RTCA, Inc.
1150 18th Street, NW, Suite 910
Washington, DC 20036-4001, USA

Minimum Operational Performance Standards (MOPS) for Flight Information Services Broadcast (FIS-B) with Universal Access Transceiver (UAT)

RTCA DO-358
March 24, 2015

Prepared by SC-206

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RTCA, Inc.
1150 18th Street, NW, Suite 910
Washington, DC 20036-4001, USA

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

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FOREWORD

This report was prepared by Special Committee 206 (SC-206) and approved by the RTCA Program Management Committee (PMC) on March 24, 2015.

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- Developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and
- Assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

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1 PURPOSE AND SCOPE

1.1 Introduction

This document contains Minimum Operational Performance Standards (MOPS) for Flight Information Services Broadcast-System (FIS-B) with Universal Access Transceiver (UAT). These standards specify system characteristics that should be useful to designers, manufacturers, installers and users of the equipment.

Compliance with these standards is recommended as one means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operation. Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

This document considers an equipment configuration consisting of the airborne processing and cockpit display of aeronautical and meteorological data known as FIS-B provided by the Federal Aviation Administration (FAA).[1] Functions or components that refer to equipment capabilities that exceed the stated minimum requirements are identified as optional features.

Section 1 of this document provides information needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment operations and operation goals, as envisioned by the members of Special Committee 206 (SC-206), and establishes the basis for the standards stated in Section 2. Definitions and assumptions essential to proper understanding of this document are also provided in this section.

Section 2 contains the minimum performance standards for the equipment. These standards specify the required performance under standard environmental conditions. Also included are recommended bench test procedures necessary to demonstrate equipment compliance with the stated minimum requirements.

Section 3 describes the performance required of installed equipment. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Section 4 lists the members of SC-206 who developed the document.

APPENDIX A, a normative appendix, provides formatting and encoding details of FIS-B Uplink Products, including the UAT Ground Uplink Message formatting, the Application Protocol Data Unit (APDU) header formatting and encoding, as well as each FIS-B product report in both textual and graphical representations, as applicable.

APPENDIX B gives the definition of a FIS-B report, describes the components of the FIS-B report, describes the FIS-B report relationship to the APDU that conveys it and provides guidance for identifying and purging redundant FIS-B reports.

APPENDIX C provides the update and transmission intervals for each FIS-B product uplinked.

APPENDIX D provides background information on the "tiered" approach used for assigning channel resources to each of the radio stations in the ground network.

[1] The FIS-B service is part of the FAA's Surveillance and Broadcast Services System.

APPENDIX E gives background on the processing of the Next-Generation Radar (NEXRAD) sensor data for uplink. It includes an accounting of the latency components along the processing chain.

APPENDIX F gives some background on the approach used within the FIS-B Radio Station in generating and uplinking the Current Report List (CRL).

APPENDIX G describes the process used by the radio stations to transmit in their assigned channel resources.

APPENDIX H gives rationale for not processing the uplink of Special Use Airspace (SUA) products.

APPENDIX I specifies an acceptable time-based method for an "all-at-once" update of the NEXRAD image on the cockpit display.

0 describes some potential evolution of the FIS-B Ground System with the intent to motivate manufacturers to provide some mechanism for field updateability of the FIS-B avionics.

The word "equipment" as used in this document includes all components and units necessary for the system to properly perform its intended function(s). For example, the "equipment" may include a processor that receives packetized data ported from the UAT, reassembles and then displays that selectable information on the flight deck. In the case of this example, all of the foregoing components and units comprise the "equipment." It should not be inferred from this example that each FIS-B design will necessarily include all of the foregoing components or units. This will depend on the specific design chosen by the manufacturer.

This MOPS applies to a specific defined function. The equipment may have additional features related to that function for which there is no specified minimum performance requirement. For example, FIS-B products may be displayed