink broadcast in accordance with §3.4.4.5.2.2.

3.2.1.3 FIS-B Product Report Generation

The FIS-B Service will provide product data to the SBS Monitor and potentially other FAA authorized users at one or more specified SDPs. The reported data must contain the same data that is broadcast to aircraft/vehicles.

a. The FIS-B Service **shall [E077]** send FIS-B Reports containing each basic product (per §3.2.1.2.3 and 3.2.1.2.4) to one or more specified SDPs whenever an FIS-B Message is successfully transmitted.

Notes:

1. *The interface requirement for these data are in §3.4.3.*
2. *The reporting rate and filtering criteria for authorized users may be specified in coordination with those users and can be independent of the reports being sent to the SBS Monitor.*

Note: *The FIS-B Reports provided to the FAA are to be provided in the same format as sent to the Radio for uplink (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

3.2.1.4 Current Report List

The Current Report List (CRL) is provided for TFR NOTAMs, AIRMETs, SIGMETs, G-AIRMETs, CWAs, TRA NOTAMs, and TMOA NOTAMs to verify that the avionics are receiving a complete set of these report types. The CRL is oriented to each radio station such that the specific set of reports being transmitted from that radio are known to the receiver. If a corresponding report is found for each of the identifying report number in the CRL, that product can be declared complete for that radios scope of coverage. When a previously uplinked report stops being transmitted from a Radio Station, it is also dropped from the next CRL uplinked. A report identifier's absence from the CRL is also used by avionics to purge non-current reports that have been previously received.

a) The FIS-B Service **shall [E5258]** generate a Current Report List (CRL) containing the Report Identifiers for those TFR NOTAMs currently being uplinked by each Radio Station.

b) The TFR NOTAM CRL **shall [E5259]** be uplinked at a transmission rate of once every 5 minutes.

c) The FIS-B Service **shall [E5260]** generate a Current Report List containing the Report Identifiers for those AIRMETs currently being uplinked by each Radio Station.

d) The AIRMET CRL **shall [E5261]** be uplinked at a transmission rate of once every 2.5 minutes.

e) The FIS-B Service **shall [E5262]** generate a Current Report List containing the Report Identifiers for those SIGMETs currently being uplinked by each Radio Station.

f) The SIGMET CRL **shall [E5263]** be uplinked at a transmission rate of once every 2.5 minutes.

g) The FIS-B Service **shall [E5264]** format each Current Report List for uplink broadcast in accordance with the description and format provided in Appendix B.

h) The FIS-B Service **shall [E5276]** generate a Current Report List containing the Report Identifiers for those Graphical AIRMETs currently being uplinked by each Radio Station.

i) The Graphical AIRMET CRL **shall [E5277]** be uplinked at a transmission rate of once every 2.5 minutes.

j) The FIS-B Service **shall [E5278]** generate a Current Report List containing the Report Identifiers for those CWAs currently being uplinked by each Radio Station.

k) The CWA CRL **shall [E5279]** be uplinked at a transmission rate of once every 5 minutes.

l) The FIS-B Service **shall [E5298]** generate a CRL containing the Report Identifiers for those TRA NOTAMs currently being uplinked by each Radio Station.

m) The TRA NOTAM CRL **shall [E5299]** be uplinked at a transmission rate of once every 5 minutes.

n) The FIS-B Service **shall [E5300]** generate a CRL containing the Report Identifiers for those TMOA NOTAMs currently being uplinked by each Radio Station.

o) The TMOA NOTAM CRL **shall [E5301]** be uplinked at a transmission rate of once every 5 minutes

3.2.1.5 Truncation of Text Records

For FIS-B products *(that are uplinked as both textual and graphical records),* any text records that exceed 1500 characters **shall [E5265]** be truncated to 1500 DLAC (Data Link Applications Coding) encoded characters by the FIS-B service as identified in Appendix C.

Note: *This truncation does not affect graphical records – it only applies to text records (either of text-only products, or the text record portion of text/graphical products).*

3.2.2 Link Specific Processing

This section establishes requirements specific to UAT and 1090ES data link systems. These requirements will apply to what are referred to as the Transmit Function and Receive Function of the TIS-B/FIS-B Services.

a. When in Offline Mode (per §3.2.3.1.1), the Transmit Function **shall [E078] not** transmit TIS-B and FIS-B Messages.

Note: *The Receive Function may receive and decode ADS-B Messages when in the Offline Mode, but it is not required to do so.*

b. The equipment used in providing the TIS-B/FIS-B Services on the 1090ES and UAT data links **shall [E3198]** comply with the spectrum certification requirements as defined in chapters 5 and 10 of the Manual of Regulations and Procedures for Federal Radio Frequency Management.

3.2.2.1 1090ES

3.2.2.1.1 1090ES ADS-B Message Receive

The ADS-B Message Receive and Decode Function will receive and decode 1090ES Version ZERO (0), ONE (1) and TWO (2) ADS-B Messages per RTCA/DO-260B. 1090ES equipped aircraft/vehicles in conformance with RTCA DO-260B are required to broadcast MOPS Version TWO ADS-B Messages. Version ZERO and Version ONE ADS-B Message formats are contained in RTCA DO-260B Appendix N. The function is also required to send reports the SBS Monitor for aircraft equipped with MOPS Versions ZERO or ONE that are present in the NAS.

a. The Receive Function **shall [E079]** receive and decode 1090ES ADS-B Messages that are transmitted from aircraft/vehicles per RTCA/DO-260 and DO-260A.

b. The Receive Function **shall [E3244]** receive and decode 1090ES ADS-B Messages that are transmitted from aircraft/vehicles per RTCA/DO-260B.

3.2.2.1.2 1090ES TIS-B Message Generation

3.2.2.1.2.1 1090ES TIS-B Message Data

a. 1090ES Message bits 1 through 88 of the 1090ES Messages **shall [E080]** correspond to the payload fields described in §3.2.2.1.3.2 and §3.2.2.1.3.3.

3.2.2.1.2.2 1090ES Address/Parity Generation

a. 1090ES Message bits 89 through 112 **shall [E081]** consist of the 24-bit Parity/Identity field calculated in accordance with RTCA DO-181C, §2.2.16.2.1, using a 24-bit parity overlay of ALL ZEROs.

3.2.2.1.3 1090ES TIS-B Message Format

3.2.2.1.3.1 1090ES TIS-B Message Types

a. The Transmit Function **shall [E082]** be capable of encoding the TIS-B Message types contained in RTCA/DO-260B, Table 3-1 and their corresponding message elements per DO-260B §2.2.17 and §A.2.

Table 3-1: 1090ES TIS-B Message Types

Message Types	RTCA/DO-260B Reference Paragraphs
TIS-B Fine Airborne Position	§2.2.17.3.1 & §A.2.4.1
TIS-B Fine Surface Position	§2.2.17.3.2 & §A.2.4.2
TIS-B Identification and Type	§2.2.17.3.3 & §A.2.4.3
TIS-B Velocity	§2.2.17.3.4 & §A.2.4.4
TIS-B/ADS-R Service Status Management	§2.2.17.2 & §A.2

3.2.2.1.3.2 1090ES TIS-B Message Encoding

The set of messages to be broadcast for the TIS-B Service is dependent on the information that is available. This section specifies which 1090ES TIS-B Messages are to be broadcast based on that information.

a. If the target being broadcast is airborne, the Transmit Function **shall [E083]** encode the following three TIS-B Message types in accordance with RTCA/DO-260B §2.2.17.3.1 and §2.2.17.3.4: an "even" and an "odd" CPR format TIS-B Fine Airborne Position Message, and a TIS-B Velocity Message.

Notes:

1. *The three messages can be repeated if necessary to achieve the TIS-B update rate performance specified in §3.3.2.11.1 subject to the latency requirements specified in §3.3.2.6*
2. *If Pressure Altitude is available, it should be encoded in the Fine Airborne Position Message.*

b. If the target being broadcast is on the surface, then the TIS-B Service **shall [E084]** encode a TIS-B Fine Surface Position Message according to RTCA/DO-260B §2.2.17.3.2.

Note: *This message can be repeated if necessary to achieve the TIS-B update rate performance specified in §3.3.2.11.1 subject to the latency requirements specified in §3.3.2.6.*

c. If the target being broadcast is on the surface, then the TIS-B Service **shall [E3245]** encode a TIS-B Velocity Message according to RTCA/DO-260B §2.2.17.3.4.

d. The Transmit Function **shall [E085]** extrapolate horizontal position (i.e., latitude and longitude) of the target to the time of TIS-B Message transmission on 1090ES before CPR encoding.

Note: *A linear extrapolation is expected to be used to compensate for any delays incurred leading up to the time of transmission. Extrapolation is only performed on targets determined to be airborne by the TIS-B Service. The pressure altitude should not be extrapolated since the altitude rate accuracy may induce larger altitude errors than the provided in the original data.*

Note: *This requirement has been updated with the words "before CPR encoding" (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

3.2.2.1.3.3 1090ES TIS-B Message Payload

a. The Transmit Function **shall [E086]** broadcast the information in each TIS-B Message as indicated in the Table 3-2.

Table 3-2. Payload Composition of 1090ES TIS-B Messages

TIS-B Message	Encoding Used	TIS-B Message Field	MSG Bit #	DO-260B Reference (unless otherwise noted)
All (except TIS-B / ADS-R Service Status)	Set to decimal 18 (10010) for all TIS-B Messages	DF TYPE	1-5	§2.2.17.2.1
	"2" for Fine TIS-B Message with AA=24-bit ICAO address and "5" for Fine TIS-B Message with AA=TIS-B Service generated 24-bit track ID	Control Field (CF)	6-8	§2.2.17.2.2
	A 24-bit address; ICAO address or service generated track ID	Address Announced (AA)	9-32	§2.2.17.2.3
	Algorithm that operates on the first 88 bits of the message	Parity / Identity (PI)	89-112	§2.2.3.2.1.7
TIS-B Fine Airborne Position	Determined from altitude type and NIC setting per requirements of §3.2.1.1.1.4.1	TYPE	33-37	§2.2.3.2.3.1
	Set to 00 for all TIS-B Messages	Surveillance Status	38-39	§2.2.3.2.3.2
	"0" to indicate a 24 bit address	ICAO Mode Flag (IMF)	40	§2.2.17.3.1.2
	12 bits of barometric altitude data.	Pressure Altitude	41-52	§2.2.3.2.3.4.1
	Set to ZERO	Reserved	53	-
	Transmit Function to alternate between "0" = even; "1" = odd.	CPR Format	54	§2.2.3.2.3.6
	CPR encoded Latitude and Longitude of target position.	CPR Latitude	55-71	§2.2.3.2.3.7
		CPR Longitude	72-88	§2.2.3.2.3.8
TIS-B Fine Surface Position	Determined from altitude type and NIC setting per requirements of §3.2.1.1.1.4.1	TYPE	33-37	§2.2.3.2.4.1
	Ground Speed of target on surface (Note: the movement field is different in DO-260B)	Movement	38-44	§2.2.3.2.4.2
	Validity of heading/ground track	Heading Status	45	§2.2.3.2.4.3
	Ground Track/Heading of target on surface	Heading	46-52	§2.2.3.2.4.4
	"0" to indicate 24 bit ICAO address; "1" to indicate service generated track ID number	ICAO Mode Flag	53	§2.2.17.3.1.2
	Transmit Function to alternate between "0" = even; "1" = odd.	CPR Format	54	§2.2.3.2.4.6
	CPR encoded Latitude and Longitude of target position.	Latitude	55-71	§2.2.3.2.4.7
		Longitude	72-88	§2.2.3.2.4.8
TIS-B ID and Type	Not used by TIS-B	TYPE	33-37	§2.2.3.2.5.1
	Not used by TIS-B	Emitter Category	38-40	§2.2.3.2.5.2
	Not used by TIS-B	Ident. Chars #1-8	41-88	§2.2.3.2.5.3

TIS-B Message	Encoding Used		TIS-B Message Field	MSG Bit #	DO-260B Reference (unless otherwise noted)
TIS-B Velocity	Set to 19 (10011) for all Velocity Messages		TYPE	33-37	§2.2.3.2.6.1.1
	Determined based on availability of data on target velocity over ground and whether target is supersonic		Subtype	38-40	§2.2.3.2.6.1.2
	"0" to indicate 24 bit ICAO address; "1" to indicate service generated track ID number		ICAO Mode Flag	41	§2.2.17.3.1.2
	TIS-B Service generated NAC_P value		NAC_P	42-45	§2.2.17.3.4.4
	Velocity data on target	Subtype 1& 2	E/W Direction	46	§2.2.3.2.6.1.6
			E/W Velocity	47-56	§2.2.3.2.6.1.7
			N/S Direction	57	§2.2.3.2.6.1.8
			N/S Velocity	58-67	§2.2.3.2.6.1.9
		All Subtypes	Vertical Rate Source (GEO Flag) (*Note 2*)	68	§2.2.3.2.6.1.10
			Vertical Rate Sign	69	§2.2.3.2.6.1.11
			Vertical Rate	70-78	§2.2.3.2.6.1.12
	Based on position TYPE codes and integrity containment radius for target position		NIC Supplement	79	§2.2.17.3.4.3
	For Messages with GEO Flag = 0	Set per the Velocity Accuracy determined for a target's TIS-B track as identified in §3.2.1.1.1.4.3	NAC_V	80-82	§2.2.3.2.6.1.14
		Set per requirements of §3.2.1.1.1.4.1	SIL	83-84	
		Set to decimal 0 (0000)	Reserved (*see Note*)	85-88	
	For Messages with GEO Flag = 1	Set to 0	Reserved	80	§2.2.3.2.6.1.15
		Based on altitude difference between barometric and geometric sources	Diff from Baro. Alt Sign	81	
			Diff. from Baro. Alt.	82-88	
TIS-B / ADS-R Service Status Management	Set to decimal 18 (10010) for all TIS-B Messages		DF TYPE	1-5	DO-317 Table H-3
	"4" for TIS-B / ADS-R Service Status Management Messages		Control Field (CF)	6-8	DO-317 Table H-3
	Set to binary "00001" to indicate a Service Status Message		Status Type Code	9-13	DO-317 Table H-3
	"1" to indicate Address #1 target is receiving both TIS-B and ADS-R services; "0" to indicate that the target is no longer receiving TIS-B and/or ADS-R Services		Service Status Address #1	14	DO-317 Table H-3
	24 bit Address of target #1		24 bit Address #1	15-38	DO-317 Table H-3
	"1" to indicate Address #2 target is receiving both TIS-B and ADS-R services; "0" to indicate that the target is no longer receiving TIS-B and/or ADS-R Services		Service Status Address #2	39	DO-317 Table H-3
	24 bit Address of target #2		24 bit Address #2	40-63	DO-317 Table H-3
	"1" to indicate Address #3 target is receiving both TIS-B and ADS-R services; "0" to indicate that the target is no longer receiving TIS-B and/or ADS-R Services		Service Status Address #3	64	DO-317 Table H-3
	24 bit Address of target #3		24 bit Address #3	65-88	DO-317 Table H-3
	Algorithm that operates on the first 88 bits of the message		Parity / Identity (PI)	89-112	§2.2.3.2.1.7

Notes:

1. *TIS-B Velocity Message is specified format in DO-260B. In DO-260B, the message was called "TIS-B Airborne Velocity Message". In addition DO-260B specifies that the TIS-B Velocity Message bit #88 is now "Reserved" instead of being encoded as "Vertical Rate Type".*
2. *In Table 3-2, subtypes 3 and 4 are not necessary (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

3. *TIS-B /ADS-R Service Status Management Messages provide an indication to ADS-B In equipped aircraft as to whether or not they are receiving both of these services.*

3.2.2.1.4 1090ES Media Access

a. The 1090ES Transmit Function **shall [E087]** adhere to the following transmission schedule limitations:

- A minimum of a 1 millisecond interval between the lead edges of the first preamble pulse of consecutive TIS-B transmissions.
- Timing between TIS-B Message transmissions are randomized so that transmissions do not occur at fixed intervals.

Notes:

1. *Transmissions on a periodic basis are not permitted on the 1090 MHz frequency as it could result in synchronous interference to 1090 MHz receiving systems.*
2. *Synchronized time sources are to be avoided for use as the basis for TIS-B Message transmission timing. This is to prevent correlation of transmission times across transmitters.*

3.2.2.2 UAT

3.2.2.2.1 UAT ADS-B Message Receive

The Receive Function **shall [E088]** receive and decode UAT ADS-B Messages that are transmitted from aircraft/vehicles per RTCA/DO-282B.

Note: *This includes Message Payloads from both Version 1 and Version 2 systems. Appendix R of DO-282B indicates the changes in the message payload relative to that of Version 1. Most of the changes are new bit fields that were formerly "reserved". One exception is the change in interpretation of the "SIL" field as indicated in the appendix.*

3.2.2.2.2 UAT TIS-B Message Generation

a. The Transmit Function **shall [E089]** use the ADS-B Message format defined in RTCA/DO-282B §2.2.3.1 for uplink of TIS-B target information.

Notes:

1. *TIS-B traffic information may be represented by either the Basic or Long ADS-B Message format as required by the TIS-B target information to be conveyed.*
2. *Even though TIS-B target updates will be transmitted by Ground Stations using the ADS-B Message format, the term "TIS-B Message" will be used in this section to distinguish this from ADS-B Messages that are transmitted by aircraft.*

b. The Transmit Function **shall [E090]** extrapolate the target horizontal position (i.e., latitude and longitude) to the latest integer UTC second prior to time of transmission on UAT.

Note: *A linear extrapolation is expected to be used to compensate for any delays incurred leading up to the time of transmission. Extrapolation is only performed on targets determined to be airborne by the TIS-B Service. The*

pressure altitude should not be extrapolated since the altitude rate accuracy may induce larger altitude errors than the provided in the original data.

c. If the Transmit Function cannot transmit the 1090ES or UAT TIS-B Message in accordance with the latency requirements of §3.3.2.6, the TIS-B Message **shall [E091]** be discarded and reported per §3.2.2.2.6.

Note: *This requirement applies to both 1090 ES and UAT data links (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

d. The information broadcast for each TIS-B target **shall [E092]** be as indicated in Table 3-3.

Table 3-3. Payload Composition of UAT TIS-B Message

Encoding	TIS-B Message Field	DO-282B Reference
ZERO if all required and available data items in the TIS-B Report fit within the "Basic" ADS-B Message, otherwise ONE	"PAYLOAD TYPE CODE"	§2.2.4.5.1.1
Encoded based on address type available consistent with referenced section of DO-282B	"ADDRESS QUALIFIER"	§2.2.4.5.1.2
A 24-bit ICAO address, or service-generated track ID number	"ADDRESS"	§2.2.4.5.1.3
Encoded consistent with referenced section of DO-282B §2.2.4.5.2.1	"LATITUDE" and "LONGITUDE"	§2.2.4.5.2.1
Encode as ZERO if Pressure Altitude data is available; otherwise encode as ONE if the "Geometric Altitude" data is available	"ALTITUDE TYPE"	§2.2.4.5.2.2
Pressure Altitude if available, otherwise Geometric Altitude if available.	"ALTITUDE"	§2.2.4.5.2.3
Set per requirements of §3.2.1.1.1.4.1	"NIC"	§2.2.4.5.2.4
Service generated and encoding consistent with DO-282B §2.2.4.5.2.5	"A/G STATE"	§2.2.4.5.2.5
	"HORIZONTAL VELOCITY"	§2.2.4.5.2.6
	"VERTICAL VELOCITY"	§2.2.4.5.2.7
Service generated and encoding consistent with DO-282B §2.2.4.5.3.1	"TIS-B SITE ID"	§2.2.4.5.3.1
Encoded per relevant section of DO-282B when data available	"EMITTER CATEGORY AND CALL SIGN CHARACTERS #1 AND #2"	§2.2.4.5.4.1, §2.2.4.5.4.2
	"CALL SIGN CHARACTERS #3, #4 AND #5"	§2.2.4.5.4.2
	"CALL SIGN CHARACTERS #6, #7 AND #8"	§2.2.4.5.4.2
Encode as UNKNOWN	"EMERGENCY/PRIORITY STATUS"	§2.2.4.5.4.4
Encode as TWO	"UAT MOPS VERSION"	§2.2.4.5.4.5
Set per requirements of §3.2.1.1.1.4.1	"SIL"	§2.2.4.5.4.6

Encoding	TIS-B Message Field	DO-282B Reference
The 6 LSBs of the MSO selected for this TIS-B Message	"TRANSMIT MSO"	§2.2.4.5.4.7
Set per requirements of §3.2.1.1.1.4.1	"SDA"	§2.2.4.5.4.8
Encoded consistent with DO-282B §2.2.4.5.4.9	"NAC_P"	§2.2.4.5.4.9
Set per the Velocity Accuracy determined for a target's TIS-B track as identified in §3.2.1.1.1.4.3	"NAC_V"	§2.2.4.5.4.10
Always encode as ZERO	"NIC_{BARO}"	§2.2.4.5.4.11
Always encode as: - CDTI Traffic Display Capability: NO - TCAS/ACAS Installed and Operational: YES	"CAPABILITY CODES"	§2.2.4.5.4.12
Always encode as ALL ZERO	"OPERATIONAL MODES"	§2.2.4.5.4.13
Always encode as ZERO	"TRUE/MAG"	§2.2.4.5.4.14
Always encode as ONE	"CSID"	§2.2.4.5.4.15
Set per requirements of §3.2.1.1.1.4.1	SIL Supplement	§2.2.4.5.4.16

3.2.2.2.3 UAT FIS-B Message Generation

The UAT Ground Uplink Message is a general purpose mechanism used primarily for the uplink of FIS data. Each Ground Uplink Message contains a 432 byte payload field. The Ground Uplink Message payload is composed of an eight-byte UAT-Specific Header, followed by 424 bytes of Application Data.

a. The UAT Ground Uplink Message **shall [E093]** be broadcast by the Transmit Function per the format described in RTCA/DO-282B §2.2.3.2.

Note: *§2.2.3.2 of DO-282B describes all the characteristics of the UAT Ground Uplink Message.*

b. If the Transmit Function cannot start the transmission of the FIS-B Message in accordance with the latency requirements of §3.3.3.2, the FIS-B Message **shall [E094]** be discarded and reported per §3.2.2.2.6.

3.2.2.2.3.1 UAT-Specific Header

The UAT-Specific Header is an 8-byte field that contains information on the location of the broadcasting Ground Station, the time slot used to send the present message, validity flags for position, time, and application data, and other fields as described in RTCA/DO-282B §2.2.3.2.2.

a. The Transmit Function **shall [E095]** populate the constituent fields of the UAT-specific header appropriate for each Ground Uplink Message transmitted.

3.2.2.2.3.2 Application Data

The Application Data is a fixed-length field of 424 bytes. The Application Data consists of one or more Information Frames, and always consists of an integral number of bytes.

a. The Transmit Function **shall [E096]** encode information in the Application Data per §3.4.4.4.

Note: *When Information Frames do not fully occupy the Application Data field, the unused portion is zero filled. When encountered by the frame parsing logic,*

the zero fill portion will appear as a frame of zero bytes in length or an incomplete frame if less than 2 bytes remain. This would be the indication to the parsing logic that the last frame has been found.

b. The Transmit Function **shall [**E097] zero-fill any remaining unused portion of the Application Data field (i.e., all bits set to ZERO).

3.2.2.2.4 UAT Media Access

3.2.2.2.4.1 Overview

Figure 3-1 illustrates the message timing structure called a UAT frame. A UAT frame is one second long and begins at the start of each UTC second. Each UAT frame is divided into two segments:

- The Ground Segment in which UAT Ground Uplink Messages are broadcast in one or more time slots;
- The ADS-B Segment in which UAT ADS-B and TIS-B Messages are broadcast.

Guard times are incorporated between the segments to allow for signal propagation and timing drift. The UAT frame contains 3952 Message Start Opportunities (MSOs) that are spaced at 250μs intervals. This spacing represents the smallest time increment used by UAT for scheduling message transmissions, and each transmission must start only at a valid MSO.

Note: *The MSO concept was established primarily to govern the transmission protocol used by UAT avionics. The MSO serves to constrain the pseudorandom transmit time to a finite number of time synchronized possibilities spaced evenly throughout the allowed UAT ADS-B Message transmission interval (i.e., ADS-B segment). Using a transmission protocol constrained to a set of synchronized MSOs as opposed to a totally random approach allows a receiver to infer the precise time of transmission, thus allowing a measurement of the propagation time of a UAT Message. For consistency, the same MSO framework is used to define the time slots used for transmission of UAT Ground Uplink Messages. The ground segment contains 32 transmission time slots, each consisting of 22 MSOs.*

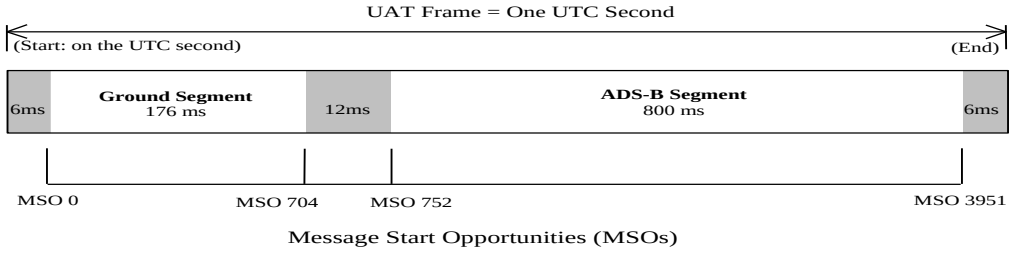


Figure 3-1. UAT Frame

Notes for Figure 3-1:

1. Shaded segments represent guard times for signal propagation and timing drift (not to scale).

2. *When the last MSO is selected for the transmission of a UAT ADS-B Message, part of a transmission (20 microseconds for a Basic UAT Message and 180 microseconds for a Long UAT Message) will occur within the final guard interval of 6 milliseconds.*

3. *As shown in* Figure 3-1*, 176 milliseconds in each 1-second UAT frame are devoted to UAT Ground Uplink Message transmissions, and 800 milliseconds are devoted to UAT ADS-B Message transmissions. MSOs start at the end of the initial 6 milliseconds guard time, are spaced at 250 microsecond intervals, and are numbered sequentially from 0 through 3951. In the 12 milliseconds guard-time between the ground segment and the ADS-B segment no messages are transmitted, bringing the total of MSOs available to 3904.*

3.2.2.2.4.2 Relationship of the MSO to the UAT Modulated Data

a. The optimum sample point of the first bit of the UAT synchronization sequence at the antenna terminal of the UAT equipment **shall [E108]** occur at T_{TX} microseconds after the 1 second UTC epoch according to the following formula:

$$\text{TTX (microseconds)} = 6000 + (250*\text{MSO})$$

where the value "6000" accounts for the initial guard interval (see Figure 3-1), within ±500 nanoseconds.

Notes:

1. *A definition of the UAT optimum sample point is provided in §3.1.*
2. *Referencing this measurement to the optimum sampling point is convenient since this is the point in time identified during the synchronization process.*

3.2.2.2.4.3 UAT TIS-B Messages

a. The Transmit Function **shall [E105]** always transmit TIS-B Message each on an even numbered MSO.

b. The Transmit Function **shall [E106]** transmit TIS-B Messages within the ADS-B Segment of the UAT frame.

c. The Transmit Function **shall [E107]** either select completely different MSOs or the MSOs selected have no correlation.

3.2.2.2.4.4 UAT Ground Uplink Messages (FIS-B)

3.2.2.2.4.4.1 Transmission Time Slots

a. The Transmit Function **shall [E098]** establish 32 Transmission Time Slots for transmission of Ground Uplink Messages as defined in Table 3-4.

Table 3-4. Transmission Time Slot Definition for the UAT Ground Segment

Slot ID #	Transmission Time Slot Span		Slot ID #	Transmission Time Slot Span	
	Starting MSO	Ending MSO		Starting MSO	Ending MSO
1	0	22	**17**	352	374
2	22	44	**18**	374	396
3	44	66	**19**	396	418
4	66	88	**20**	418	440
5	88	110	**21**	440	462
6	110	132	**22**	462	484
7	132	154	**23**	484	506
8	154	176	**24**	506	528
9	176	198	**25**	528	550
10	198	220	**26**	550	572
11	220	242	**27**	572	594
12	242	264	**28**	594	616
13	264	286	**29**	616	638
14	286	308	**30**	638	660
15	308	330	**31**	660	682
16	330	352	**32**	682	704

Note: *MSOs represent discrete points in time.*

3.2.2.2.4.4.2 Transmission Time Slot Rotation and "Data Channels"

a. Transmission Time Slot resources assignable to the Transmit Function **shall [E099]** be made on a continually shifting basis.

Note: *This assignable resource will be subsequently referred to as a "Data Channel" to distinguish it from a Transmission Time Slot.*

b. The Transmission Time Slot used for a given data channel **shall [E100]** increment by 1 Time Slot per second according to the following rule:

Transmission Time Slot = 1+ (Data Channel number +UTC second -1) mod 32

The Data Channel number and Transmission Time Slot number shall [E101] be at midnight UTC time and every 32 seconds thereafter (see

c. Figure 3-2).

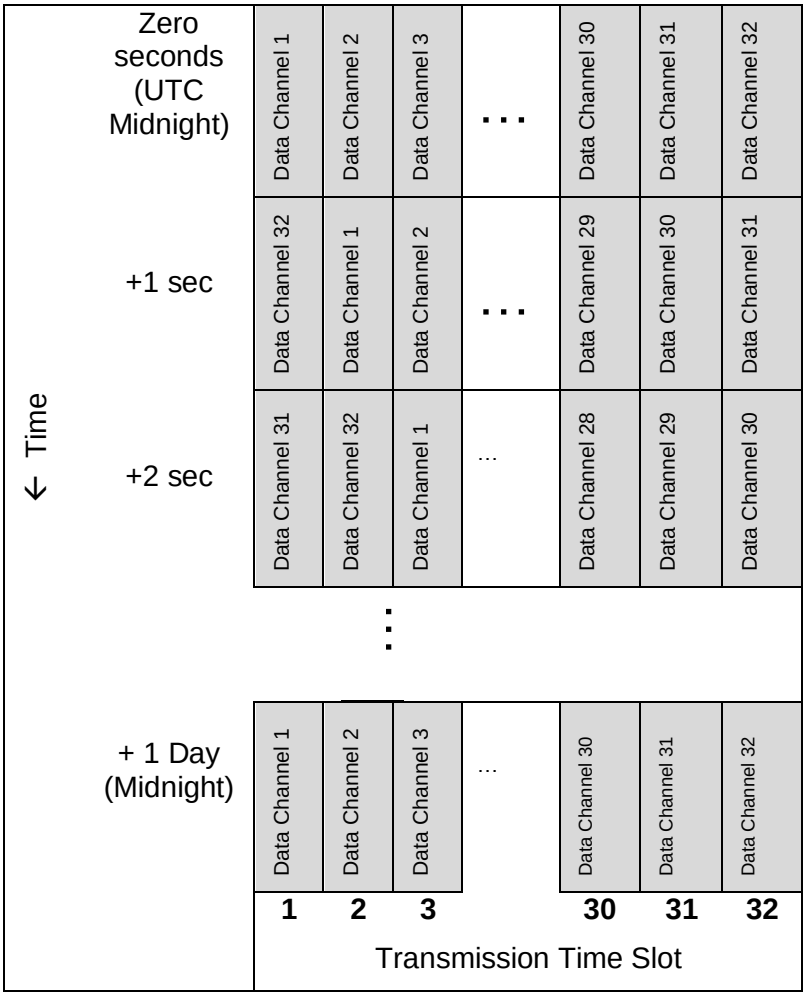


Figure 3-2. Relationship of "Data Channel Numbers" to Transmission Time Slot Numbers

Notes:

1. *The reason for the Transmission Time Slot rotation is to make aircraft reception of Ground Uplink Messages robust in the presence of time synchronized sources of interference in the band.*
2. *With the addition of a leap second the Transmit Function does not shift slots from the previous second. With the subtraction of a leap second, a shift of slots is omitted.*

3.2.2.2.4.4.3 Transmission of UAT Ground Uplink Message

a. Ground Uplink Message transmissions **shall [E102]** begin at the start of the Transmission Time Slot determined by the next available assigned Data Channel.

b. The UAT Transmit Function **shall [E103]** be configurable to select from 1 to 5 of the 32 Ground Uplink Channels in any combination with the constraint that a gap of 4 channels exists between selected channels (see §3.2.2.2.4.4.2).

Note: *The duration of a Ground Uplink Message is approximately 1.5 milliseconds less than the Transmission Time Slot duration. This additional time provides*

a propagation guard time when adjacent Data Channels (Transmission Time Slots) are assigned to transmission sites with common line of sight to the same aircraft.

c. The Transmit Function **shall [E104]** transmit a Ground Uplink Message every second for each specified Data Channel.

Note: *Regardless of the availability of application data, the Ground Uplink Message contains location and timing data useful to the aircraft/vehicle.*

3.2.2.2.5 UAT TIS-B / ADS-R Service Status Message

There are no UAT link-specific requirements to support TIS-B / ADS-R Service Status. This is supported as payload in UAT Ground Uplink Messages. See §3.4.4.6 for interface requirements.

3.2.2.2.6 Transmit Status Reporting

3.2.2.2.6.1 TIS-B

The requirements in this section apply to both the 1090ES and UAT Transmit Functions.

a. The Transmit Function **shall [E109]** maintain a count of discarded TIS-B Messages.

b. The Transmit Function **shall [E110]** maintain a count of transmitted TIS-B Messages.

c. The discarded TIS-B Message count and the transmitted TIS-B Message count **shall [E111]** be included in the Transmit Function status.

d. The discarded TIS-B Message count and the transmitted TIS-B Message count **shall [E112]** be reset upon generation of the Transmit Function status.

3.2.2.2.6.2 FIS-B

The requirements in this section apply to only the UAT Transmit Function.

a. The UAT Transmit Function **shall [E113**] maintain a count of discarded FIS-B Messages.

b. The UAT Transmit Function **shall [E114**] maintain a count of transmitted FIS-B Messages.

c. The discarded FIS-B Message count and the transmitted FIS-B Message count **shall [E115**] be included in the UAT Transmit Function status.

d. The discarded FIS-B Message count and the transmitted FIS-B Message count **shall [E116**] be reset upon generation of the UAT Transmit Function status.

3.2.3 Maintenance Processing

The Maintenance Processing must provide the government with sufficient information to independently assess the service performance. The following requirements address service provision in a Service Volume and the health of the Transmit and Receive Functions.

3.2.3.1 Maintenance Data Sets

The Maintenance Processing will send broadcast services data and status data to the FAA to enable the FAA to verify the performance of the services being provided by the service provider. These data will include, but are not limited to, real-time data sent to and received

from users, alerts, alarms, and system performance parameters. Table 3-5 summarizes the maintenance data sets that are needed by the FAA.

a. The Maintenance Processing data sets **shall [E117]** be reported to the FAA in accordance with Table 3-5.

Note: *The interface requirements for these data are in §3.4.2.*

Table 3-5. Maintenance Data Sets

Data Set	Data Format	Update Interval
Service Status Report	CAT023	Every 5 sec ±2 sec
ADS-B Test Report	CAT033 (ADS-B)	Configurable (see §3.2.3.1.3)

Note: *The Service Status Report includes Transmit/Receive Function and Service Status mode information (§3.2.3.1.1) and monitored parameter states (§3.2.3.1.2) among other information.*

3.2.3.1.1 Mode Reporting

The Transmit/Receive Function and TIS-B/FIS-B Service **shall [E119]** be in one of the following modes:

- Online—operational with no alarms;
- Degraded—a mode of service operation in which part of the service is not performing to standards;
- Offline—non operational with alarms;
- Test—being evaluated prior to introduction into the national air traffic system;
- Not Offered—service not provided in this Service Volume

a. When in Online Mode, the Maintenance Processing **shall [E120]** continue status reporting with an indication that the Transmit/Receive Function is in the Online Mode.

b. When in Degraded Mode, the Maintenance Processing **shall [E3199]** continue status reporting with an indication that either the TIS-B and/or FIS-B Service is in the Degraded Mode.

c. When in Offline Mode, the Maintenance Processing **shall [E121]** continue status reporting with an indication that the Transmit/Receive Function is in the Offline Mode.

d. When in Test Mode, the Maintenance Processing **shall [E122]** continue status reporting with an indication that the Transmit/Receive Function is in the Test Mode.

e. When either the TIS-B or FIS-B Service is not offered in a Service Volume, the Maintenance Processing **shall [E123]** indicate in the Service Status Report that the particular service is Not Offered.

f. When in the Offline Mode, the Transmitter/Receiver Function **shall [E3226]** discontinue TIS-B/FIS-B Message transmission.

3.2.3.1.2 Monitored Parameter State Reporting

a. The Maintenance Processing **shall [E124]** report all parameters to the FAA in the Service Status Report (i.e., CAT023).

b. A Maintenance Processing performance parameter **shall [E125]** be in one of the following states:

- Normal—unit or service online and operating within specified performance parameters;
- Alert—a maintenance action is required, but service is still being provided within specified performance parameters.
- Alarm—a critical fault has been detected and the unit or service is offline.

c. A Maintenance Processing monitored parameter **shall [E126]** change state when the monitored parameter value transitions from a value within one range to a value within another range, if applicable for the parameter.

d. The Maintenance Processing **shall [E127]** determine the change between normal, alert and alarm states of a monitored parameter by comparing data to pre-established thresholds.

e. The Maintenance Processing **shall [E128]** automatically declare a return to normal event when a monitored parameter that was previously outside the normal range changes to a value that is inside the normal range.

f. The Maintenance Processing **shall [E3235]** automatically declare an alert event for equipment when redundant equipment elements are faulted or unavailable.

g. The Maintenance Processing **shall [E129]** automatically declare an alarm event when a monitored parameter and/or element status changes to a value crossing from normal or alert to the alarm range.

h. The Maintenance Processing **shall [E130]** not generate spurious alarm events in any state or transition.

i. The Maintenance Processing **shall [E131]** report a monitored parameter state change event once per occurrence.

j. Each Alarm **shall [E3227]** be reported in the next periodic Service Status Report.

Note: *Alarm reporting is to persist for the duration of the failure condition (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

3.2.3.1.3 Service Volume Message Counts

a. The ADS-B Service **shall [E3200]** maintain counts of the following:

- ADS-B Messages Received (total including all UAT receivers)
- ADS-B Message Discards
- TIS-B Messages Transmitted (total including all UAT transmitters)
- TIS-B Message Discarded (total including all UAT transmitters)

b. The ADS-B Service **shall [E3201]** include all counts in the Service Status Report.

c. The ADS-B Service **shall [E3202]** reset all counts upon generation of the Service Status Report.

3.2.3.1.4 ADS-B Test Report

The ADS-B Test Report is a synthetic ADS-B Message generated by the Receive Function of the data link that is passed through the entire message-receive chain to include the antenna, cabling and receiver. This report is intended to provide confidence that the receiving system is operating properly.

a. The Receive Function **shall [E132]** support an internally generated ADS-B Test Message with sufficient information to monitor basic receiver performance on a continuous basis in the absence of traffic.

b. The ADS-B Test Message **shall [E133]** be generated at a configurable rate from every 1 seconds to 12 seconds ±1 second.

c. The ADS-B Test Message **shall [E134]** be inserted at the Receiver Function input.

d. Reserved.

Note: *Requirement E135 was moved to 3.2.3.1.4.2.*

e. The level of the ADS-B Test Message present at the Receive Function **shall [E136]** be in the range of 3-9 dB above the design level required to achieve a rate of successful message reception of 90% or better in the absence of interference for UAT and in the range of 11-17 dB above the design level required to achieve a rate of Successful Message Reception of 90% or better in the absence of interference for 1090.

Note: *Change in signal level made per Contract Letter ADS-B 0123 dated October 1, 2009.*

f. The signal level of the ADS-B Test Message present at the Receive Function input **shall [E137]** not exceed -60 dBm.

Note: *The signal may be injected at the receiver or the antenna.*

g. The position of the radio station as determined by the most recent measurement from the GNSS sensor associated with the ADS-B receive function **shall [E5231]** be encoded in the LATITUDE and LONGITUDE fields of the ADS-B Test Report based on the configured GNSS Position Coast Time.

Note: *In this requirement, GNSS is considered synonymous with GPS (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

h. The GNSS Position Coast Time **shall [E5267]** be configurable from 0 to 3601 seconds in 1 second increments with a default value of 60 seconds.

i. When the GNSS Position Coast Time is set to 3601 seconds, the GNSS measured position **shall [E5268]** be coasted indefinitely.

j. When the GNSS Position Coast Time is set to 0 seconds, no position coasting **shall [E5275]** occur.

k. If the GNSS Position Coast Time is greater than 0 AND the GNSS measured position age is greater than this GNSS Position Coast Time, but less than 3601, the ADS-B service **shall [E5269]** encode the LATITUDE and LONGITUDE fields as ALL ZEROS in the ADS-B Test Report.

l. The probability of the GNSS sensor providing a measured position for the radio station within GNSS Position Coast Time' seconds of the time that the test message with this position information is reported **shall [E5232]** be 99% or greater.

3.2.3.1.4.1 1090ES

a. The 1090ES Receive Function **shall [E138]** generate an ADS-B Test Message to verify operation of the Receive Function.

b. The ADS-B Test Message **shall [E139]** be a 1090ES ADS-B Airborne Position Message composed according to Table 3-6.

Table 3-6. Payload Composition of 1090ES ADS-B Test Message

Encoding	ADS-B Message Field	DO-260B Reference
18	"DOWNLINK FORMAT" (DF)	§2.2.3.2.1.1
"1" (non-ICAO Address)	"CODE FORMAT" (CF)	§2.2.3.2.1.3
Configuration item	"ADDRESS" (AA)	§2.2.3.2.1.5
"18" Airborne Position	"TYPE CODE"	§2.2.3.2.3.1
"0"	"SURVEILLANCE STATUS"	§2.2.3.2.3.2
"0"	"NIC Supp"	§2.2.3.2.3.3
Code for "Data Unavailable"	"ALTITUDE"	§2.2.3.2.3.4
"0"	"TIME" (T)	§2.2.3.2.3.5
Alternates between "0" and "1" on successive ADS-B Test Messages to provide "even" and "odd" CPR encoding of LAT/LONG	"CPR FORMAT"	§2.2.3.2.3.6
GNSS Measured Position: (The reported Latitude is CPR encoded based on the "even" or "odd" CPR Format value.)	"LATITUDE"	§2.2.3.2.3.7
GNSS Measured Position: (The reported Longitude is CPR encoded based on the "even" or "odd" CPR Format value.)	"LONGITUDE"	§2.2.3.2.3.8
24 bit Parity field as per §3.2.3.2.2.2.7.2	"PARITY/INTERROGATOR ID" (PI)	§2.2.3.2.1.7

Note: *In Table 3-6, GNSS is considered synonymous to GPS (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

d. ADS-B 1090-ES Test Reports **shall [E3246]** be generated based on a state machine maintained for each 1090 receiver channel based on a ADS-B 1090-ES Test Report interval that is adaptable from 2-30 seconds in 2 second increments.

e. The state machine for each 1090 receive channel **shall [E3247]** issue an ADS-B 1090-ES Test Report during the report interval if at least one ADS-B Test Message is successfully received within that interval.

f. The ADS-B 1090-ES Test Report interval **shall [E3248]** always be greater than the ADS-B 1090-ES Test Message generation interval within each 1090 receive channel.

Note: *The above requirements are added per contract letter ADS-B 0114 dated 15 July 2009.*

3.2.3.1.4.2 UAT

a. The UAT Receive Function **shall [E140]** generate an UAT ADS-B Test Message to verify operation of the Receive Function.

b. The ADS-B Test Message **shall [E141]** not conflict with any ADS-B Message reception during the ADS-B segment of the UAT frame.

c. The ADS-B Test Message **shall [E142]** be a UAT Basic ADS-B Message composed according to Table 3-7.

Table 3-7. Payload Composition of UAT ADS-B Test Message

Encoding Used	ADS-B Message Field	DO-282B Reference
ZERO ("Basic" ADS-B message)	"PAYLOAD TYPE CODE"	§2.2.4.5.1.1
"5" (Code for "Fixed ADS-B Beacon")	"ADDRESS QUALIFIER"	§2.2.4.5.1.2
Configuration item ADS-B_TEST_MSG_ADDR	"ADDRESS"	§2.2.4.5.1.3
GNSS Measured Position	"LATITUDE" and "LONGITUDE"	§2.2.4.5.2.1
ZERO	"ALTITUDE TYPE"	§2.2.4.5.2.2
All ZEROS (Code for "Information not available")	"ALTITUDE"	§2.2.4.5.2.3
All ZEROs	"NIC"	§2.2.4.5.2.4
All ZEROs	"A/G STATE"	§2.2.4.5.2.5
All ZEROs	"HORIZONTAL VELOCITY"	§2.2.4.5.2.6
All ZEROs	"VERTICAL VELOCITY"	§2.2.4.5.2.7
All ZEROs	"UTC"	§2.2.4.5.2.8
All ZEROs	"Reserved"	§2.2.4.5.2.9

Note: *In Table 3-7, GNSS is considered synonymous with GPS (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

e. ADS-B UAT Test Reports **shall [E5233]** be generated based on a state machine maintained for each UAT receiver based on a ADS-B UAT Test Report interval that is adaptable from 2-30 seconds in 1 second increments.

f. The state machine for each UAT receive channel **shall [E5234]** issue an ADS-B UAT Test Report during the report interval if at least one ADS-B UAT Test Message is successfully received within that interval.

g. The ADS-B UAT Test Report interval **shall [E5235]** always be greater than the ADS-B UAT Test Message generation interval within each UAT receive channel.

Note: *These requirements establish a state machine for ADS-B UAT Test Report to provide more consistent Test Report outputs during periods of interference on 978MHz.*

3.2.3.1.5 Processing Requirements for Generating the CAT 033 ADS-B Test Report

A final step in the generation of ADS-B Test Reports requires setting of the following CAT 033 report elements as specified below and in Table 3-8.

a. The TOA field in FRN 4 of the ADS-B Test Target Report **shall [E5242]** be set to the time that the test report is transmitted from the state machine to the SDP.

b. The NAC_P field in FRN 6 of the CAT 033 Report for the Test Target **shall [E3249]** be based upon an error estimate of the measured radio station position in comparison to the surveyed position for the Radio Station (RS) according to the algorithm in Appendix A of the Automatic Dependent Surveillance – Broadcast (ADS-B) / ADS-B Rebroadcast (ADS-R) critical Services Specification.

c. The NIC field in FRN 6 of the CAT 033 Report for the Test Target **shall [E3250]** be based upon an error estimate of the measured radio station position in comparison to the surveyed position for the RS plus an additional error component that is based upon the accuracy of the surveyed position according to the algorithm in Appendix A of the Automatic Dependent Surveillance – Broadcast (ADS-B) / ADS-B Rebroadcast (ADDS-R) critical Services Specification.

d. The UTC field in FRN 6 of the CAT 033 Report for the Test Target **shall [E3252]** be set to 1 when the GPS Timing source for the RS is Operational.

e. The UTC field in FRN 6 of the CAT 033 Report for the Test Target **shall [E3253]** be set to 0 when the GPS Timing source for the RS is not operational or failed.

f. The NAC_V field in FRN 6 of the Cat 033 Report for the Test Target **shall [E3254]** be set to 1.

Note: *The above requirements are added per Contract Letters ADS-B 0118 dated 2 September 2009 and ADS-B 0122 dated 23 September 2009.*

Table 3-8. Test Message Mapping to CAT 033 ADS-B Report

ADS-B Message >>>>	**FAA CAT 033 v3 Report**		
Source for Cat 033 Report Data	**FRN**	**Bit #**	**FRN Report Field**
Inserted by Service Provider. Identification of the Primary Service Volume for the SDP.	1	16-1	Service Volume Identifier
Bit 6 (Version Status): Established by the FAA CAT033 VERSION_STATUS configuration item Bits 5-1 (Version Number): Fixed field value of "THREE"	2	6-1	FAA Cat 033Version #
Set to TWO	3	7-5	Link Version #
Set to reflect which test message is being reported (i.e., UAT or 1090ES)	3	4-1	Link Technology Indicator
Set to the time that the Test Target Report is transmitted from the state machine	4	32-1	Time of Applicability
Reported per standard rules for the link based on reception of Test Message	5	28	Duplicate Address Flag
Reported per standard rules for the link based on reception of Test Message	5	27-25	Address Qualifier
Reported per standard rules for the link based on reception of Test Message	5	24-1	24 bit ICAO Address

ADS-B Message >>>>	**FAA CAT 033 v3 Report**		
Source for Cat 033 Report Data	**FRN**	**Bit #**	**FRN Report Field**
Set per the operational status of the GPS timing source for the radio station	6	24	UTC
Reported per standard rules for the link based on reception of Test Message	6	23-20	NIC
Set to "0" (per hour basis)	6	19	SIL Supplement
Set to "3" (10^{-7}/hr)	6	18-17	SIL
NAC_P computed per the algorithm of SBS Critical Specification Appendix A	6	16-12	NAC_P
Set to ZERO	6	11	Reserved
Based on test status of SBSS	6	10	Service in Test Mode
Set to "0" (no enhanced validation available)	6	9	Enhanced Validation
Set to "3" (determined to be valid)	6	8-7	Validation
Set to "1" (<10 m/sec)	6	6-3	NAC_V
Set to "0" (altitude NOT cross checked)	6	2-1	NIC_{BARO}
Reported per standard rules for the link based on reception of Test Message	7	48-1	Latitude/ Longitude
Reported per standard rules for the link based on reception of Test Message	8	16-15	Resolution
Reported per standard rules for the link based on reception of Test Message	8	14-1	Pressure Altitude
Set to codes for "Data not available"	9	39	VV Src
	9	38	SO
	9	37	NS
	9	36-25	N/S Velocity
	9	24	EW
	9	23-12	E/W Velocity
	9	11	UD
	9	10-1	Vertical Rate
FRN 10-17 NOT reported			
Computed per paragraphs 3.2.1.1 f and 3.2.1.2d of the SBS CS Specification	18	32-1	Time of Message Reception
FRN 19-20 NOT reported			
Always set to "00" (unknown) for V1	21	14-13	Geometric Vertical Accuracy
Report bits 12-11 always set to "00" respectively for V1.	21	12-11	NIC 6 Supplement
Set to "2" (MAJOR Hazard Level)	21	10-9	SDA
Set to "0" (unknown)	21	7-5	UAT Uplink Feedback

ADS-B Message >>>>	FAA CAT 033 v3 Report		
Source for Cat 033 Report Data	**FRN**	**Bit #**	**FRN Report Field**
Reported per standard rules for the link based on reception of Test Message	21	3-1	SQL

3.2.3.1.6 Monitoring ADS-B Test Reports

When M or greater reports out of N reporting intervals are missing for a given radio channel, all SVs associated with that radio channel **shall [E3255]** be set to a degraded state.

Note: *The values for M and N are set independently for UAT and 1090ES.*

3.3 Performance Requirements

The TIS-B/FIS-B Services performance requirements are presented in the following sections.

3.3.1 General Requirements

3.3.1.1 Expandability

a. The FIS-B Service **shall [E146]** be expandable to accommodate future products that may be requested by the FAA.

3.3.1.2 System Timing

The TIS-B/FIS-B Services will be considered unavailable if the timing source is not available to the system or its accuracy exceeds the allowable limit specified in this section. Transmission must cease to avoid stepping on other transmissions from ground stations and ADS-B aircraft/vehicles.

a. The TIS-B/FIS-B Services **shall [E147]** use a timing source referenced to UTC with an absolute timing accuracy relative to UTC of +/-500 nanoseconds or less.

b. The TIS-B/FIS-B Services **shall [E148]** not transmit either TIS-B or FIS-B messages if the UTC timing source is degraded or unavailable.

3.3.1.3 Service Ceiling

a. The TIS-B and FIS-B Service ceiling **shall [E5200]** be at least 24,000 feet for all service volumes.

Note: *This is a new requirement (reference FAA contract letter ADS-B 0015 dated December 18, 2007).*

3.3.2 TIS-B Service

3.3.2.1 Applications Supported

The TIS-B Service will support the following Surveillance and Broadcast Services applications:

- Enhanced Visual Acquisition,
- Airport Surface Situation Awareness.

3.3.2.2 TIS-B Service Management

a. Changes made to the TIS-B target filtering criteria **shall [E149]** be effected without taking the TIS-B Service Offline.

3.3.2.3 TIS-B Service Volume

The TIS-B Service Volume is the airspace within which users can expect to receive transmitted information on other proximate targets. However, since TIS-B Service depends on ground-based surveillance from either radar or multilateration systems. Therefore, the following requirements only apply in volumes where surveillance coverage from these systems exists.

a. The TIS-B Service **shall [E150]** transmit the minimum number of TIS-B Messages for all targets with operating transponders within Service Volume such that each aircraft/vehicle receives traffic information within 15 NM and within +/-3500 ft (terminal/en route SVs) or 5NM and within +/-2000 feet (surface SVs) of its position while meeting the update requirements in §3.3.2.11.4 and the 1090 MHz interference environment in §3.3.2.11.6.1. Excluded from this requirement are the TIS-B targets that have been designated for suppression by FAA policy or by one of the report filtering criteria in §3.2.1.1.2.

   Notes:

   1. *For terminal and en route SVs, the requirement above includes altitude filtering of +/-3500 feet relative to the TIS-B Client.*
   2. *For Surface SVs, TIS-B Clients that are below 2000 feet AGL or on the surface only need receive TIS-B for other targets from the surface to 2000 feet above the client.*

b. The TIS-B Service **shall [E151]** receive ADS-B throughout a TIS-B Service Volume.

c. The TIS-B Service **shall [E3236]** not uplink surface targets that are determined to be "on the ground" to aircraft operating in an En Route or Terminal Service Volume, but not a Surface Service Volume.

d. The TIS-B Service **shall [E3237]** uplink targets designated as "on the ground" in a Surface Service Volume to aircraft in the Surface Service Volume that are either airborne or "on the ground".

3.3.2.4 TIS-B / ADS-R Service Status

The service status indicates the availability of the TIS-B and ADS-R services to ADS-B In equipped aircraft.

a. The TIS-B Service **shall [E152]** provide each aircraft/vehicle operating within the Service Volume with a TIS-B / ADS-R Service Status indication at least once every 20 seconds with 95% confidence.

3.3.2.5 TIS-B Service Capacity

a. The TIS-B Service **shall [E153]** be capable of simultaneously processing received sensor data for all aircraft/vehicles with operating radar transponders or ADS-B transmitters within the Service Volume.

Note: *This requirement does not imply every received measurement will result in a TIS-B Message transmission.*

b. The TIS-B Service **shall [E154]** be capable of processing the following radar plots/targets density from each contributing radar system

- 1400 beacon targets containing any mix of Mode-S and ATCRBS (360 degrees) plus 300 uncorrelated search targets;
- 350 beacon targets plus 200 uncorrelated search targets distributed non-uniformly in a 90 degree azimuth quadrant;
- 100 beacon targets plus 100 uncorrelated search targets distributed non-uniformly in each of 2 contiguous 11.25 degree azimuth wedges;
- 32 beacon targets plus 32 uncorrelated search targets within a 2.4 degree azimuth wedge.

c. The TIS-B Service **shall [E155]** be capable of processing sensor reports on 200 aircraft/vehicles per second from each airport surface multilateration system.

d. The TIS-B Service **shall [E156]** be capable of simultaneously tracking at least 25,000 targets received from all surveillance systems feeding the TIS-B Service including ADS-B.

Note: *This requirement applies NAS wide rather than on any particular Service Volume.*

e. The TIS-B Service **shall [E157]** be capable of interfacing with and receiving sensor data from FAA designated sensors providing contributing coverage for the Service Volume.

Note: *As used in this requirement, radar sensor data is meant to include: search and beacon measurement reports, status reports, RTQC reports and sector mark reports. Multilateration sensor data includes both measurement or track reports and status reports.*

3.3.2.6 TIS-B Service Latency

TIS-B latency is the difference between the time of measurement of the source position data and the time of transmission of the TIS-B Message.

a. The delay for TIS-B Service processing of TIS-B data **shall [E158]** be less than 1.5 seconds as measured from the FAA Surveillance SDP (for surveillance data to the Service Provider) to the start of the TIS-B Message transmission.

Notes:

1. This requirement applies to services delivered to the airport surface, terminal airspace and en route airspace. The TIS-B MASPS allocates 3.25 s from sensor

measurement to TIS-B Message transmission. The expected maximum delay associated with getting target measurements from a radar sensor is 1.725 s, leaving the balance of time to the TIS-B Service.

2. *The latency requirement applies when operating at the TIS-B Service capacity (§3.3.2.5).*
3. *The latency requirement may be unachievable in cases where the source radar disorder is too large. It is assumed that all radars feeding the TIS-B Service will provide plots in azimuth order with a maximum disorder of 375 ms. Should the maximum disorder of the radar exceed this value, then the latency may exceed the 1.5 s of this requirement by the amount that the disorder exceeds the maximum 375 ms allocated to the radar disorder (reference FAA contract letter ADS-B 0043 dated March 27, 2008).*

3.3.2.7 TIS-B Update Interval

The TIS-B Service updates target position and velocity data based on surveillance measurement events and is therefore dependent on the availability of source sensors for new data. The following requirements apply only when sensor data is available to the TIS-B Service.

a. The TIS-B Service **shall [E160]** update each target's position and velocity data within a maximum update interval of 12.1 seconds for aircraft within a Service Volume designated as En Route.

b. The TIS-B Service **shall [E161]** update each target's position and velocity data within a maximum update interval of 6 seconds for aircraft within a Service Volume designated as Terminal.

c. The TIS-B Service **shall [E162]** update each target's position and velocity data within a maximum update interval of 2 seconds for aircraft/vehicle within a Service Volume designated on the airport surface.

3.3.2.8 TIS-B Information Integrity

a. The probability that TIS-B Service introduces an error into a TIS-B Message that is broadcast **shall [E163]** not exceed 10^{-5} per Message.

Note: *This integrity requirement is applicable between data received at the surveillance SDP to the Tracking Function input; and between the Tracking Function output to the TIS-B air interface. This requirement does not apply internally to the Tracking Function because the Tracking Function is required to change the data to perform its function (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*

3.3.2.9 TIS-B Service Availability

The TIS-B Service is a safety-essential service as classified by the FAA. The availability of the TIS-B Service specified in this section is limited to the Service Provider system. It includes the ADS-B Receive Function, but does not include FAA surveillance sensors providing sensor data.

a. The service availability for TIS-B Service **shall [E164]** be at least 0.999.

Note: *Requirement E165 deleted (reference FAA contract letter ADS-B 0007 dated November 5, 2007).*

3.3.2.10 Broadcast Services Processing

This section provides the track initiation, track accuracy and track reliability requirements for the TIS-B Service in the terminal and en route service volumes. Appendix A provides the corresponding verification scenarios and describes scenarios for verification of the accuracy and reliability performance requirements.

For TIS-B Service in the surface Service Volume, the ASDE-X will provide tracked reports and meet the requirements of FAA-E-2942 Section 3.5.3. The service provider should use the track data from the ASDE-X that is assumed to meet these requirements, but TIS-B performance must not be degraded when using the tracks from the ASDE-X for TIS-B uplink as verified by comparing track inputs from ASDE-X with TIS-B reports.

Note: *Based on this clarification, the TIS-B Service does not need a surface tracker. Rather, a) the TIS-B Service will receive ASDE-X track data for any target on or near the surface; and b) upon receiving ASDE-X track data for a target, the TIS-B Service will broadcast (as necessary to meet update intervals) TIS-B messages containing these exact ASDE-X track positions (extrapolated from the TOA when velocity is present) (Reference FAA contract letter ADS-B 0015 dated December 18, 2007).*

3.3.2.10.1 TIS-B Track Initiation

a. The TIS-B Service **shall [E166]** have a TIS-B track initiation delay that is less than or equal to: 2 measurements for ADS-B; 3 measurements for discrete beacon-reinforced and Wide Area Multilateration targets (95%); 5 measurements for non-discrete beacon-reinforced targets (95%); and equal to 5 consecutive measurements for beacon-only targets without 2nd-sensor confirmation (95%).

Notes:

1. *This effectively puts a bounding constraint on the track initiation time period. The Probability of Detection (Pd) is assumed to be 1 for all sensors used in the scenarios with which this requirement will be tested.*
2. *Beacon-reinforced targets may not be real. It is quite possible for beacon false-targets to have radar reinforcement via radar clutter.*
3. *Wide Area Multilateration surveillance inputs utilizing CD-2 from NAS providers will be available at selected locations such as Juneau Alaska.*
4. *Wide Area Multilateration requires three measurements to initiate track (with 95% probability) because of the complexities created by the following: a. the CD-2 WAM format does not permit inclusion of the ICAO address, and b there is quantization error and timing uncertainty created when using the CD-2 WAM format.*

3.3.2.10.2 TIS-B Track Accuracy

The TIS-B Service performance requirements for airborne track accuracy (i.e., for position, heading, speed, and altitude) have been derived from operational FAA tracking systems.

The airborne accuracy requirements are specified for two principal sensor configurations of three sensors, four types of simulation flight paths (radial, tangential, turning, and linearly accelerating), four speeds, and different ranges from the central sensor. The sensor types selected for these requirements are long and short range radars with ATCBI-5 with error characteristics as shown in Appendix A, Table A-1.

Table 3-9 contains the performance requirements for both the short range and long range cases.

In Table 3-9, when two values are provided in a cell, the requirement must be interpreted as follows. The value in parentheses represents the requirements for the track when multiple sensors contribute to the track. The value outside the parentheses is the requirement for the single sensor track. Under the "range" column the case number provided in parentheses indicates which flight scenario, defined in Appendix A, Figures A-3 and A-4, provided the multisensor track requirements. The case numbers are assigned to the radials with respect to the central sensor and are used (sometimes in conjunction with the range parameter) to identify a specific flight scenario within each figure. When a speed range is specified in Table 3-9, the accuracy requirement represents the worst case performance permitted over the range of speeds. Scenarios that contain both steady state and transient trajectories should be segregated when computing statistical results when testing accuracy requirements.

Table 3-9. Requirements for Track Accuracy

Central Sensor	Flight Path	Speed (kts)	Rng. (NM)	Position Error (NM)		Heading Error (°)		Speed Error (kts)	
				Peak RMS Position Error	Mean Position Error	Peak RMS Heading Error	Mean RMS Heading Error	Peak RMS Speed error	Mean RMS Speed error
Short Range Sensor (ATCBI-5)	Linear Acceleration†	650->250->650	Center	0.4		13		37	
			All	0.6		19		60	
	180°	100	48	0.4 (0.4+)		97 (70+)		20 (10+)	
		250-700	(case 3)	0.4 (0.4+)		32 (30+)		20 (10+)	
	Radial	100	50		0.1 (0.1#)		7 (2#)		5 (4#)
	Tangential	100	(case 2)		0.1 (0.1#)		5 (5#)		9 (7#)
Long Range Sensor (ATCBI-5)	Linear Acceleration†	650->250->650	n/a	0.5		13		60	
	90° turn	100-400	84 (case 2)	1.1 (0.4+)		70 (38+)		60+	
		700		1.8 (0.4+)		34 (14+)		54 (14+)	
	Radial	100-700	100		0.5				11
	Tangential	100-700	80		0.4		10		15

Notes for Table 3-9:

1. *Table symbology:*

   † These scenarios were generated and the values in this table are based on best engineering judgment.

   + These multisensor cases use existing scenarios (because they are not spatially distributed).

   # These multisensor cases use a single target path from existing scenarios and are run multiple times through a standalone filter algorithm, with independent noise generated each time (i.e., run Monte Carlo iterations).

2. *All sensor measurements include a 0.1 measurement standard deviation uncorrected registration error in both range and azimuth (e.g., for sensor with range accuracy, σ_r*

= 125 feet the bias in range, b_r, would be 12.5 feet, and bearing accuracy, σ_θ =0.25 degrees, the bias in azimuth, b_θ, would be 0.025 degrees). The bias error can be either added to the truth data as is done for the random error range and azimuth.

3. *The requirements in* Table 3-9 *do not apply to targets operating on the airport surface.*

3.3.2.10.2.1 Horizontal Position

a. The TIS-B Service **shall [E167]** provide target data with horizontal position accuracy better than 30 meters (98 feet) with a 95% probability for aircraft on the airport surface.

b. The TIS-B Service **shall [E168]** achieve steady state position accuracy for targets according to the requirements in Table 3-9 under the "mean position error" column for the specified tangential and radial scenarios.

c. The TIS-B Service **shall [E169]** achieve a turn/linear acceleration maneuver position accuracy for targets according to the requirements in Table 3-9 under the "peak rms position error" for the specified linear acceleration/turn scenarios.

3.3.2.10.2.2 Horizontal Velocity

a. The TIS-B Service **shall [E170]** generate and maintain tracks for all targets at a range of speed spanning at least 20 to 700 knots.

b. The TIS-B Service **shall [E171]** achieve steady state speed accuracy for targets according to the requirements in Table 3-9 under the "rms speed error" column for the specified tangential and radial scenarios.

Note: *In a multisensor environment, it is assumed that at least one contributing sensor is meeting the required accuracy prior to and including the sampling interval.*

c. The TIS-B Service **shall [E172]** achieve a turn/linear acceleration maneuver speed accuracy for targets according to the requirements in Table 3-9 under the "peak rms velocity error" for the specified linear acceleration/turn scenarios.

3.3.2.10.2.3 Heading/Ground Track

a. The TIS-B Service **shall [E173]** achieve a steady state ground track heading accuracy for targets according to the requirements in Table 3-9 under the "rms heading error" column for the specified tangential scenarios.

Note: *In a multisensor environment, it is assumed that at least one contributing sensor is meeting the required accuracy prior to and including the sampling interval.*

Note: *Requirement changed to address Waiver 00067-W-004 date 20 October 2009.*

b. The TIS-B Service **shall [E174]** achieve a turn/linear acceleration maneuver ground track (heading) accuracy for targets according to the requirements in Table 3-9 under the "peak rms heading error" for the specified linear acceleration/turn scenarios.

3.3.2.10.2.4 Vertical Position

a. The TIS-B Service **shall [E175]** provide target data with altitude accuracy of 45 meters (147.6 feet) with a 95% probability in either straight and level flight or in an altitude maneuver.

3.3.2.10.2.5 Vertical Velocity

a. The TIS-B Service **shall [E176]** achieve altitude speed accuracies for beacon targets in straight and level flight of <=387 feet/minute.

b. The TIS-B Service **shall [E177]** achieve altitude speed accuracies for beacon targets in an altitude maneuver of <=422 feet/minute.

c. The TIS-B Service **shall [E178] not** use altitude data resulting in the altitude speed exceeding 6000 feet/minute.

3.3.2.10.3 TIS-B Track Reliability

3.3.2.10.3.1 False Track Rate

False tracks are characterized by dual tracks, split tracks, swap tracks or clutter tracks, which are defined in §3.1. The following requirements characterize the false target performance for the TIS-B Service.

a. The TIS-B Service **shall [E179]** generate less than 0.1% dual tracks of all targets being tracked.

b. The TIS-B Service **shall [E180]** detect and remove dual tracks within 30 seconds 90% of the time.

c. The TIS-B Service **shall [E181]** output fewer clutter or split track reports than clutter or split measurements received.

d. The TIS-B Service **shall [E182]** maintain a track swap rate in accordance with Table 3-10 in the environment of the scenarios specified in Appendix A, §A.3.1.

Table 3-10. Track Swap Requirements

Aircraft/Vehicle Equipment	100 kt Overtake	Head-on Approach	Crossing (30 deg)
Non-Discrete Code vs. Non-Discrete Code (same code, no Mode C)	0%	0%	1.1%
Discrete Code Track vs. Discrete Code (different code) Track*	0%	0%	0%
Discrete Code Track vs. Non-Discrete Code Track*	0%	0%	0%

** Includes beacon garble*

Notes for Table 3-10:

1. *Requirements assume a clutter-free environment and no beacon garble, unless otherwise indicated.*
2. *Aircraft speeds are 300 knots and 400 knots for 100 knots overtake, 300 knots for 30 degrees crossing, and 200 knots for head-on approach.*
3. *The sensor characteristics to be used in conjunction with track swap scenarios are those specified in Table 3-9 and Appendix A.*
4. *Requirements apply to a tracker using inputs from one or multiple radars when the radar closest to the aircraft is a short-range radar.*

5. *Beacon-reinforced targets need not necessarily be real. It is quite possible for beacon false-targets to have radar reinforcement via radar clutter.*
6. *False targets (beacon or radar) tend to form in clusters. They are not accurately modeled by a uniform random distribution.*

3.3.2.10.3.2 Track Continuity Rate

a. The TIS-B Service **shall [E183]** maintain a track continuity rate that is better than 99.9%.

Notes:

1. *This requirement refers to how often tracks are inadvertently dropped rather than dropped due to the target leaving coverage nor does it include the period during track initiation.*
2. *The track continuity rate is defined as:*

$$\frac{\text{(actual time in track)}}{\text{(expected time to be in track)}}$$

3. *As an example, for a simple ND consecutive missed detection rule for track termination, the probability of track continuity, Pc, is given by*

$$P_c = 1 - q^{N_D}$$

where q is the probability of a missed detection.

For ND =5, a continuity rate of 99.9% can be achieved for a detection probability, PD, of 0.75.

0.999 = 1 - q5

q~0.25, and PD=1-q=0.75

For ND=3, the detection probability would be equal to or better than 0.9 to achieve 99.9 percent track continuity.

b. The TIS-B Service **shall [E184]** maintain track on a target maneuvering at magnitudes of acceleration of up to 1.5 g.

3.3.2.10.3.3 Track Loss Rate

Track loss probability is the probability that a track is lost under various conditions based on aircraft maneuvers and data types. A track is considered lost if there is no correlation of the track's 4096 identification code with the correct sensor data for ten consecutive track update opportunities. These requirements were derived from existing FAA tracking systems.

a. The TIS-B Service **shall [E185]** maintain a track loss rate of 0% in the discrete code versus discrete code and discrete code versus non-discrete code environment of the scenarios specified in Appendix A, §A.4.

3.3.2.11 Link Specific Processing

3.3.2.11.1 Performance Environment

TIS-B/FIS-B Services must operate in environmental conditions that will vary between, and even within, Service Volumes. The service provider must consider the operating temperatures and all environmental factors that apply to each Service Volume.

a. TIS-B/FIS-B Services **shall [E186]** meet the availability requirements in §3.3.2.9 and §3.3.3.4 under the most extreme environmental operating conditions in the Service Volume.

   Note: *Guidance for environmental operating conditions can be found in MIL-STD-810F, Appendix C.*

b. The Transmit Function failure modes **shall [E187] not** adversely affect use of the channel within the Service Volume.

   Note: *For example, failure of transmitters in a "key-down" mode must be detected and corrected automatically.*

3.3.2.11.2 Traffic Density and Equipage Scenarios

The traffic density and equipage scenario information specifies the necessary performance attributes associated with ordered Service Volumes. There are three traffic density environments that are used to define a Service Volume:

- Low Density,
- Medium Density,
- High Density.

The traffic density environments are specified for each of the Service Volume Domains: En Route, Terminal and Surface. Additionally, ADS-B equipage assumptions for aircraft/vehicles and the percentages of UAT and 1090ES equipage are specified. This information defined the operating environment under which the ADS-B Service and the ADS-R Service performance requirements are to be satisfied. In the case of 1090 MHz ES, interference environments are also specified since performance of the ADS-B Service and the ADS-R Service are impacted by the co-channel interference amounts. The traffic density environments are described by the number of aircraft/vehicles within a defined geographic area for the purpose of determining RF coverage for the Service Volume. The Airport Surface Domain does not define a geographic area since the airport surfaces are not large areas but have varied topologies which includes a surface coverage area and may include an altitude region as well. The traffic density environments for the Terminal Domain are defined by a 60 NM radius from the center of the Domain. The traffic density environments for the En Route Domain are represented by a 300 NM radius from the center of the Domain. The actual geographic area for any ordered En Route Domain varies in size and may be larger than the area described by a 300 NM radius. Determination of total traffic counts by assuming the same traffic density described herein for the entire Service Volume. The following ADS-B Message rates for aircraft are assumed:

<u>UAT equipped aircraft/vehicle</u> =
1 ADS-B Message per second transmitted
1 potential ADS-B Report for rebroadcast on 1090ES per second of required message

1090ES equipped aircraft/vehicle =
5.4 ADS-B Messages (Extended Squitters) per second transmitted
1 potential ADS-B Report for rebroadcast on UAT per second

The Airport Surface High-Density Environment consists of 200 maximum aircraft and surface vehicles, with up to 200 UAT equipped aircraft/vehicles or up to 200 1090ES equipped aircraft/vehicles.

Note: *Since the Service Volume for which the ADS-B and/or ADS-R Service will be ordered for the airport surface will include airport runways, taxi ways and potentially gate areas, providing surface coverage will need to consider airport layout, obstructions, etc., to determine siting of transmitters and receivers. Since it is expected that aircraft/vehicles will be in close proximity to the transmitters and receivers providing service, the interference effects are not expected to be a significant factor.*

2. The Airport Surface Medium-Density Environment consists of 100 maximum aircraft and surface vehicles, with up to 100 UAT equipped aircraft/vehicles or up to 100 1090ES equipped aircraft/vehicles.
3. The Airport Surface Low-Density Environment consists of 50 maximum aircraft and surface vehicles, with up to 50 UAT equipped aircraft/vehicles or up to 50 1090ES equipped aircraft/vehicles.
4. The Terminal Airspace High-Density Environment consists of 400 aircraft and surface vehicles, with up to 85% 1090ES equipped aircraft/vehicles and up to 60% UAT equipped aircraft/vehicles.
5. The Terminal Airspace Medium-Density Environment consists of 250 maximum aircraft/vehicles, with up to 250 1090ES and up to 250 UAT equipped aircraft/vehicles.
6. The Terminal Airspace Low-Density Environment consists of 200 maximum aircraft/vehicles, with up to 200 1090ES and up to 200 UAT equipped aircraft/vehicles.
7. The En Route Airspace High-Density Environment consists of 2000 aircraft, with up to 85% 1090ES aircraft and up to 40% UAT equipped aircraft.
8. The En Route Airspace Medium-Density Environment consists of 800 aircraft, with up to 85% 1090ES aircraft and up to 40% UAT equipped aircraft.
9. The En Route Airspace Low- Density Environment consists of 360 aircraft, with up to 360 1090ES equipped aircraft and up to 200 UAT equipped aircraft.

The traffic density environments are summarized in Table 3-11.

Table 3-11. Traffic Density Environments

Traffic Density	Total Traffic Count	Maximum ES	Maximum UAT
Surface - Low	50	50	50
Surface - Medium	100	100	100
Surface - High	200	200	200
Terminal - Low	200	200	200
Terminal - Medium	250	250	250
Terminal - High	400	320	240
En Route - Low	360	360	200
En Route - Medium	800	680	320
En Route - High	2000	1700	800

3.3.2.11.3 ADS-B Update Interval

ADS-B Message are received and used by the TIS-B Service. To meet the TIS-B Service performance requirements, ADS-B Messages transmitted from aircraft/vehicles in the Service Volume must be received within a specified update interval. The update interval requirements in this section assume the aircraft/vehicles are transmitting ADS-B Messages in compliance with the UAT (DO-282B) or 1090ES (DO-260B) MOPS.

a. The Receive Function **shall [E188]** receive ADS-B target data at a rate such that an aircraft/vehicle within a Service Volume designated as En Route is updated within 12.1 seconds (95%) of the previous update.

b. The Receive Function **shall [E189]** receive ADS-B target data at a rate such that an aircraft/vehicle within a Service Volume designated as Terminal is updated within 6 seconds (95%) of the previous update.

c. The Receive Function **shall [E190]** receive ADS-B target data at a rate such that an aircraft/vehicle within a Service Volume designated as Surface is updated within 2 seconds (95%) of the previous update.

3.3.2.11.4 TIS-B Update Interval

a. The Transmit Function **shall [E191]** transmit TIS-B target data at a rate and power such that an aircraft/vehicle within a Service Volume designated as En Route will receive an update for each target within 12.1 seconds (95%) of the previous update.

b. The Transmit Function **shall [E192]** transmit TIS-B target data at a rate and power such that an aircraft/vehicle within a Service Volume designated as Terminal will receive an update for each target within 6 seconds (95%) of the previous update.

c. The Transmit Function **shall [E193]** transmit TIS-B target data at a rate and power such that an aircraft/vehicle within a Service Volume designated as Surface will receive an update for each target within 2 seconds (95%) of the previous update.

Notes:

1. *The requirements above assume sensor data updates are available at intervals less than or equal to those stated above.*
2. *The requirements above are based on reception by A1 class 1090ES and A0 class UAT ADS-B avionics. The aircraft/vehicle antenna is assumed to be 0 dBi omni-directional gain pattern with free space loss.*

3. *Adjustment to the requested Service Volume may be necessary to meet this requirement given other constraints (i.e., transmission duty factor).*

3.3.2.11.5 TIS-B Extrapolation Accuracy

a. The TIS-B Service **shall [E3204] not** introduce any additional position error to that which might otherwise be introduced by a linear extrapolation using the instantaneous velocity provided for the target.

3.3.2.11.6 1090ES

3.3.2.11.6.1 1090ES Interference Environment

a. The TIS-B Service **shall [E194]** meet all performance requirements specified in §0 while operating in the interference environment specified in this section (see §3.3.2.11.6.1).

Note: *The aircraft/vehicle antenna is assumed to be 0 dBi omni-directional gain pattern with free space loss.*

Interference environments under which the TIS-B Services must be provided are specified below. The UAT interference environment of interest consists primarily of UAT transmissions from other aircraft and is not described further in this section. Since there are interference sources on the 1090 MHz frequency that 1090ES receivers need to tolerate including Mode S and ATCRBS signals, the interference environment is provided for both ATCRBS Mode A/C interference and Mode S interference. Mode S and ATCRBS signal pulse characteristics are assumed to meet the nominal values contained in RTCA DO-181C. The Mode S interference consists of Mode S reply signals from Mode S equipped aircraft/vehicles as well as Extended Squitters from aircraft within the Service Volume and aircraft outside the Service Volume.

Interference characteristics for a given Service Volume are one of four environments:

- Low,
- Medium,
- High,
- Very High.

The interference rates for Mode S and ATCRBS are contained in Figure 3-3 through Figure 3-6. The interference levels are provided for each environment for a 1090 MHz receiver located on the surface and also for the case of an airborne 1090 MHz receiver. The 1090 MHz receiver located at the surface provides the maximum interference that a Ground Station or an aircraft/vehicle participant on the surface would experience. The airborne receiver interference characteristics provide the maximum interference rates to enable determination of 1090 MHz Ground Station characteristics to meet the update rates of the TIS-B Service to airborne participants per section §3.3.2.11.4. The interference levels are specified as the RF power at the antenna providing reception on the ground assuming an omni receive antenna. The interference can be assumed to be homogenous in azimuth and elevation and are rates that would be seen by a Ground omni-antenna located at a height of 60 feet.

Note*: Omni-directional antenna is assumed for the purpose of defining interference characteristics. Ground Station antenna characteristics and use of omni, sector or directional antennae are selected by the Service Provider.*

For the case of an airborne receiver, the interference levels are specified as the RF power at the antenna providing reception on an aircraft assuming an omni-directional receive antenna. The interference can be assumed to be homogenous in azimuth and elevation and are rates that would be seen by an aircraft located in the Service Volume.

Note: *Airborne receiver and decoder characteristics for A1, A2 and A3 equipage classes are described in RTCA DO-260B.*

The contribution of Extended Squitter to the Mode S interference rates contained in Figure 3-3 and Figure 3-5 are as follows:

- 76% for Low,
- 64% for Medium,
- 44% High
- 38% Very High.

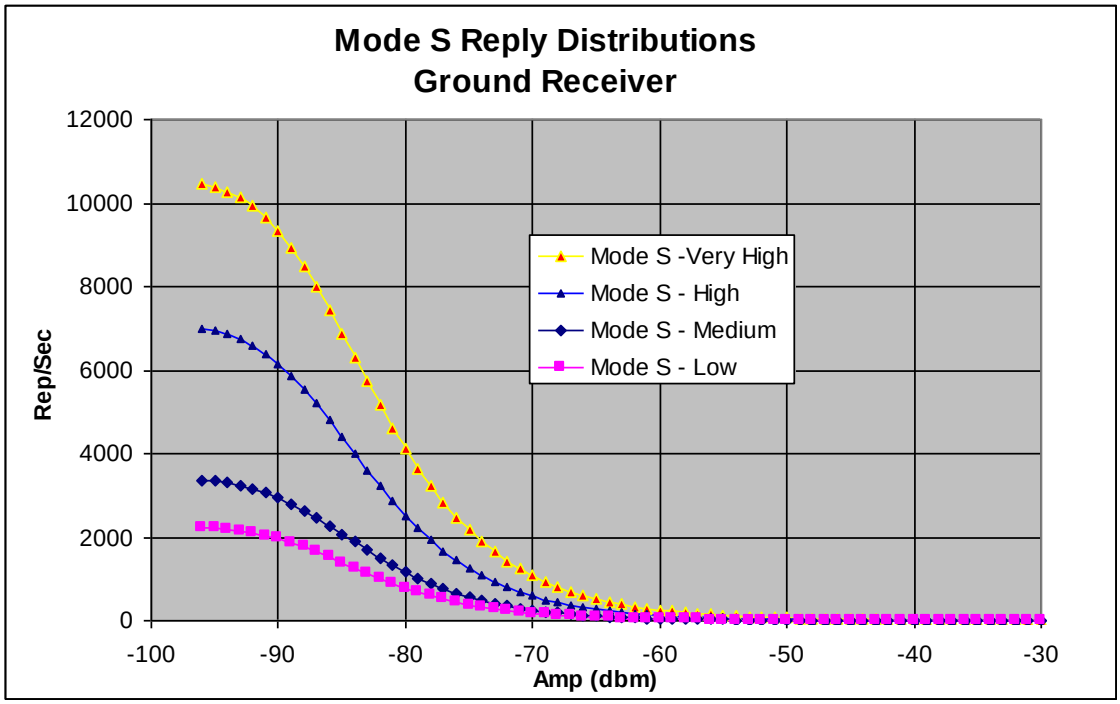


Figure 3-3. Mode S Reply Rate Distributions for Ground Receiver

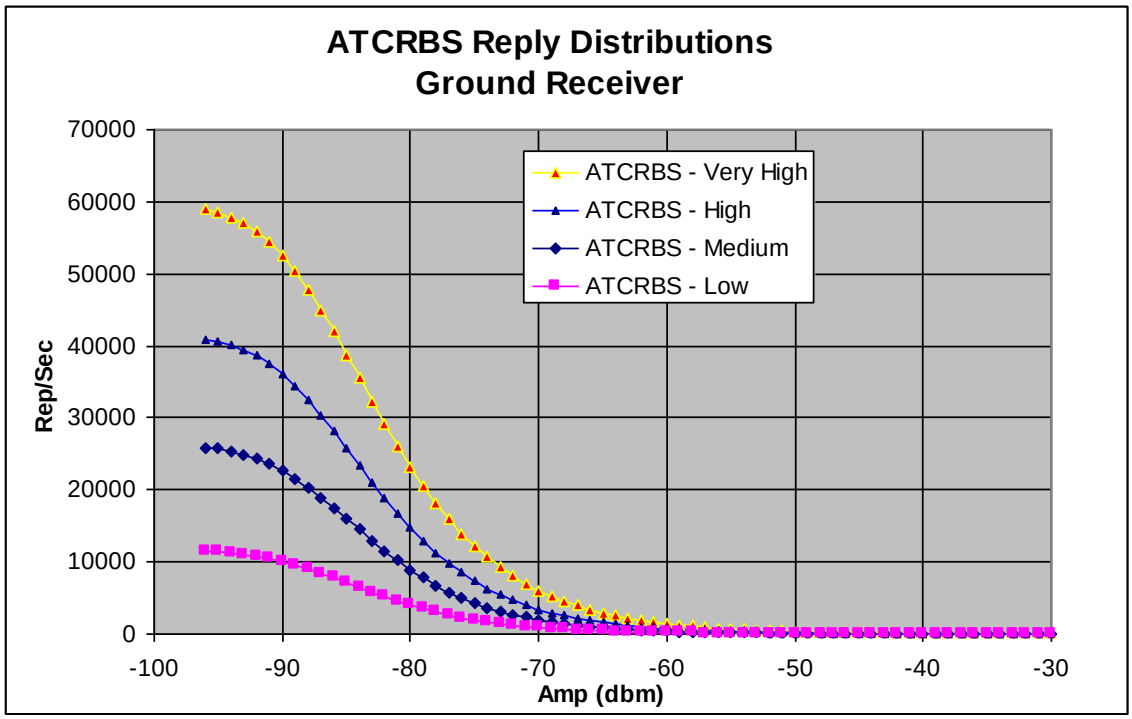


Figure 3-4. ATCRBS Reply Rate Distributions for Ground Receiver

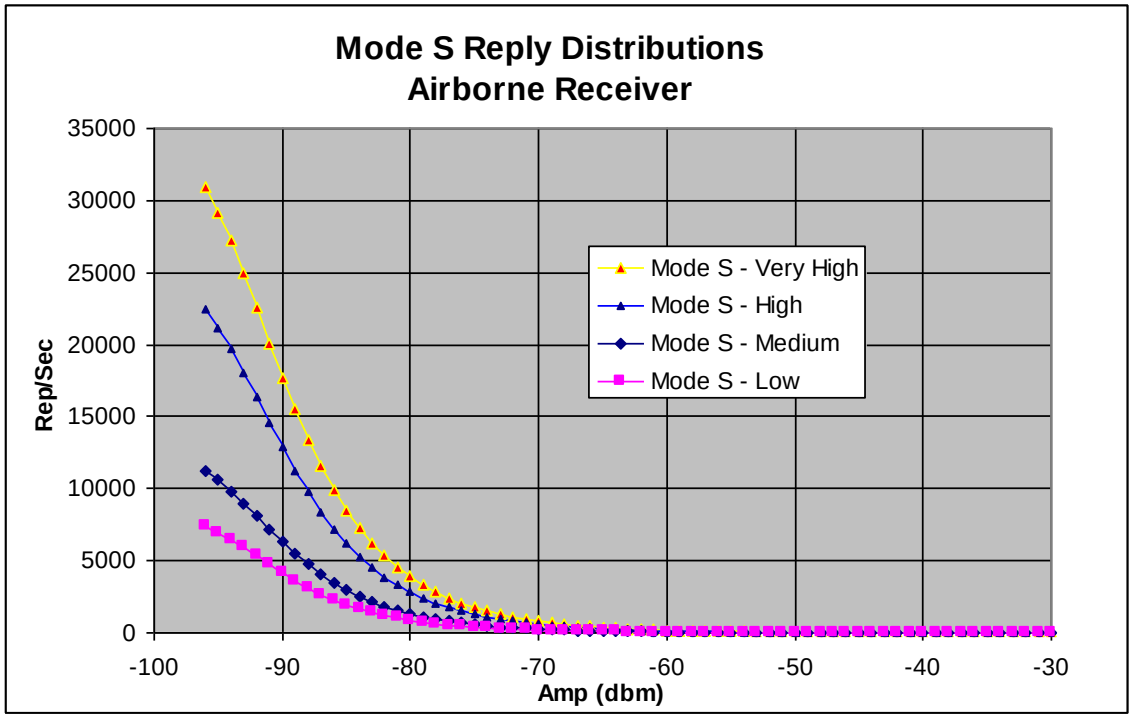


Figure 3-5. Mode S Reply Rate Distributions for Airborne Receiver

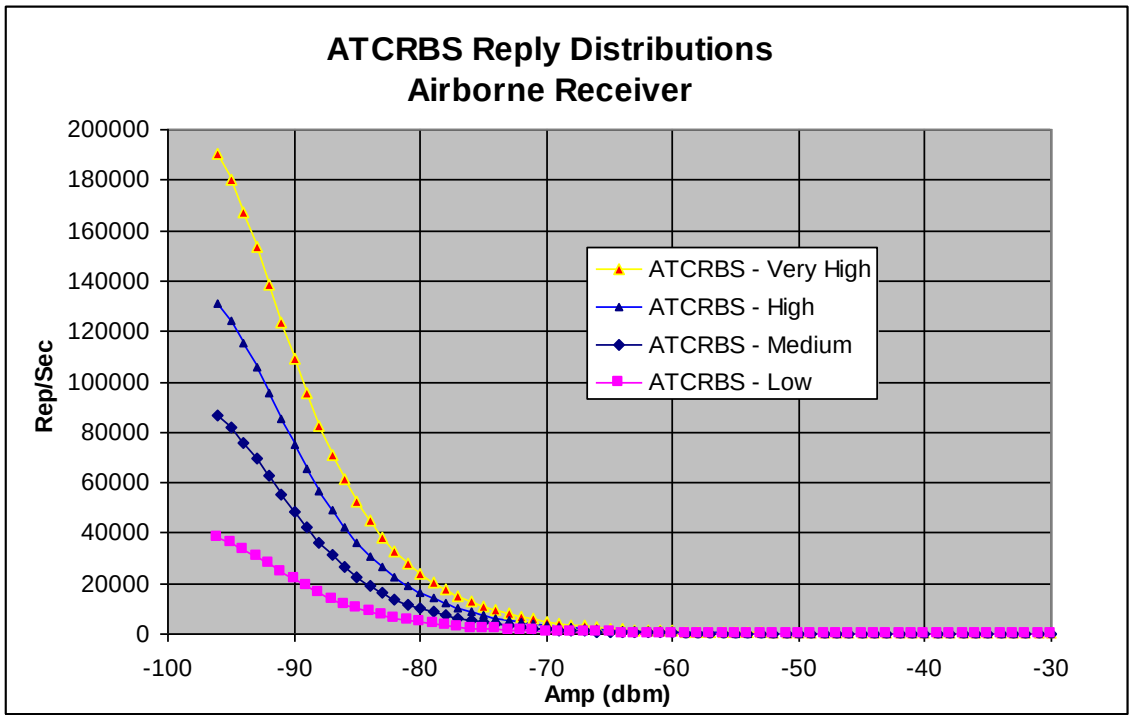


Figure 3-6. ATCRBS Reply Rate Distributions for Airborne Receiver

3.3.2.11.6.2 1090ES Transmit Function Characteristics

a. The 1090ES Transmit Function **shall [E195]** meet all the requirements of RTCA/DO-260B §2.2.2.2.1 through §2.2.2.2.9, §2.2.2.2.11, and all of §2.2.3.

3.3.2.11.6.3 1090ES Transmit Duty Cycle Limitation

a. When a 1090ES MHz transmitter or multiple transmitters are located beyond radio line-of-sight (RLOS) of a Secondary Surveillance Radar (SSR) and/or multilateration receiver/transmitter (R/T) units (victims), the cumulative number of messages transmitted by all transmitters within reception range of any aircraft **shall [E196] not** exceed 1,000 messages per second with a received signal strength greater than -78 dBm.

Notes:

1. *When TIS-B Service is provided in conjunction with ADS-R Service, this message per second limitation applies to both ADS-R and TIS-B combined, and ADS-R has priority over TIS-B (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*
2. *The uplink of TIS-B / ADS-R Service status messages do not count against the message limits in this paragraph and the message limits in the below subsections.*

3.3.2.11.6.3.1 SSR Sidelobe Reception

a. When a 1090ES MHz transmitter or multiple transmitters are located *within* RLOS of an SSR (victim), and the power density at the *side lobes* of the SSR antenna, exceeds -X dBW/m^2, with "X" being the power density reflected in Figure 3-7, then the cumulative number of messages received by the SSR per second from all transmitters **shall [E197] not** exceed the amounts depicted in Figure 3-7.

b. The maximum power at the victim antenna **shall [E198] not** exceed -65 dBW/m^2 in order to prevent receiver saturation.

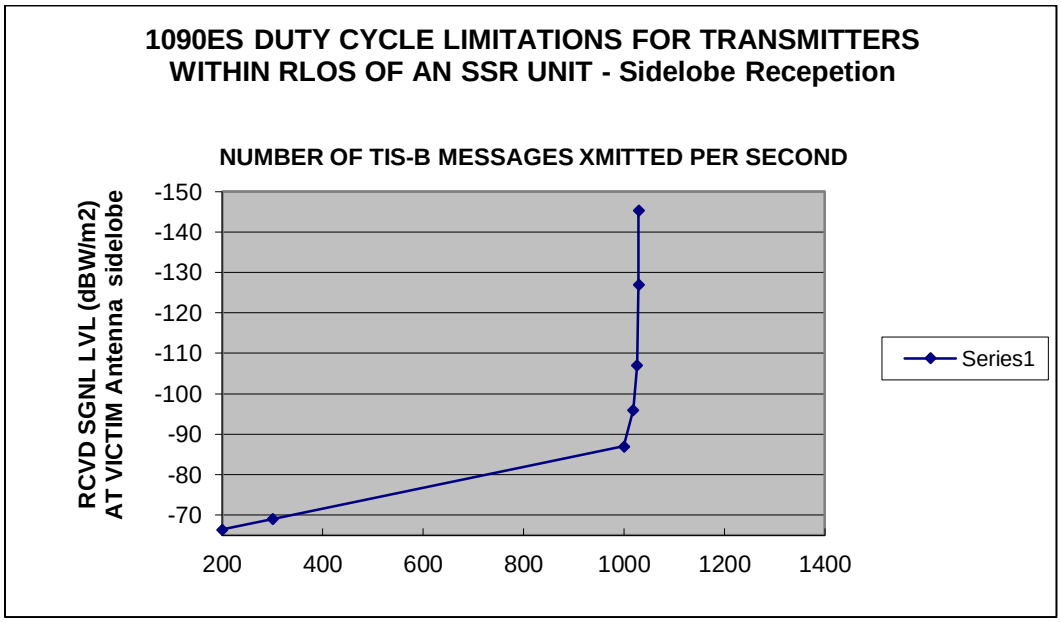


Figure 3-7. 1090ES Duty Cycle Limitations for Transmitters Within RLOS of an SSR Unit – Sidelobe Reception

3.3.2.11.6.3.2 SSR Main Beam Reception

a. When a 1090ES MHz transmitter or multiple transmitter's are located within RLOS of an SSR and the power density at the main beam of the victim(s) antenna exceeds –X dBW/m^2, with "X" being the power density reflected in Figure 3-8, then the cumulative number of messages received by the victim per second from all transmitters **shall [E199] not** exceed the amounts depicted in Figure 3-8.

b. If the power density at a victim SSR antenna exceeds –90 dBW/m^2, then a method **shall [E200]** be implemented to prevent the transmitter from transmitting when the main beam of the SSR rotates through the antenna beam of the transmitter.

c. The maximum power density at the victim antenna **shall [E201] not** exceed -90 dBW/m^2 in order to prevent receiver saturation.

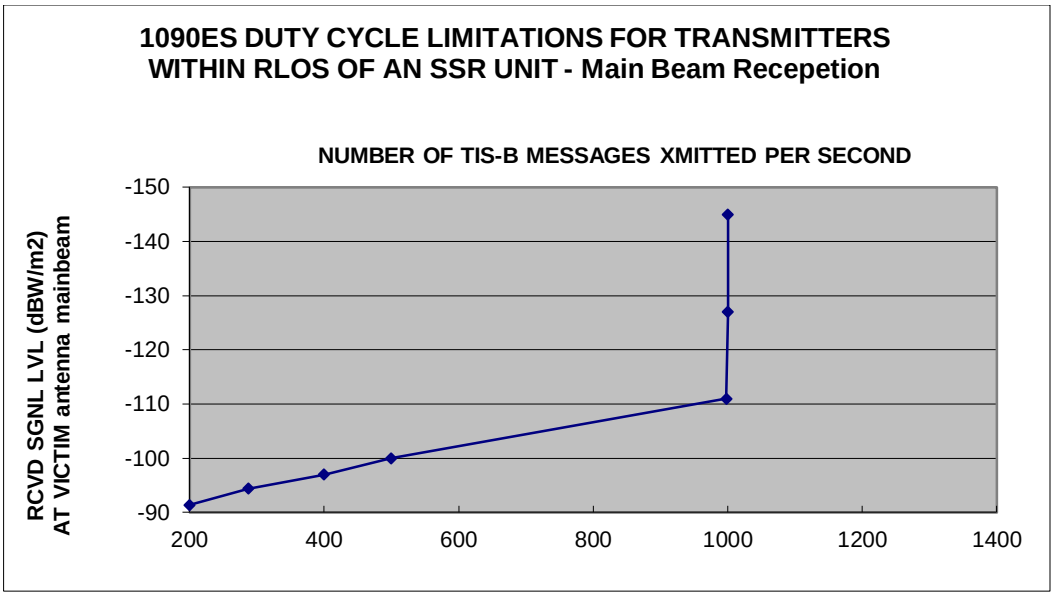


Figure 3-8. 1090ES Duty Cycle Limitations for Transmitters Within RLOS of an SSR Unit – Main Beam Reception

3.3.2.11.6.3.3 Multilateration R/T Reception

When a 1090ES MHz transmitter or multiple transmitters are located *within* RLOS of multilateration R/T units (victims), and the power density at the receiver antenna of the victims, as received through the *side lobes* of the victim(s) antenna, exceeds -X dBW/m^2, with "X" being the received power density reflected in
Figure 3-9, then the cumulative number of messages received by the victim per second from all transmitters **shall [E202] not** exceed the amounts depicted in
Figure 3-9.

a. The 1090ES power density **shall [E203] not** exceed -55 dBW/m^2 at the receiver of a multilateration R/T unit.

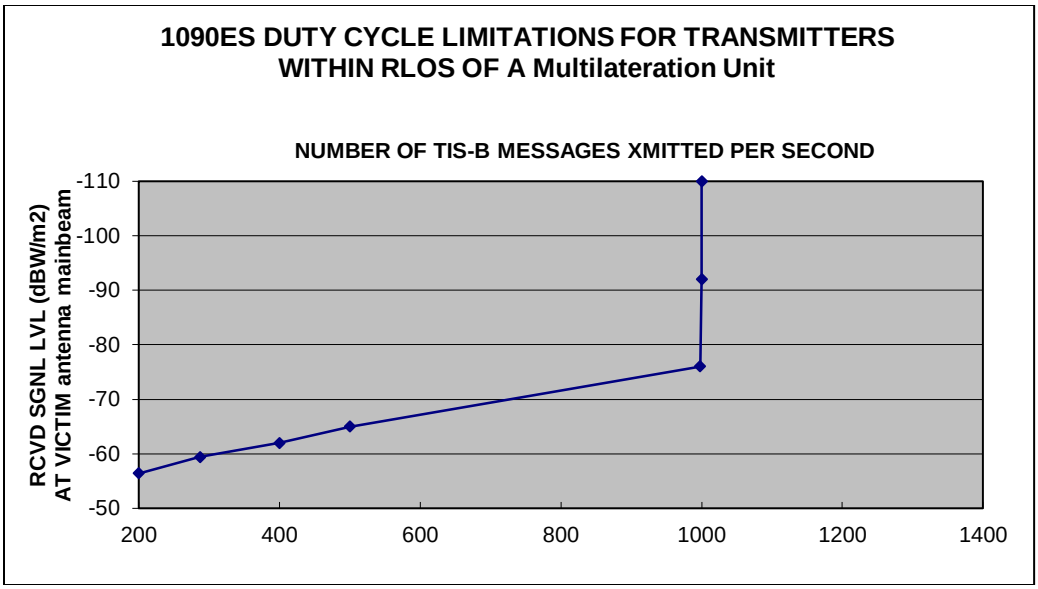


Figure 3-9. 1090ES Duty Cycle Limitations for Transmitters Within RLOS of a Multilateration Unit

3.3.2.11.7 UAT

3.3.2.11.7.1 UAT Transmit Function Characteristics

a. The UAT Transmit Function **shall [E204]** meet all the requirements of RTCA/DO-282B §2.2.2.1 through §2.2.2.7 with exceptions or qualifications as detailed in the subparagraphs below.

3.3.2.11.7.1.1 UAT Modulation Rate

a. The UAT Transmit Function **shall [E205]** have a modulation rate of 1.041667 megabits per second ±2 PPM

Note: *This requirement is necessary to ensure proper decoding of the longer Ground Uplink Messages by avionics equipment*

3.3.2.11.7.1.2 UAT Modulation Distortion

a. The UAT Transmit Function **shall [E206]** meet the modulation distortion requirements in RTCA/DO-282B §2.2.2.4 for Ground Uplink Message transmissions.

3.3.2.11.7.1.3 UAT Message Transmission Power

a. The effective radiated power for all Ground Uplink Message transmissions **shall [E207]** be such as to provide a field strength of at least 280 microvolts per meter (minus 97 dBW/m^2) throughout the Service Volume on the basis of free-space propagation.

Note: *This is determined on the basis of delivering a -91 dBm (corresponds to 200 microvolts per meter) signal level at the antenna (assuming an omni-directional antenna). The 280 microvolts per meter recommendation corresponds to the delivery of a -88 dBm signal level at the antenna end of the transmission line. The 3 dB difference between -88 dBm and -91 dBm provides margin for excess path loss over free-space propagation*

b. The maximum EIRP **shall [E208]** not exceed +58 dBm.

3.3.3 FIS-B Service

3.3.3.1 FIS-B Service Capacity

a. The FIS-B Service **shall [E215]** be capable of simultaneously processing received FIS-B source data for all basic products in §3.2.1.2.3 and §3.2.1.2.4 that are available for the weather and status of NAS resources in the Service Volume, subject to the constraints of the UAT Ground Uplink Segment in a Service Volume, and other FIS-B performance requirements.

3.3.3.2 FIS-B Service Latency

The amount of time it can take to deliver a complete product to users will vary depending on the payload size and, available uplink bandwidth. Products may also vary in size depending on atmospheric conditions or complexity of the NAS resource for which the product refers. The FIS-B Service latency is measured from the time a product's source-data has been completely received until the product is queued for transmission to the aircraft/vehicle at the scheduled transmission interval (per Table 3-12).

a. The FIS-B Service latency of a product **shall [E216]** be less than 10 seconds (99%) for all products except for the Status of SUA and less than 20 seconds (99%) for the Status of SUA.

Note: *This latency specification is to be applied to the product latency distribution, and is intended to mean that 99% of all measured latencies are less than the specification.*

3.3.3.3 FIS-B Information Integrity

The probability the FIS-B Service introduces an error into a FIS-B Message that is broadcast **shall [E217]** not exceed 10^{-5} per Message.

3.3.3.4 FIS-B Service Availability

The FIS-B Service is a safety-essential service as classified by FAA and applies only to the Service Provider's system. The service availability reflects the availability of each individual FIS-B product being processed and broadcast to users in each designated Service Volume. The availability does not include product source data or the systems providing these data.

a. Each basic and optional FIS-B product provided by the FIS-B Service **shall [E218]** meet a minimum availability of 0.999.

b. The FIS-B Service **shall [E219]** notify aircraft/vehicles of a FIS-B Service outage in a Service Volume within 30 seconds of the outage occurrence and continue to provide the notification until service is returned.

Note: *This requirement assumes the communications link is intact. Requirements in the FIS-B MASPS accommodate lost link conditions (reference FAA Contract letter ADS-B 0015 dated December 18, 2007).*

Note: *Service availability does not apply to outages that may occur on individual aircraft or to individual product sources. An application-level agreement*

between the service provider and the avionics vendors to provide an indication to users about the availability of individual products may be necessary.

3.3.3.5 Broadcast Services Processing

3.3.3.5.1 FIS-B Product Processing

Products will generally be received from the data source provider and processed on a first-in, first-out basis; however, a prioritization scheme may be used to ensure certain time-sensitive products are delivered in a timely manner. Each product will be retransmitted at a rate appropriate for the intended use of the information.

a. Basic FIS-B products **shall [E220]** be updated, initially transmitted and re-transmitted in accordance with the intervals specified in Table 3-12.

b. Optional FIS-B products that are not in the Basic product set, **shall [E221 SE]** be updated, initially transmitted and re-transmitted in accordance with the intervals specified in Table 3-12.

Table 3-12. FIS Product Update and Transmission Intervals

Product	Update Interval	Transmission Interval (95%)	Basic Product
AIRMET	As Available	5 minutes	Yes
AWW/WW	As Available, then at 15 minute intervals for 1 hour	5 minutes	No
Ceiling	As Available	10 minutes	No
Convective SIGMET	As Available, then at 15 minute intervals for 1 hour	5 minutes	Yes
D-ATIS	As Available	1 minute	No
Echo Top	5 minutes	5 minutes	No
METAR/SPECI	1 minute (where available), As Available otherwise	5 minute	Yes
MRMS NEXRAD (CONUS)	2 minutes	14 - 15 minutes(3)	Yes
MRMS NEXRAD (Regional)	2 minutes	2 - 2.5 minutes(3)	Yes
NOTAMs-D/FDC	As Available	10 minutes	Yes
NOTAMs-TFR	As Available	10 minutes	Yes
PIREP	As Available	10 minutes	Yes
SIGMET	As Available, then at 15 minute intervals for 1 hour	5 minutes	Yes
SUA Status	As Available	10 minutes	Yes
TAF/AMEND	6 Hours (±15 minutes)	10 minutes	Yes
Temperature Aloft	12 Hours (±15 minutes)	10 minutes	Yes
TWIP	As Available	1 minute	No
Winds aloft	12 Hours (±15 minutes)	10 minutes	Yes
Lightning strikes(2)	5 minutes	5 minutes	Yes
Turbulence(2)	1 minute	15 minutes	Yes
Icing, Forecast Potential (FIP)(2)	60 minutes	15 minutes	Yes

Cloud tops[(2)]	30 minutes	15 minutes	Yes
1 Minute AWOS [(2)]	1 minute	10 minutes	No
Graphical-AIRMET[(2)]	As Available	5 minutes	Yes
Center Weather Advisory (CWA) [(2)]	As Available	10 minutes	Yes
Temporary Restricted Areas (TRA)	As Available	10 minutes	Yes
Temporary Military Operations Areas (TMOA)	As Available	10 minutes	Yes

Notes: *1. The Update Interval is the rate at which the product data is available from the source. The Transmission Interval is the amount of time within which a new or updated product transmission must be completed (95%) and the rate or repetition interval at which the product is rebroadcast (95%).*

2. The transmission and update intervals for the expanded set of basic meteorological products may be adjusted based on FAA and vendor agreement on the final product formats and performance requirements.

3. The MRMS product transmission interval is configured to the lower values for both regional (2 minutes) and CONUS (14 minutes) products unless bandwidth limits on FIS-B necessitate a larger value that doesn't exceed the identified range.

3.3.3.6 Link Specific Processing

3.3.3.6.1 UAT

FIS-B products **shall [E222]** be encoded for uplink within the UAT Information Frames conveyed within UAT Ground Uplink Messages. Product format requirements are in §3.4.4.5.2.

3.4 Interface Requirements

This section contains the functional and physical interface requirements for interfaces to systems external to the TIS-B/FIS-B Services.

The TIS-B Service will receive data from surveillance systems for the generation of TIS-B Messages to be delivered to aircraft within the Service Volume using both the 1090ES and UAT data links. This will require one or more interfaces, depending on the particular requirements for a configured Service Volume.

Additionally, the FIS-B Service will receive data from government and/or commercial systems for the generation of FIS-B products to be delivered to aircraft within the Service Volume using only the UAT data link. The number of interfaces required to receive FIS product source data may vary depending on where and how many products are available from a particular approved source.

3.4.1 Reports from Surveillance Systems

En route and terminal radars data will be provided through a physical interface to the En Route Communications Gateway (ECG). The user interface is specified in Interface Control Document for ECG/IP LAN User Systems, NAS-IC-82320001-01. ARSR and ASR data are carried using the ECG protocol over UDP/IP.

ARSRs output measurements and radar status reports in the Common Digitizer (CD) format. Digital ASRs output measurements and radar status reports in ASR format, a variant of the CD report format. Full range resolution can be sent via the ECG.

Multilateration (MLAT) systems output measurements and status reports in ASTERIX Category 010 or Category 011 format per SUR.ET1.ST05.2000-STD-07-01 and SUR.ET1.ST05.2000-STD-08-01, respectively.

Note: *The number of surveillance systems that must be interfaced with may vary depending upon the service volume and will be detailed in the contract schedule.*

a. The TIS-B Service interface to radars systems that interface to the ECG **shall [E223]** be compatible with ECG/IP LAN User Systems per NAS-IC-82320001-01.

b. The TIS-B Service interface to radar systems that provide output via the CD format **shall [E224]** be compatible with ATCBI-6-SE13-002 and NAS-IC-34032105, as appropriate.

c. The TIS-B Service interface to MLAT systems that provide output via the ASTERIX Category 010 **shall [E225]** be compatible with SUR.ET1.ST05.2000-STD-07-01.

d. The TIS-B Service interface to MLAT systems that provide output via the ASTERIX Category 011 **shall [E226]** be compatible with SUR.ET1.ST05.2000-STD-08-01.

3.4.2 Reports from Maintenance Processing

The TIS-B/FIS-B Service will output the maintenance data sets (see §3.2.3.1) to the SBS Monitor from Maintenance Processing. The Service Status Report (CAT023 format) provides equipment status, service status, and TIS-B surveillance sensor status. The ADS-B Test Report (CAT033 format) provides synthetic ADS-B data that has been transmitted and received by the system.

a. The TIS-B Service **shall [E232]** provide the SBS Monitor with Service Status data at one or more specified SDPs in the CAT023 format and in accordance with NAS-IR-SBS.

b. The TIS-B Service **shall [E234]** provide the SBS Monitor with Surveillance Status to one or more specified SDPs in the CAT023 format and in accordance with NAS-IR-SBS.

c. The TIS-B Service **shall [E233]** provide the SBS Monitor with ADS-B Test Target Reports at one or more specified SDPs in the CAT033 format and in accordance with NAS-IR-SBS.

3.4.3 Reports from Broadcast Service Processing

The TIS-B/FIS-B Service will output the data sets from Broadcast Services Processing to the SBS Monitor and other FAA authorized users. These data sets are provided in reports containing TIS-B target data and FIS-B products. Note that TIS-B target data includes information from multiple surveillance sources including ADS-B.

a. The TIS-B Service **shall [E235]** provide the SBS Monitor and authorized users with TIS-B Reports at one or more specified SDPs in the CAT033 format and in accordance with NAS-IR-82530001.

b. The TIS-B Service **shall [E3238]** send a TIS-B Type B (CAT033) Report to the FAA Monitor upon receipt of a TIS-B target transmission acknowledgement in accordance with Appendix B of NAS-IR-82530001.

Note: *The requirement for provision of the Time of Message Receipt in the TIS-B Type B Reports to the FAA Monitor is included in Appendix B of the SBS SDP IRD (NAS-IR-82530001) and is not captured as a separate Level 1 requirement in this Specification.*

c. The TIS-B Service **shall [E3239]** send a TIS-B Type A (CAT033) Report to the FAA Monitor upon generation of a track update triggered by a radar sensor report, but no more frequently than once per second, before target suppression in accordance with Appendix B of the NAS-IR-82530001.

Note: *The requirement for provision of the Time of Message Receipt in the TIS-B Type A Reports to the FAA Monitor is included in Appendix B of the SBS SDP IRD (NAS-IR-82530001) and is not captured as a separate Level 1 requirement in this Specification.*

Note: *Target Suppression may include suppression of (1) Targets without Clients, (2) Exclusion Zone Criteria, or (3) Specified Attributes (e.g. Target Address).*

d. The TIS-B Service **shall [E5247]** provide the SBS Monitor and authorized users with 1090-ES TIS-B / ADS-R service status reports at one or more specified SDPs in the format defined in Appendix F of NAS-IR-82530001 version 3.7 dated January 24, 2014.

e. The FIS-B Service **shall [E236]** provide the SBS Monitor and authorized users with FIS-B product data at one or more specified SDPs in a format defined by the Service Provider and in accordance with NAS-IR-82530001.

3.4.4 UAT Information Frames (Avionics)

This section details the format of UAT Information Frame field of the Ground Uplink Message, the FIS product encoding and the basic FIS-B product formats. Refer to §3.2.2.2 and RTCA/DO-282B for lower level UAT requirements (e.g., physical layer, media access, etc.).

Each Information Frame consists of 'N' bytes, comprising four fields formatted as shown in Figure 3-10.

Byte #	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1	MSB	Length						
2	LSB	Reserved			MSB	Frame Type		LSB
3 - N	Frame Data							

Figure 3-10. UAT Information Frame

Notes:

1. *Byte numbers in this table are relative to the beginning of the current Information Frame.*
2. *Within each byte, bit 1 is transmitted first and bit 8 is transmitted last*

a. The FIS-B Service **shall [E240]** transmit UAT Ground Uplink Messages that contain UAT Information Frames as defined in RTCA/DO-282B, §2.2.3.2.2.2.

3.4.4.1 UAT Length Field

The Length field (Byte 1: Bit 1 through Byte 2: Bit 1) is a 9-bit field that contains the length of the Frame Data field in bytes. Values range from 0 through 422 (decimal). The Length value is always equal to 'N-2'.

Note: *When Information Frames do not fully occupy the Application Data field, the unused portion is zero filled. When encountered by the frame parsing logic, the zero fill portion will appear as a frame of zero bytes in length or an incomplete frame if less than 2 bytes remain. This would be the indication to the parsing logic that the last frame has been found.*

a. The FIS-B Service UAT Ground Uplink Messages **shall [E241]** contain UAT Ground Uplink Message Information Frame Length field that is encoded as defined in RTCA/DO-282B, §2.2.3.2.2.2.

3.4.4.2 UAT Reserved Field

The Reserved field (Byte 2: Bits 2 through 4) is a 3-bit field that is reserved for future use, and will be set to ALL ZEROES.

a. The FIS-B Service **shall [E242]** transmit UAT Ground Uplink Messages that contain an UAT Ground Uplink Message Information Frame Reserved field that is encoded as defined in RTCA/DO-282B, §2.2.3.2.2.2.

3.4.4.3 UAT Frame Type Field

The Frame Type field (Byte 2: Bits 5 through 8) is a 4-bit field that contains the indication for the format of the Frame Data field. The Frame Types are defined in Table 3-13.

Table 3-13. UAT Frame Types

MSB	**Value** (binary)	LSB	**Frame Data Format**
0000			FIS-B APDU
0001			Reserved for Developmental Use
0010 – 1101			Reserved for future use
1110			Current Report List (per Appendix B)
1111			TIS-B / ADS-R Service Status

When the Frame Type is the binary value "0000", the Frame Data contains FIS-B data packaged as an Application Protocol Data Unit (APDU) as described in RTCA DO-267A §3.6.1, and Appendix D . When the Frame Type is the binary value "1111", the Frame Data contains TIS-B / ADS-R Service Status data (see §3.4.4.6).The remaining values are reserved for future application data.

a. The FIS-B Service **shall [E243]** encode the UAT Ground Uplink Message Information Frame Type field as defined in RTCA/DO-282B, §2.2.3.2.2.2, with the exception that a value of 15 **shall [E244]** be used to indicate the Frame Data contains TIS-B / ADS-R Service Status.

3.4.4.4 UAT Frame Data Field

The Frame Data field conveys the basic units of uplink application data. For FIS-B this data unit is known as the Application Protocol Data Unit (APDU) as defined in RTCA DO-267A.

a. The FIS-B Service **shall [E245]** encode the UAT Frame Data field as defined in RTCA/DO-282B, §2.2.3.2.2.2.

3.4.4.5 FIS Product Encoding (APDUs)

a. The FIS-B Service **shall [E246]** transmit each APDU with an APDU Header followed by the APDU Payload.

3.4.4.5.1 APDU Header

The APDU header format with options is as described in Appendix D of RTCA DO-267A with one exception as described below.

The UAT transmission of the APDU header does not include the 16 bit FIS-B APDU ID field. Per RTCA DO-267A, this field is a fixed two byte field of 0xFF and 0xFE. Since FIS-B APDUs are fully identified as such by the Frame Type field (§3.4.4.3), transmission of these 2 bytes over the air interface are unnecessary. If this two byte field is required for interoperability reasons on board the aircraft, this two byte field can be reconstituted after receipt onboard.

a. The FIS-B Service **shall [E247]** transmit each APDU Header as defined in Appendix D of RTCA/DO-267A except for the FIS-B APDU ID field, which can be reconstituted after receipt onboard the aircraft.

b. The FIS-B Service **shall [E3256]** populate the APDU Header Time field with the UTC date/time the product information was observed, issued, cut-off or is otherwise applicable.

Note: *The method for determining the currency or age of the FIS-B information is based on product date/time(s) for specific weather products the FIS-B MOPS, RTCA DO-358.*

Note: *The APDU time stamp for a given product enables the avionics to know when to display, not display and purge products it may have received and is storing locally.*

Note: *The retransmission of products that have not been updated within the retransmission interval should retain the original time stamp.*

3.4.4.5.2 UAT FIS-B Basic Products Formats

The APDU payload is used to transport the basic products, identified in §3.2.1.2.3 and §3.2.1.2.4, broadcast by the FIS-B Service. The message formats for these products are contained in the FIS-B MOPS, RTCA DO-358.

The Service Provider may propose alternative basic product formats as long as the following conditions are met:

- The product formats are backward compatible with existing products being provided by the FAA to users pre-existing this specification;
- The product formats are coordinated with and mutually agreed to by the FAA and avionics community;

- The product formats are published in the FIS-B MOPS RTCA DO-358.

3.4.4.5.2.1 Textual Products Formats

a. The following self-sorting text products **shall [E250]** use the format identified in the FIS-B MOPS, RTCA DO-358, identified by the name "Generic Textual Data Product - Type 2 (DLAC)" and Product ID 413:

- METAR/SPECI
- PIREP
- TAF/AMEND
- Winds and Temperatures Aloft

Note: *The TIS-B / ADS-R Service Status format is detailed in §3.4.4.6.*

3.4.4.5.2.2 Graphical Products Formats

a. The Regional MRMS NEXRAD Precipitation Product **shall [E251]** conform to the Global Block Representation of the FIS-B MOPS, RTCA DO-358A with an assigned Product ID of 63, and a minimum of 8 levels of reflectivity.

Note: *The Global Block Representation encoding algorithm is documented in §A.3.2 of the FIS-B MOPS, RTCA DO-358A.*

b. The CONUS MRMS NEXRAD Precipitation Product **shall [E252]** conform to the Global Block Representation of the FIS-B MOPS, RTCA DO-358A with an assigned Product ID of 64 and a minimum of 8 levels of reflectivity.

Note: *The Global Block Representation encoding algorithm is documented in §A.3.2 of the FIS-B MOPS, RTCA DO-358A.*

c. The Lightning Product **shall [E5302]** conform to the Global Block Representation of the FIS-B MOPS, RTCA DO-358A with an assigned Product ID of 103.

d. The Turbulence Product **shall [E5303]** conform to the Global Block Representation of the FIS-B MOPS, RTCA DO-358A with assigned Product IDs of 90 and 91.

e. The Icing, Forecast Potential (FIP) Product **shall [E5304]** conform to the Global Block Representation of the FIS-B MOPS, RTCA DO-358A with assigned Product IDs of 70 and 71.

f. The Icing, Forecast Potential (FIP) Product **shall [E5305]** provide an adaptable means of run encoding that is configurable as follows:

i. Run encoding based on a contiguous set of cells having the same value for the icing Severity field within the product,

ii. Run encoding based on a contiguous set of cells having the same value for the icing Probability field within the product,

iii. Run encoding based on a contiguous set of cells having the same values for both the icing Severity field and the icing Probability field within the product, or

iv. No run encoding.

g. The Icing, Forecast Potential (FIP) Product **shall [E5306]** encode those fields not used in establishing the run encoding to the maximum value of that field from all cells included in the run (i.e. SLD, Probability, and/or Severity).

h. The Cloud Tops Product **shall [E5307]** conform to the Global Block Representation of the FIS-B MOPS, RTCA DO-358A with an assigned Product ID of 84.

3.4.4.5.2.3 Text/Graphical Overlay Formats

a. The following products **shall [E253]** conform to the FIS-B MOPS, RTCA DO-358A, identified by the name "Aerodrome and Airspace FIS-B Product Definitions":

- AIRMET (Product ID 11)
- NOTAM-D and FDC (includes TFRs) (Product ID 8)
- SIGMET/Convective SIGMET (Product ID 12)
- SUA Status (Product ID 13)
- NOTAM-D and FDC for TRAs (Product ID **xxxx**) and TMOAs (Product ID **xxxx**)
- G-AIRMET (Product ID 14)
- Center Weather Advisory (Product ID 15)

b. The Graphical Overlay Operator bits **shall [E5266]** be set to ZERO (00) for all graphical products that are uplinked as both textual and graphical records.

c. The FIS-B Service **shall [E5308]** provide the Record Applicability Year in the Graphical Overlay Records for applicable NOTAM-D, NOTAM-FDC, NOTAM-TFR, NOTAM-TRA, and NOTAM-TMOA products per FIS-B MOPS, RTCA DO-358A paragraph A.3.3.1.3.4.

3.4.4.6 UAT TIS-B / ADS-R Service Status Message

a. The UAT TIS-B / ADS-R Service Status **shall [E254]** be conveyed in a UAT Ground Uplink Message as a list of target addresses for aircraft/vehicles with UAT ADS-B In.

Notes:

1. *The presence of a status message for a TIS-B / ADS-R customer indicates that TIS-B and ADS-R Services are available for traffic in the immediate proximity. Upon entry into airspace where both UAT RF coverage and Surveillance Coverage are available the (i.e., ADS-B Messages received), service status messages are transmitted.*
2. *The Frame Type field requirements to identify the UAT TIS-B / ADS-R Service Status Message are in §3.4.4.3.*

b. The format in Figure 3-11 **shall [E255]** be used to represent TIS-B / ADS-R Service Status to individual aircraft/vehicle with UAT ADS-B In capability.

Note: *The Address Qualifier and Address fields are to be populated with the same values reported by the ADS-B target.*

c. Each TIS-B / ADS-R Service Status **shall [E256]** be packed sequentially into the Frame Data portion of the UAT Information Frame as described in §3.4.4.

Note: *A single Ground Uplink message could convey a maximum of 105 TIS-B / ADS-R Service Status signals if all payload of the Ground Uplink message is used for signaling. This assumes all 105 signals were packed into a single Information Frame.*

Tx order	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
1st	**Reserved**				**Sig.**	**Address Qualifier**		
2nd	(MSB)A1	A2	A3	. . .				
3rd	**Address**							
4th					. . .	A22	A23	A24(LSB)

.

Figure 3-11. UAT TIS-B / ADS-R Service Status Format

d. The SIGNAL TYPE (Sig.) bit **shall [E257]** always be encoded as "1".

3.5 Security Requirements

3.5.1 General Requirements

a. The TIS-B/FIS-B Service **shall [E258]** comply with the security constraints identified in the SBS contract.

4 QUALITY ASSURANCE

The goal of Quality Assurance is to ensure that TIS-B/FIS-B Services are provided in accordance with the functional and performance requirements in §3 under stress and NAS loading conditions. This includes supporting initial certification of the Service as it is made available in each new Service Volume as well as monitoring the performance of the certified Service on an ongoing basis.

4.1 Test Program

4.1.1 General

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 [E3205]** develop and execute a quality assurance program that ensures all services provided meet all requirements specified in §3, as modified by the contract, and continue to meet the specified requirements on an ongoing basis.

b. The Service Provider **shall [E3207]** execute a testing program that verifies the achievement of the TIS-B/FIS-B Service requirements specified in §3.

c. Upon successful completion of Service Provider and Government qualification tests, the service implementation provided by the Service Provider **shall [E3208]** be an approved baseline configuration.

d. Additional service volumes provided by the Service Provider **shall [E3209]** be of the same baseline configuration.

4.1.2 Phases of Test

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 and Life Cycle Testing/Monitoring as defined in §4.1.2.1, §4.1.2.2, and §4.1.2.2.1.

a. In the event that changes to the baseline configuration are required, the Service Provider **shall [E3210]** perform Government approved Service Re-qualification tests as defined below.

4.1.2.1 First Article

a. Upon successful completion of Service Provider and Government Qualification Tests, the service implementation provided by the Service Provider **shall [E3211]** be an approved baseline configuration.

b. Additional service volumes provided by the Service Provider **shall [E3212]** be of the same baseline configuration.

4.1.2.1.1 Service Provider Qualification Tests

4.1.2.1.1.1 Factory Acceptance Test (FAT)

a. The Service Provider **shall [E3213]** 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.

4.1.2.1.1.2 Service Integration Test (SIT)

a. The Service Provider **shall [E3214]** 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 other systems or platform designated within the National Airspace System (e.g., SBS Monitor, radar data feeds).

4.1.2.1.1.3 Service Acceptance Test (SAT)

a. The Service Provider **shall [E3215]** 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 §4.1.2.2.

4.1.2.1.2 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 TIS-B/FIS-B services.

4.1.2.1.2.1 End-to-End System Test (EEST)

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

4.1.2.1.2.2 Operational Test and Evaluation (OT&E)

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

4.1.2.1.2.3 Independent Operational Test and Evaluation (IOT&E)

Evaluations 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.

4.1.2.2 Implementation

4.1.2.2.1 Implementation Service Acceptance Test (ISAT)

a. The Service Provider **shall [E3216]** perform Implementation Service Acceptance Tests at each post-key site installation prior to independent testing and assessment by the Government.

4.1.2.2.2 Implementation System Test (IST)

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

4.1.2.3 Life Cycle

4.1.2.3.1 Service Re-Qualification Test (SRQT)

a. The Service Provider **shall [E3217]** perform Service Re-Qualification Tests whenever the service baseline is modified.

b. The SRQT **shall [E3218]** verify that the service performance is maintained whenever changes are implemented by the Service Provider.

4.1.2.3.2 Service Performance Monitoring (SPM)

a. The Service Provider **shall [E3219]** perform Service Performance Monitoring Tests once a service volume is certified and operational.

b. SPM tests **shall [E3220]** verify the system continues to meet §3 requirements on an ongoing basis.

4.1.2.3.3 Government Performance Monitoring (GPM)

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

4.1.3 Verification Requirements Traceability Matrix (VRTM)

a. The Service Provider **shall [E3221]** develop a VRTM to illustrate the compliance to all §3 requirements in this specification.

b. Each requirement **shall [E3222]** be assigned a verification method, as defined in §4.1.4.

c. The verification of each requirement **shall [E3223]** be allocated to one or more test phases, as defined in §4.1.2.

4.1.4 Verification Methods

The acceptable methods for verifying each requirement are the following:

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.

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.

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.

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 GLOSSARY

1090ES	1090 megahertz Extended Squitter
A/V	Aircraft/Vehicle
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-R	Automatic Dependent Surveillance - Rebroadcast
AGL	Above Ground Level
AIRMET	Airman's Meteorological Information
AMEND	Unscheduled Amendments
ARSR	Air Route Surveillance Radar
ARTS	Automated Radar Terminal System
ASDE	Airport Surface Detection Equipment
ASDE-X	Airport Surface Detection Equipment with X-Band Radar
ASR	Airport Surveillance Radar
ASTERIX	All Purpose STructured Eurocontrol Radar Information EXchange
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATS	Air Traffic Services
AWW	Severe Weather Forecast Alerts
CD	Common Digitizer
CONUS	Conterminous United States
CRL	Current Report List
CWA	Center Weather Advisory
D-ATIS	Digital Automated Terminal Information Service
DLAC	Data Link Applications Coding
dBm	Decibels relative to a milliwatt
dBW	Decibels relative to a Watt
ECG	En Route Communication Gateway
ECGP	En Route Communication Gateway Protocol
FAA	Federal Aviation Administration
FDC	Flight Data Center
FIS-B	Flight Information Service – Broadcast

G-AIRMET	Graphical AIRMET
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
Hz	Hertz
ICD	Interface Control Document
ID	Identification
IP	Internet Protocol
kbps	Kilobits per second
kbyte	Kilobyte
kts	Nautical miles per hour (knots)
LSB	Least Significant Bit
MASPS	Minimum Aviation System Performance Standards
METAR	Meteorological Aerodrome Report
MHz	Megahertz
MLAT	Multilateration
MRMS	Multi-Radar Multi Sensor
MSB	Most Significant Bit
MSL	Mean Sea Level
NAC_P	Navigation Accuracy Category - Position
NAC_V	Navigation Accuracy Category - Velocity
NAS	National Airspace System
NEXRAD	Next Generation Weather Radar
NIC	Navigation Integrity Category
NM	Nautical Mile
NOTAM	Notice to Airmen
Pd	Probability of Detection
PIREP	Pilot Report
PPM	Parts Per Million
RF	Radio Frequency
rms	root mean square
SDP	Service Delivery Point

SIGMET	Significant Meteorological Information
SIL	Surveillance Integrity Level
SPECI	Unscheduled Specials
SSR	Secondary Surveillance Radar
SUA	Special Use Airspace
TAF	Terminal Area Forecast
TFR	Temporary Flight Restriction
TIS-B	Traffic Information Service – Broadcast
TMOA	Temporary Military Operations Area
TRA	Temporary Restricted Area
TRACON	Terminal Radar Control
TWIP	Terminal Weather information for Pilots
UAT	Universal Access Transceiver
UDP	User Datagram Protocol
UTC	Universal Coordinated Time
W	Watt
WAAS	Wide Area Augmentation System
WJHTC	William J. Hughes Technical Center
WW	Severe Weather Watch Bulletin

APPENDIX A TIS-B Performance Scenarios

This Appendix provides the accuracy and track reliability requirement verification scenarios for the TIS-B Service. The scenarios in this Appendix pertain to the performance requirements in §3.3.2.10.

A.1 ACCURACY REQUIREMENT VERIFICATION SCENARIOS FOR POSITION, HEADING AND SPEED

The radars used in the requirements verification have the characteristics in Table A-1.

Table A-1. Sensor Characteristics for Test Scenarios

	Sensor Channel	
	ATCRBS	**Primary**
Long-Range Radars		
Scan time	10 – 12 seconds	10 – 12 seconds
False reports	Less than 1/scan	Less than 350/scan
Blip/Scan	95%	90%
Azimuth standard deviation	0.23 degrees	0.18 degrees
Azimuth quantization	0.0879 degrees	0.0879 degrees
Range standard deviation	0.12 NM	0.08 NM
Range quantization	0.125 NM	0.125 NM
Altitude standard deviation*	50 feet	-
Altitude quantization	100 feet	-
Maximum radar bias		
Range	0.5 NM	0.5 NM
Azimuth	0.176 degrees	0.176 degrees
Short-Range Radars		
Scan time	4 – 5 seconds	4 – 5 seconds
False reports	Less than 1/scan	Less than 350/scan
Blip/Scan	95%	90%
Azimuth standard deviation	0.23 degrees	0.18 degrees
Azimuth quantization	0.0879 degrees	0.0879 degrees
Range standard deviation	0.04 NM	0.04 NM
Range quantization	0.0156 NM	0.0156 NM
Altitude standard deviation*	50 feet	
Altitude quantization	100 feet	
Maximum radar bias		
Range	0.125 NM	0.125 NM
Azimuth	0.176 degrees	0.176 degrees

* Includes altitude quantization

A.1.1 SCENARIOS FOR POSITION, HEADING, SPEED ACCURACY PERFORMANCE VERIFICATION

In this section flight paths are identified for performance evaluation in the following areas:

- steady state (i.e., straight line flight) track quality,
- transient state (i.e., maneuver and linear acceleration) track quality,
- single versus multi-sensor track quality.

Verification of the requirements is based on government furnished scenarios for AAS performance requirements presented in [3]. For the multi-sensor runs, two types of configurations of three sensors are provided. The first configuration consists of three long range radars, shown in Figure A-1, and the second configuration consists of two short range radars and one long range radar, shown in Figure A-2. In each configuration, the central sensor is located at (0,0). Additional sensor 1 is at the radial 315 at the range of 40 NM from the central sensor (when the central sensor is a short range sensor) and at a range of 100 NM (when the central sensor is a long range sensor). Additional sensor 2 is at radial 180 degrees at a range of 100 NM from the central sensor and is always a long range sensor.

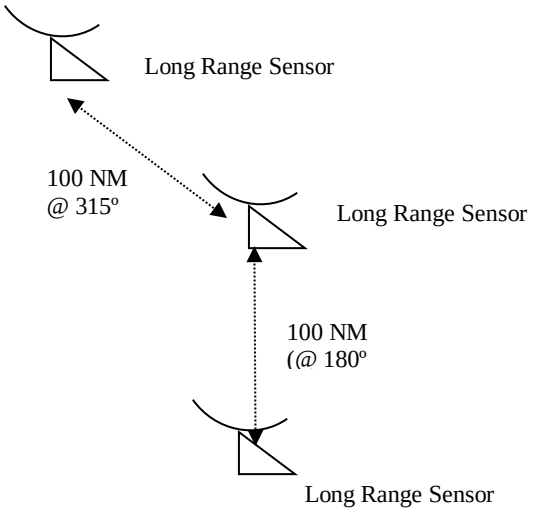


Figure A-1. Configuration of Three Long Range Sensors

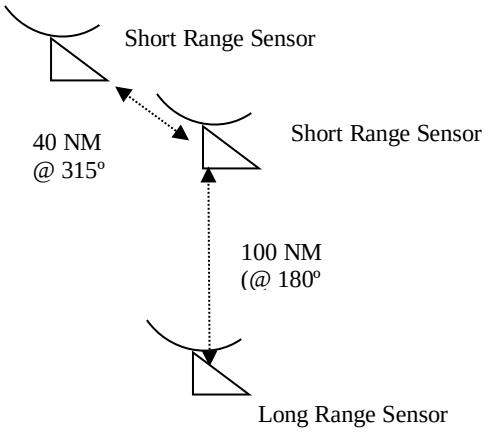


Figure A-2. Configuration of Two Short Range Sensors and One Long Range Sensor

Figure A-3 illustrates the flight scenarios for the configuration where the central sensor is a short range radar and the additional sensors are one short and one long range radar. The flight paths are shown with respect to the central sensor. Figure A-4 illustrates the flight scenarios for the configuration where all the sensors are long range radars.

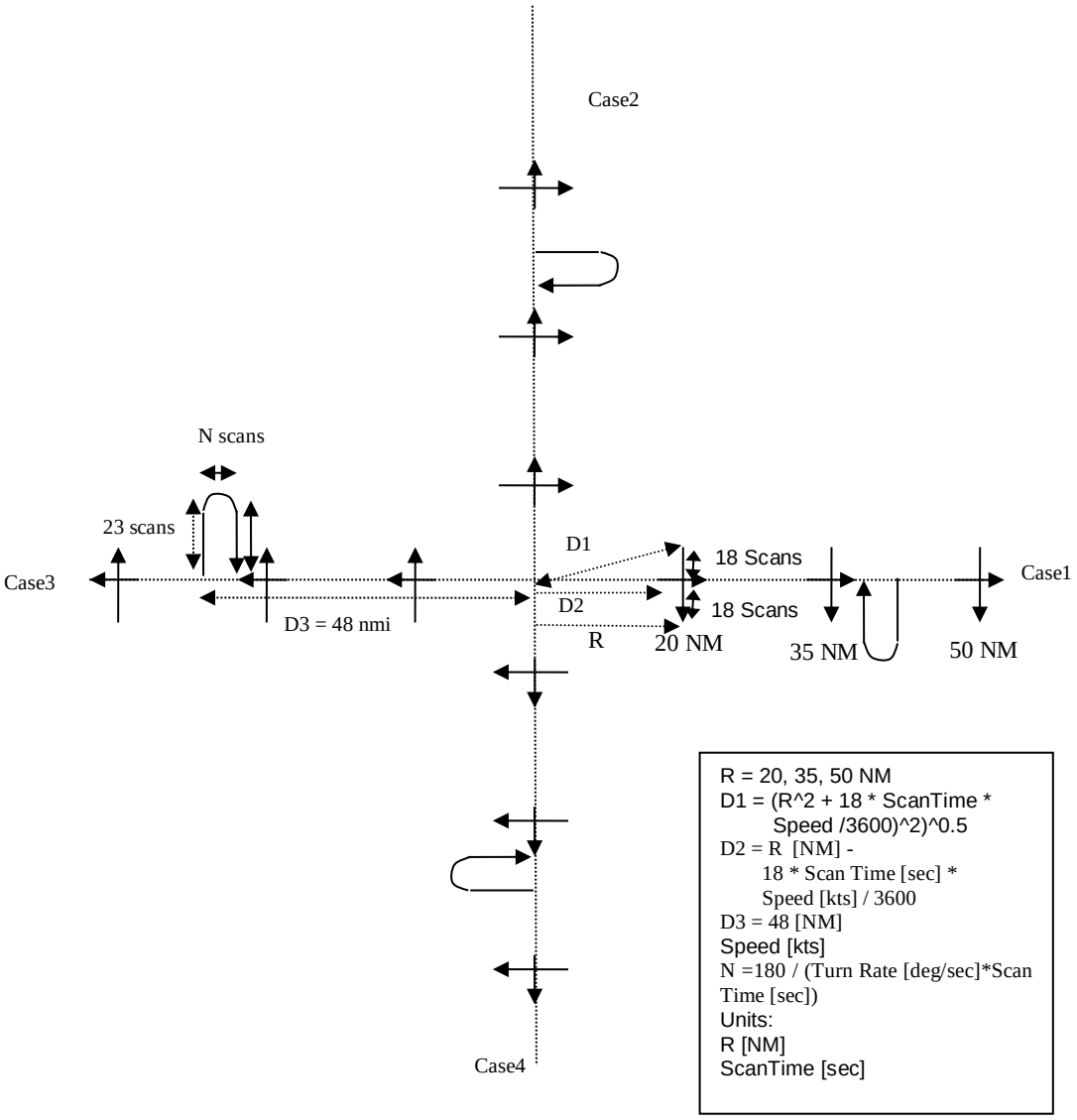


Figure A-3. Scenario for Configuration with Two Short Range Sensors and One Long Range Sensor

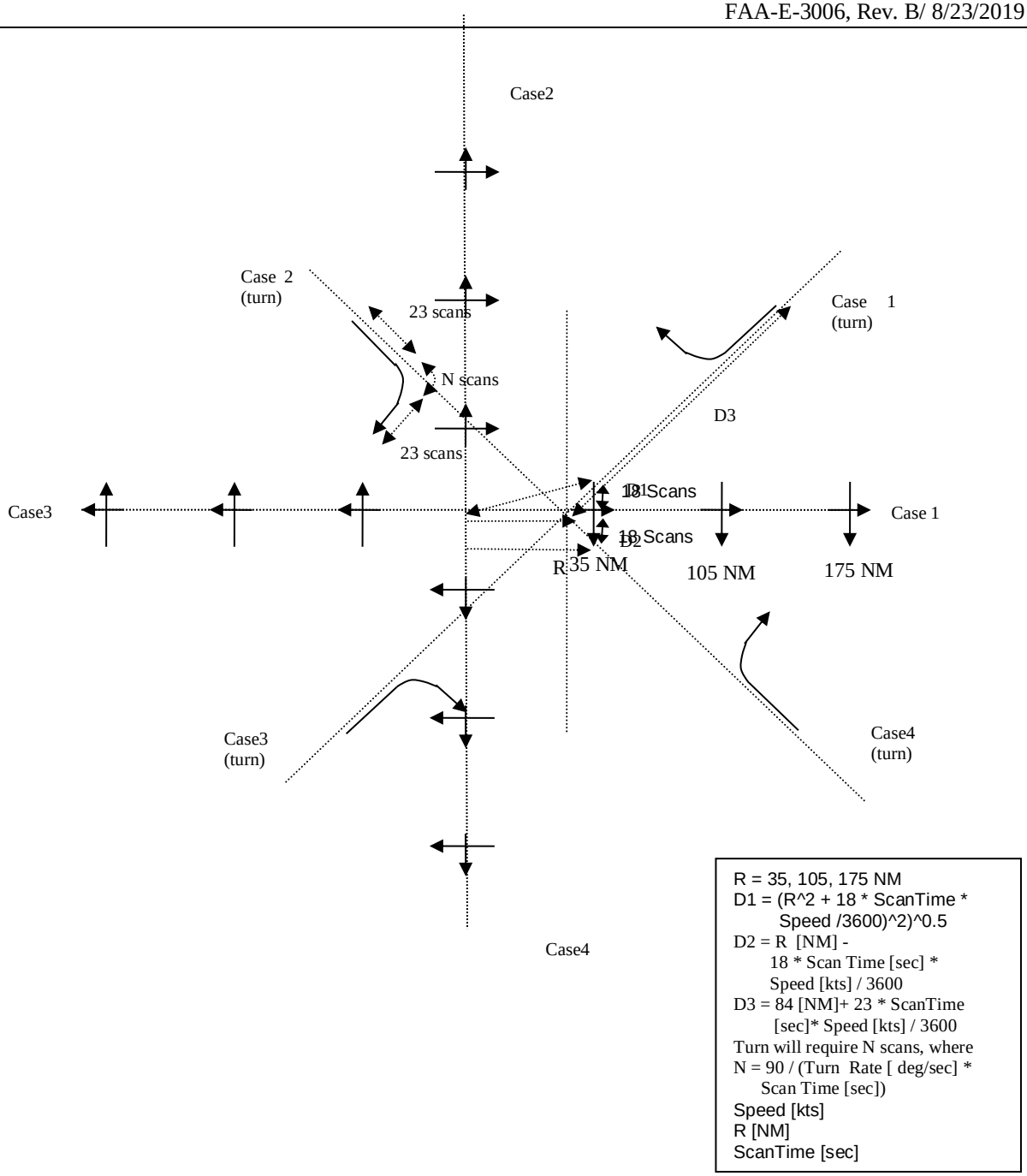


Figure A-4. Scenario for Configuration with Three Long Range Sensors

Since the tracking performance test results are statistical measures, it is important that they not be sensitive to sample size. The performance parameters in the existing documents were computed by running 100 Monte Carlo iterations. There are a number of approaches to generating an input file that does not require running 100 cases sequentially. One approach would be to generate for each flight path case (referenced in Table 3-9) 100 flight paths with identical characteristics except for 500 feet separation in altitude. However, due to the possibility of exceeding the maximum loading constraints of the tracker (i.e., target density within a beamwidth), two techniques were adopted: (1) distributing the 100 flight paths over 360 degrees or (2) staggering the 100 flight paths in time by up to six scans.

To validate the requirements associated with single sensor accuracies, 50 radial and tangential flight paths are distributed over 360 degrees, separated by 7.2 degrees, and the scenario is run twice to generate the requisite 100 flight paths. The plots of these radial and tangential scenarios are shown in Figure A-5 and Figure A-6 for the short range radar and long range radar configurations, respectively. The FAA Multi-Sensor Surveillance Simulator (MSSS) is used to generate these scenarios.

To validate the requirements associated with the multi-sensor accuracies (the values shown in parentheses in Table 3-9), the 100 flight paths are staggered in time by up to six scans. Figure A-7 and Figure A-8 depict the multi-sensor scenarios for radial, tangential, turning and linear acceleration for the short range and long range configurations, respectively. The straight legs of the turning scenarios serve dual purposes, i.e., they are used for computing radial or tangential accuracies when appropriate. In the long range configuration, the 90 degree turn is not only used to compute the accuracies during the turn, but also to compute the accuracies during the radial leg (before the turn) and tangential leg (after achieving steady state) of the turn as shown in Figure A-8. This is a compromise because the flight paths for the multi-sensor radial and tangential accuracies in Table 3-9 were referenced to "case 3" in Figure A-4; this is at a different location than the turning flight path of Figure A-8. In the short range configuration, the straight leg before the 180 degree turn can be used for computing the tangential accuracies. Its location, shown in Figure A-7, is very close (off by 2 miles) to the location specified in Table 3-9 (case 3 of Figure A-3). However, the 180 degree turn does not provide an opportunity for computing radial accuracies.

To validate the requirements associated with linear acceleration/deceleration, 100 flight paths are staggered in time by 30 seconds; with targets starting at the maximum range south-west of the central radar and traveling east along a parallel line 20 nautical miles south of the central sensor (see Figure A-7 and Figure A-8 for the short range and the long range configurations, respectively). For the first 23 scans, the initial speed of the targets is 250 knots. Afterwards, the targets accelerate at 1 knot/sec for 400 seconds to reach 650 knots, after which the targets maintain constant speed for another 23 scans. This is followed by a deceleration at 1 knot/sec for 400 sec to reach 250 knots after which the speed is held constant for another 23 scans. The scenario takes 18 minutes and 38 seconds for each of the 100 staggered targets. Data collection to verify the accuracy requirements will begin after the first 23 scans.

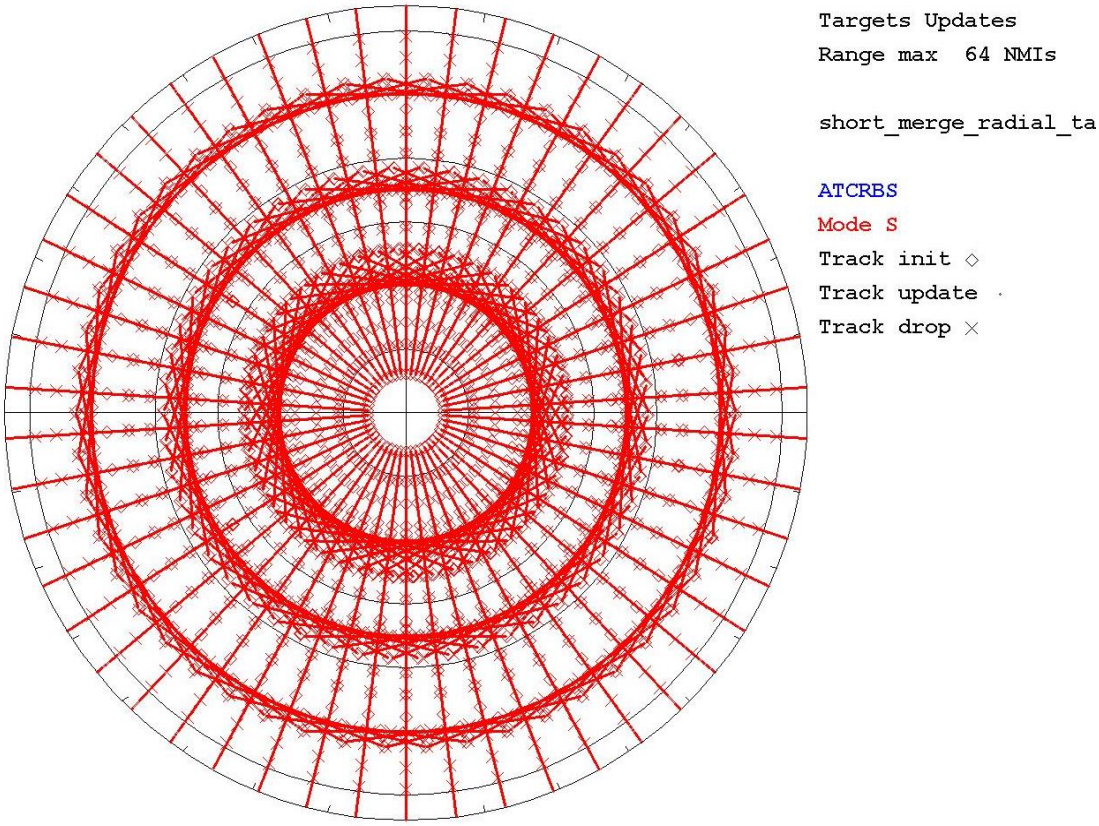


Figure A-5. Radial and Tangential Flight Paths for Computing Single Sensor Accuracies for the Short-Range Radar

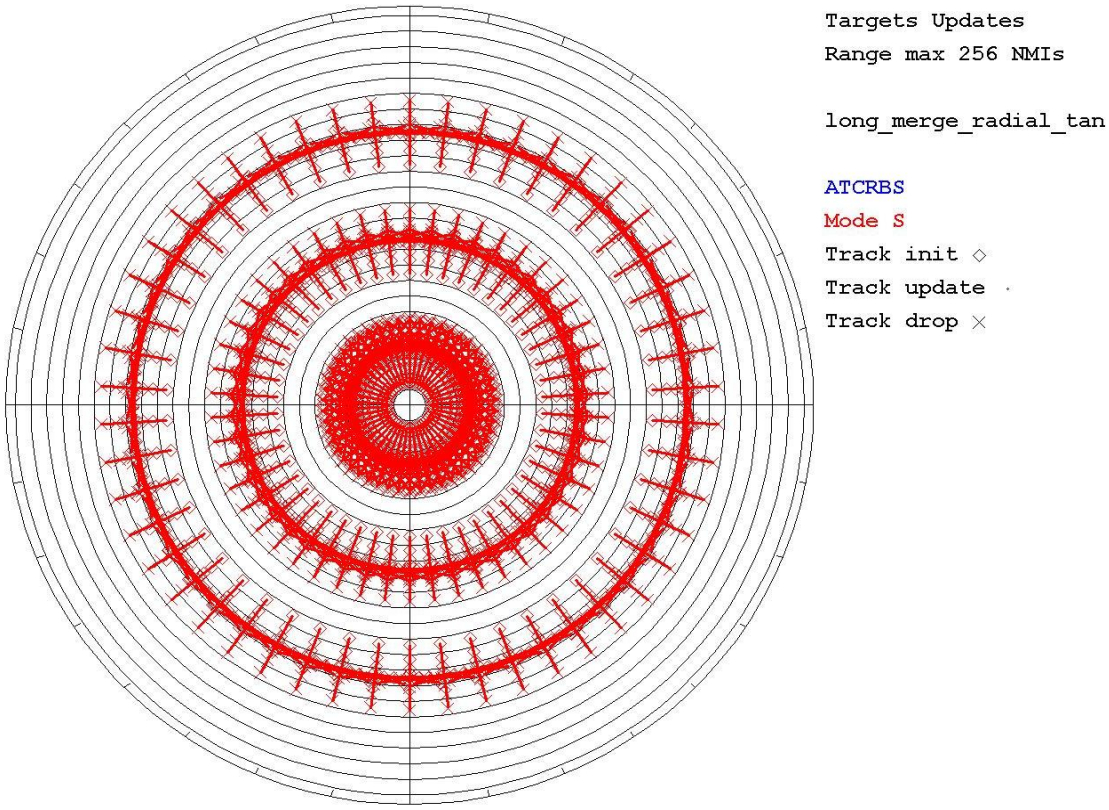


Figure A-6. Radial and Tangential Flight Paths for Computing Single Sensor Accuracies for the Long Range Radar

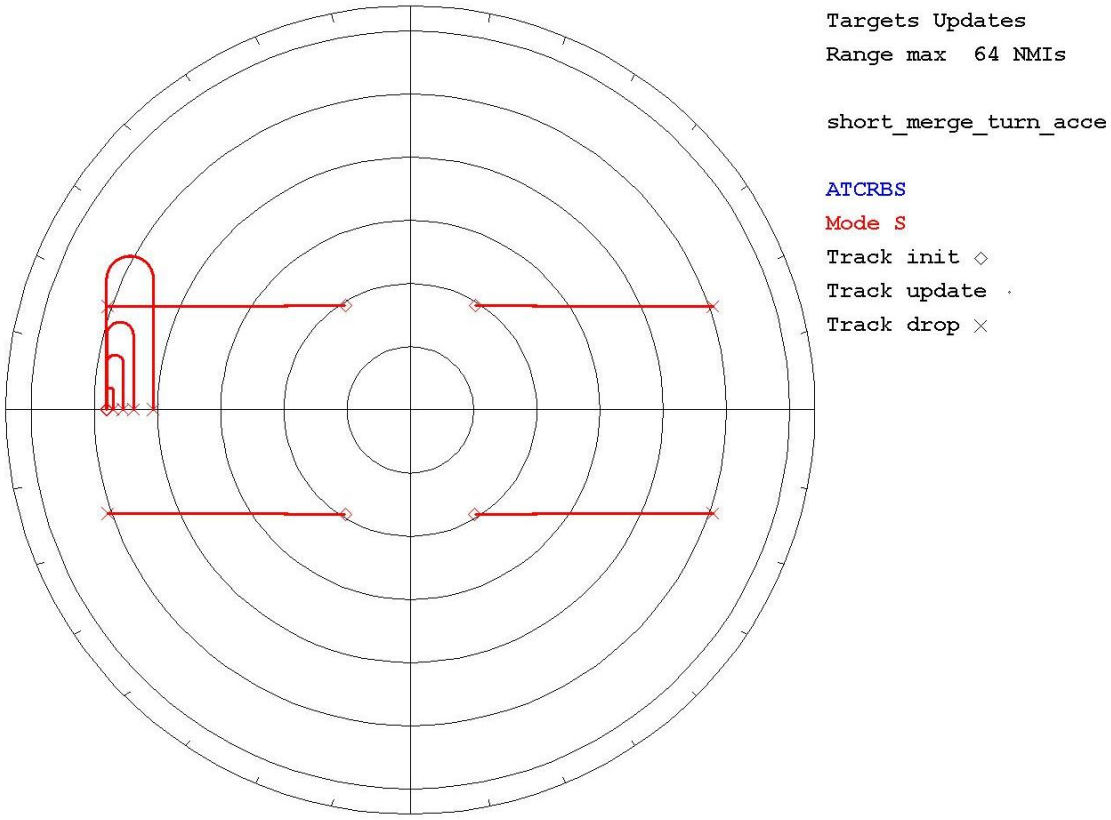


Figure A-7. Multi-Sensor Scenarios for Computing Turning, Tangential and Linearly Accelerating Accuracies for the Short-Range Radar Configuration

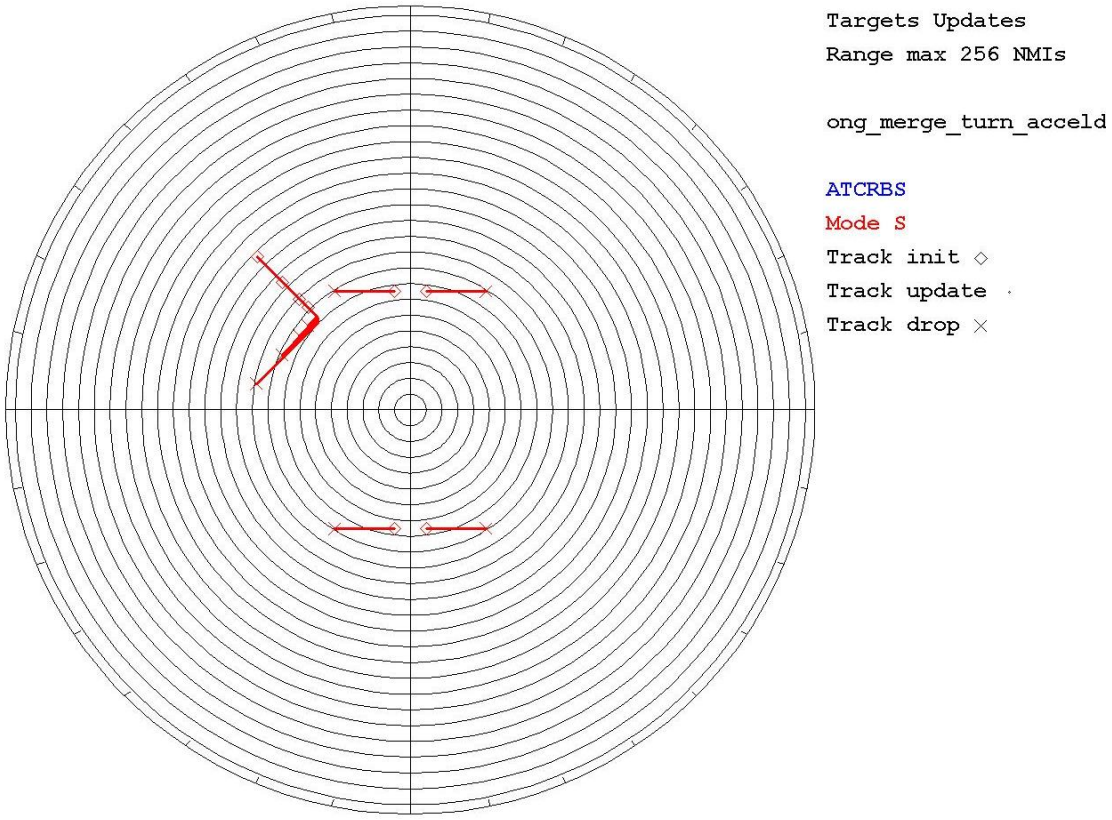


Figure A-8. Multi-Sensor Scenarios for Computing Turning, Tangential, Radial and Linearly Accelerating Accuracies for the Long-Range Radar Configuration

A.2 ACCURACY REQUIREMENTS FOR ALTITUDE AND ALTITUDE VELOCITY

A.2.1 SCENARIOS FOR ALTITUDE AND ALTITUDE VELOCITY ACCURACY PERFORMANCE VERIFICATION

As was the case in §A.1 for the position, heading and speed accuracy performance requirements, the altitude and altitude velocity accuracy requirements are defined specific scenarios. In this case, the two scenarios are called Straight Flight and Altitude Maneuver. Each scenario has targets within an area 400 x 400 nautical miles that is centered within a Surveillance Coverage Volume of 1000 x 1000 nautical miles. Within the Surveillance Coverage Volume are 64 radars, 19 short-range radars (nominal coverage is 60 NM) and 45 long-range radars (nominal coverage is 250 NM). The layout of the radars is shown in Figure A-9. Each radar has a blip/scan ratio of 98%. Each target is reported by no more than four radars.

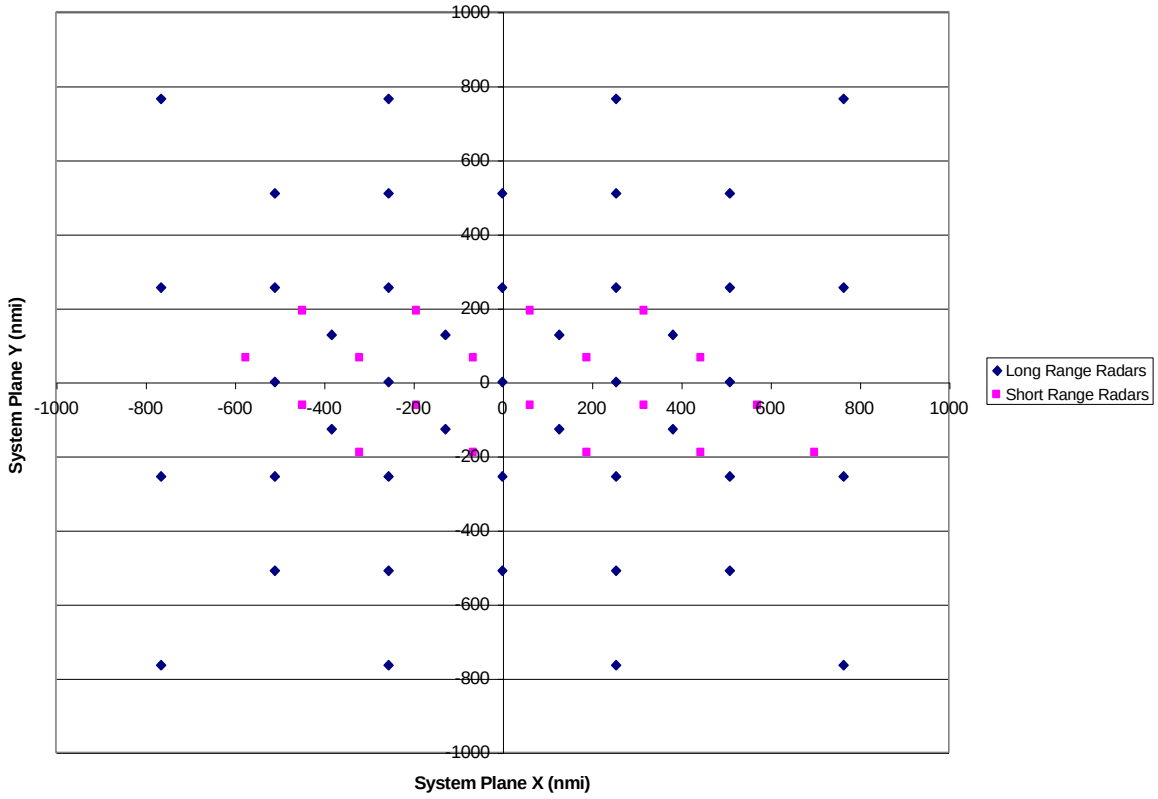


Figure A-9. Radar Locations for Altitude and Altitude Velocity Scenarios

In straight and level flight, each target will fly at a constant speed, between 250 and 500 knots, a constant heading, and a constant altitude, between 10,000 and 20,000 feet. This scenario duration is 10 minutes. Data collection to verify the accuracy requirements will begin at the start of the second minute of scenario time.

In altitude maneuvering flight, for the first minute of scenario time, the targets will fly at a constant speed between 250 and 500 knots, a constant heading and a constant altitude of 20,000 feet. Afterwards, half of the targets will ascend and half will descend for three minutes, after which the scenario ends. The absolute altitude change rate for each target will be constant (randomly determined within a range of 0 to 3,000 feet/min). This scenario duration is four minutes. Data collection to verify the accuracy requirements will begin at the start of the second minute of scenario time.

A.3 TRACK RELIABILITY

In this section, the track swap and track loss requirements with appropriate scenarios are provided. These requirements are taken from the STARS functional requirements [2].

A.3.1 TRACK SWAP REQUIREMENTS

Track swap probability is the probability that a track ceases to correlate with the correct target and instead tracks a proximate target after a swap opportunity. A track swap occurs if it results in a persistent misidentification (five scans) or a track loss after a swap opportunity. The track swap requirements are base upon the following assumptions. Two aircraft tracked with beacon-only reports should not swap if the codes are different. This applies to the discrete code track vs. discrete code track (different codes) and discrete code

track vs. non-discrete code track environments. An aircraft that is tracked with non-discrete beacon-only reports should not swap with an aircraft that is tracked with search-only reports.

Scenarios depicted in Figure A-10 to Figure A-12 consist of 16 pairs of targets of discrete coded targets in straight and level flight [1]. The scenarios are each run six times, each time under different radar noise situations. The six runs create 192 discrete tracks. Discrete Track Swap probability is computed by dividing the total number of swaps by the total number of swap pairs (96) and expressing the result as a percentage.

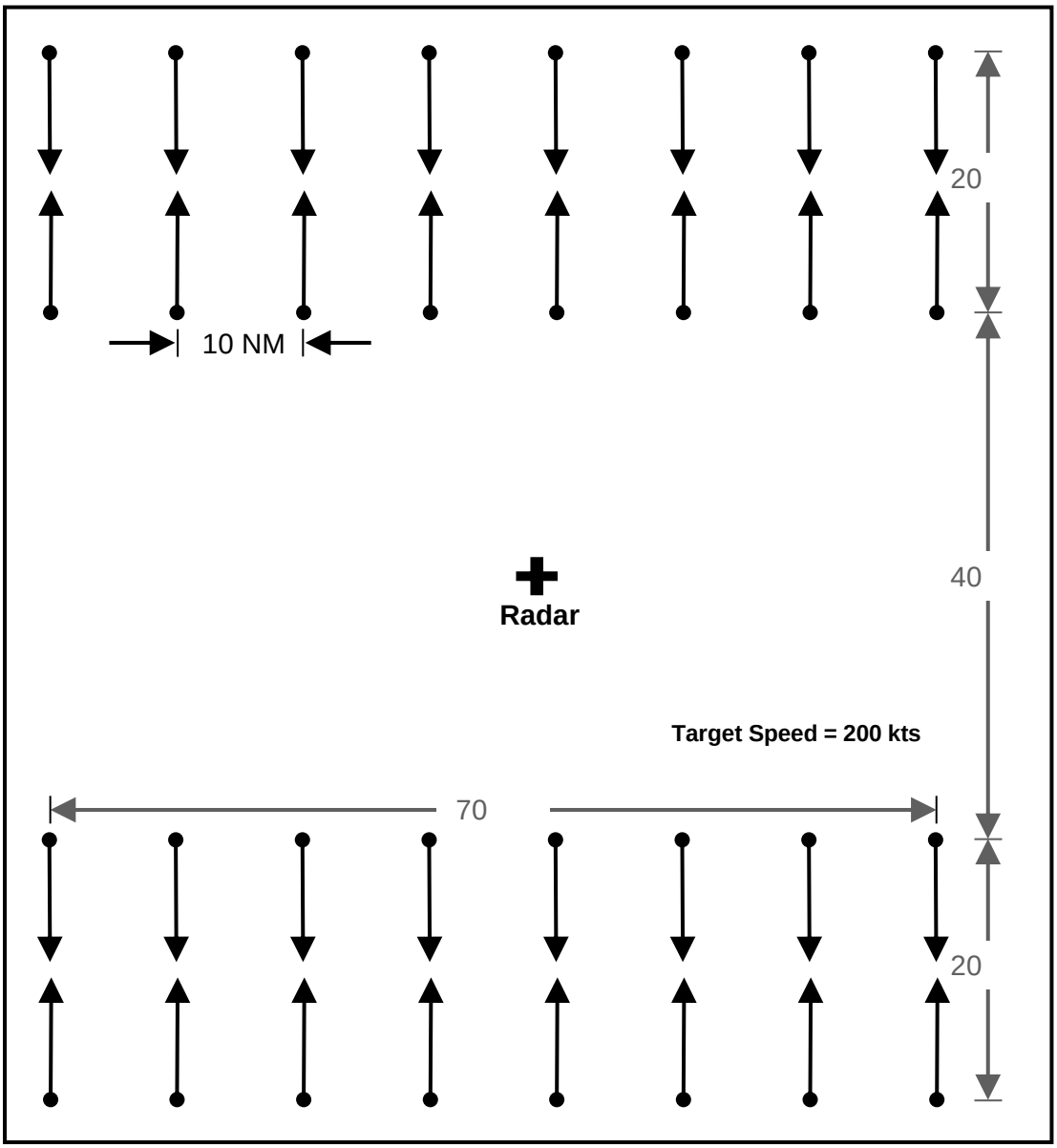


Figure A-10. Head-On Approach Scenario

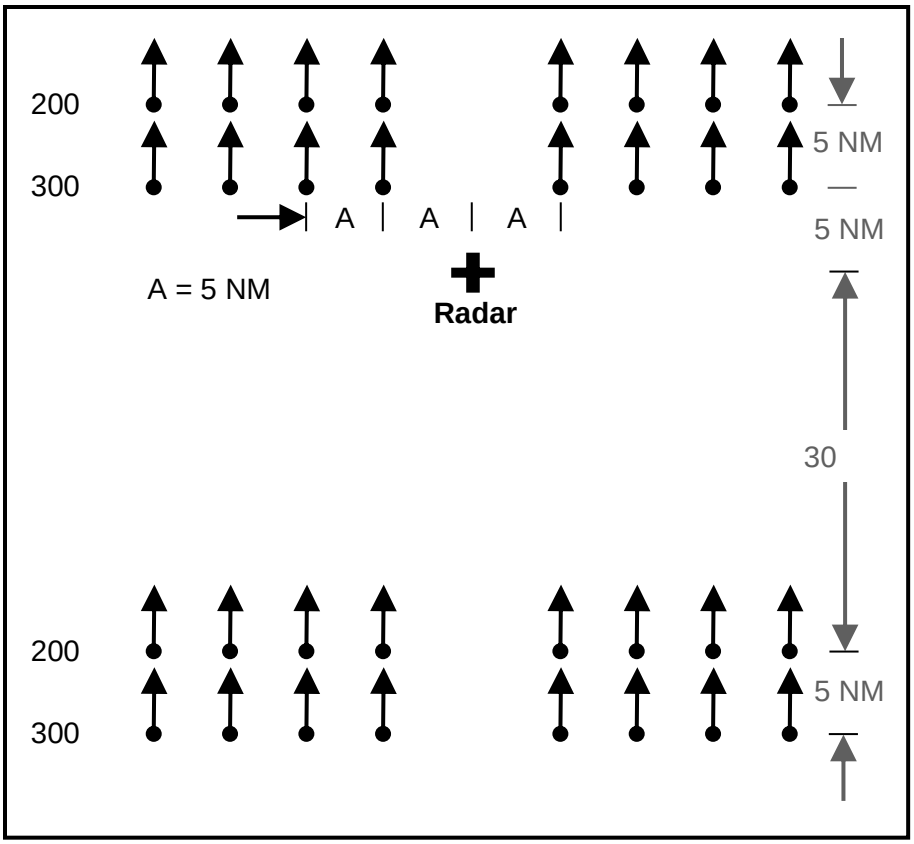


Figure A-11. 100 kt Overtake Scenario

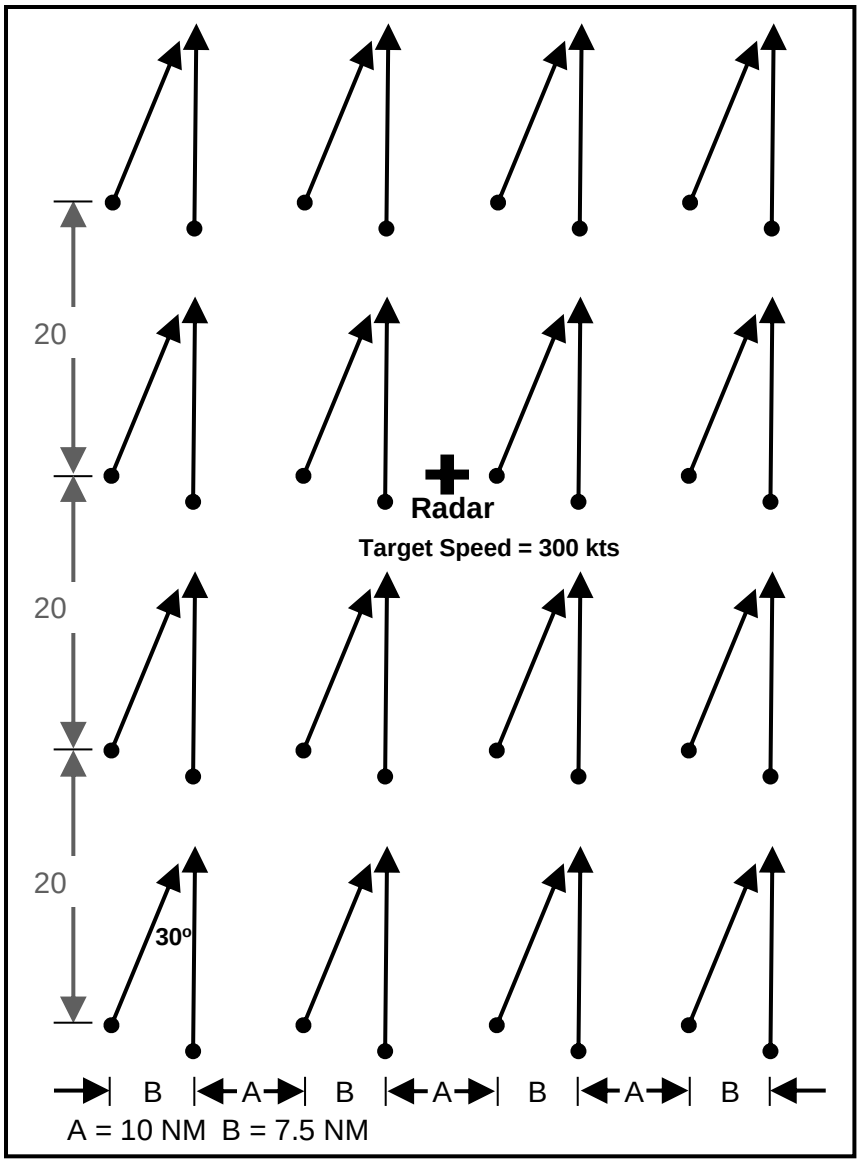


Figure A-12. 30° Crossing Scenario

A.4 TRACK LOSS SCENARIO

The Track Loss scenario consists of 16 pairs of discrete coded targets in straight and level flight in 30 degree crossing situations as shown in Figure A-12. The scenario is run six times, each under different radar noise situations. The six runs create 192 discrete tracks. The scenario in Figure A-12 is run again, this time one target in each pair has a discrete code and the other target has a non-discrete code. The scenario is run six times, each time under different noise situations and with different aircraft identifications. The six runs create 96 discrete coded tracks.

Discrete track loss probability is computed by dividing the total number of losses by the total number of discrete tracks (192+96=288 tracks) and expressing the result as a percentage.

A.5 REFERENCES FOR THIS APPENDIX

1. Miskill, D. K., January 1977, Technical Performance of the ARTS III Tracking Function, MTR-7300, The MITRE Corporation
2. Bodie, S.R., Sarantakis, B.K., August 1995, Development Methodology for the Standard Terminal Automation Replacement System (STARS) Functional Requirements MTR-95W0000071
3. IBM, Radar Data Processing Performance Evaluation, DTFA01-84-C-00039
4. Lockheed Martin Corporation, En Route Automation Modernization (ERAM) Software Requirement Specification (SRS) Surveillance, FAA-ERAM-2005-0012, : January 27, 2005
5. Cratch, P. H., Geoghan, R.D., STARS Evaluation Results for Tracking and Safety Functions, July 2001

APPENDIX B Current Report List

B.1 CURRENT REPORT LIST

The Current Report List is conveyed within Frame Type 14. The Current Report List frame is encoded within the UAT Uplink message as shown in Figure B-1.

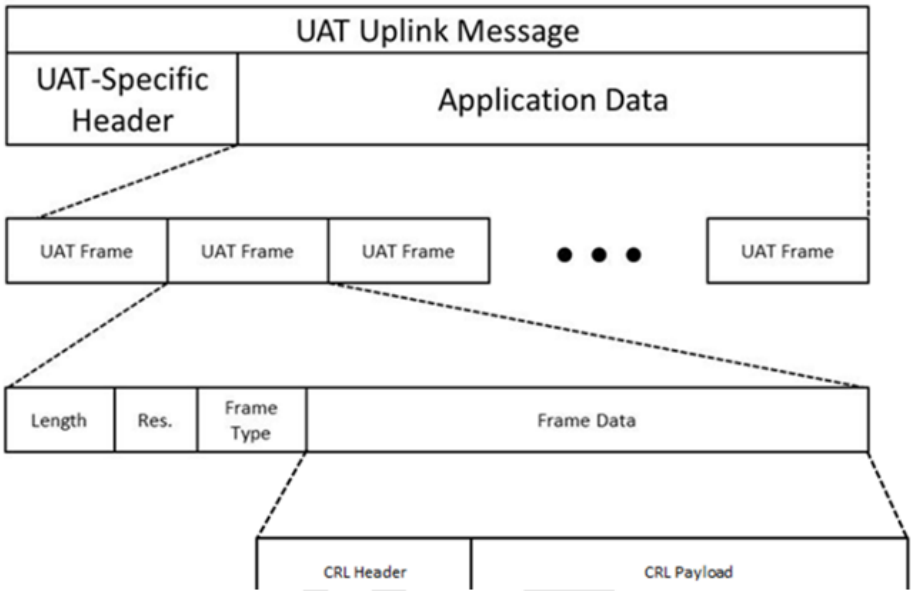
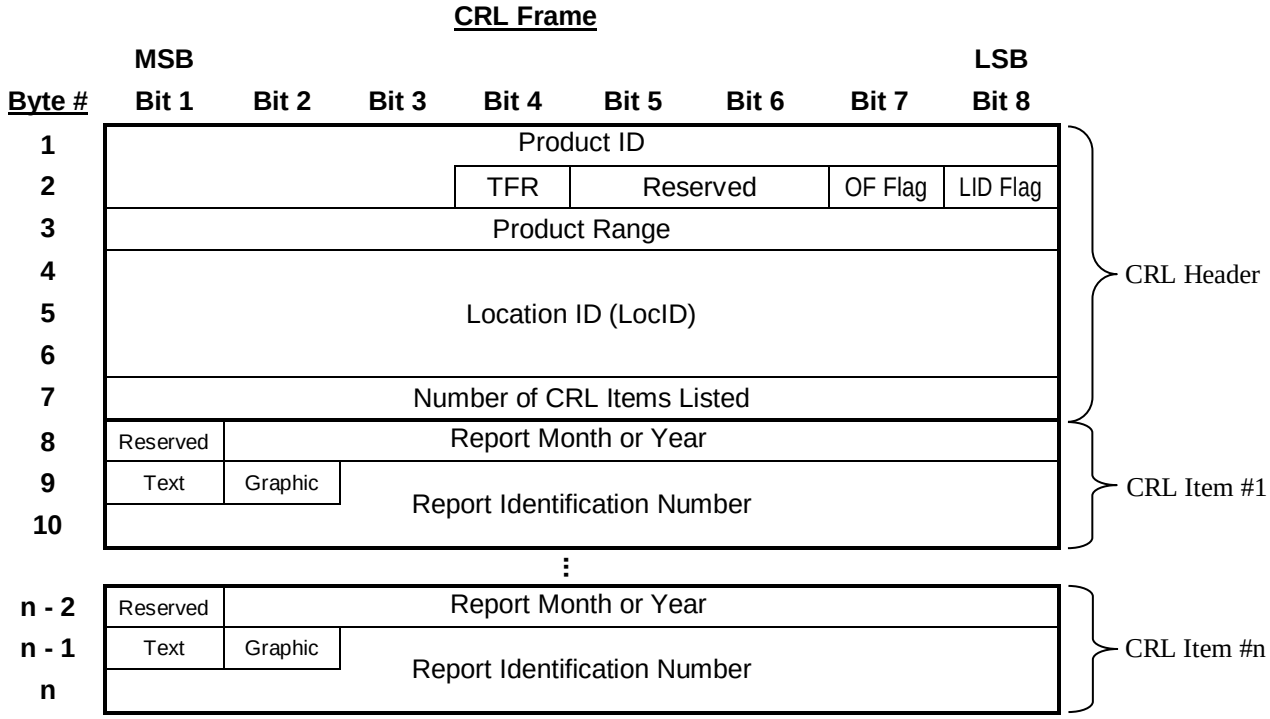


Figure B-1. Current Report List Frame

Each CRL Frame is contained in a single uplink burst that fits within the application data payload. The length of a CRL Frame cannot exceed 424 bytes. For efficiency, small CRL Frames can be packed into a single uplink burst as long as each packed CRL Frame is fully contained in the burst (424 bytes maximum).

B.1.1 CRL HEADER AND PAYLOAD ENCODING

The CRL Frame is formatted as shown in Figure B-2.



Notes:

1. n = 7 + (Number of Reports * 3) when Location ID is included
2. n = 4 + (Number of Reports * 3) when Location ID is not included
3. Maximum Number of Reports in a single Frame is 138

Figure B-2. Current Report List Encoding

A CRL Frame contains a CRL Header and either zero, one, or multiple CRL Items. Each list item will refer to the Report Month/Year and the Report Identification Number for each report transmitted for a particular product specified by the product ID in the CRL Header. When no reports are currently being uplinked for a given Product ID, a NULL CRL is uplinked. A NULL CRL contains the Product ID, the Product Range, and ZERO (0) CRL Items. While it is not expected that a CRL would exceed 138 reports, if more than 138 reports are available for a particular product from a single radio, the first 138 CRL Items will be listed in the CRL frame and the Over-Flow (OF) Flag will be set to 1 to indicate that not all Items are being uplinked in the CRL.

B.1.1.1 PRODUCT ID

The Product ID field is an 11 bit filed that corresponds to the Product ID of the reports found in the CRL Items. The Product ID field is set to 8 for TFR NOTAMs, 11 for AIRMETs, 12 for SIGMETs, 14 for G-AIRMETs and 15 for CWA. TRA and TMOA Product IDs are set in accordance with the latest version of RTCA DO-358.

B.1.1.2 TFR

This bit is used to specify that the CRL for Product ID #8 (NOTAMs) refers to those NOTAMs defined as TFRs. The CRL is only sent for these types of NOTAMS but may

be expanded in the future to include other types such as D-NOTAMS. This bit has no meaning for other product ID values.

B.1.1.3 RESERVED

This 2-bit field is reserved for future use and is set to ALL ZEROs.

B.1.1.4 LID FLAG

The LID Flag field indicates whether the LocID field is included in the CRL Header. The field is set to ONE (1) if the LocID field is present and ZERO (0) if the LocID field is not present. This flag is currently set to ZERO (0) by the FIS-B Service because the LocID field is not provided with the AIRMET, SIGMET, and TFR NOTAM CRLs.

B.1.1.5 PRODUCT RANGE

This field defines the look ahead range in nautical miles for the Product ID represented in this CRL. The CRL encompasses all the products with this ID that are within this look ahead range relative to the position of the broadcasting radio station. The Product Range is represented by a 8 bit value with an LSB of 5NM. Therefore, the Product Range has values from 0 to 1275NM in 5NM increments.

B.1.1.6 LOCATION ID

The LocID field indicates the local identifier associated with the reports found in the CRL Items. It is optional and reserved for future use by the FIS-B Service for D-NOTAMS.

B.1.1.7 NUMBER OF CRL ITEMS LISTED

This field indicates the number of items in the CRL Frame. When there are no reports currently being uplinked, the FIS-B service will set this field to ZERO (0),to provide the avionics a positive indication that there are no current reports being transmitted for this Product ID. The maximum value possible for this field is 138 reports.

B.1.1.8 OF FLAG

This field indicates an overflow condition for the CRL. If more than 138 reports are transmitted by a Radio Station for any single Product ID, then the OF flag is set to ONE (1) to indicate that all products being uplink by the radios are not included in the CRL for this Product ID. Otherwise this flag is set to ZERO (0)

B.1.1.9 RESERVED BIT

This field is reserved and set to ZERO (0) to maintain byte boundary consistency.

B.1.1.10 REPORT MONTH OR YEAR

The Report Month or Year field indicates the month or year of the report within each CRL List Item.

B.1.1.11 TEXT

The Text bit is set to indicate this report is associated with a Textual record.

B.1.1.12 GRAPHIC

The Graphic bit is set to indicate this report is associated with a Graphical record.

B.1.1.13 REPORT NUMBER

The Report Number field provides the unique report identifier for the Product ID report associated with this CRL Item.

APPENDIX C Text Record Truncation

C.1 TRUNCATION OF LONG TEXT RECORDS

C.1.1 BACKGROUND

The format of the text record for the Text with Graphic Overlay product class (specifically NOTAMs, AIRMETs and SIGMETs) accommodates a text record length of up to 65 kilobytes. A small subset of NOTAMs have been observed to have text records that consist of thousands of characters. Long text records such as these are problematic in the cockpit due to a) pilot workload, b) cockpit display space, and c) the excessive segmentation required to uplink the entire text record. This last factor tends to make these reports much less robust since if any one of potentially dozens of segments is missing, the entire report must be discarded.

C.1.2 SOLUTION

Truncate the Text Record at 1500 DLAC characters to include an indication that the text record is incomplete

C.1.3 ALGORITHM DESCRIPTION OF TRUNCATION

If the Text Record is greater than 1500 DLAC characters (1125 bytes), truncation will be performed.

The first 1119 bytes of the Text Record are retained, with all further bytes discarded.

The next 6 bytes of the payload will be filled with the string “(INCMPL)”, after it is DLAC encoded. The 8-character string “(INCMPL)” translates to the following pattern of 48 bits in DLAC encoding:

101000 001001 001110 000011 001101 010000 001100 101001

(I N C M P L)

The first 1119 bytes of the Text Record are concatenated with the 6 bytes containing the “INCMPL” indication. The 1125 byte Text Record is then uplink by the FIS-B Service.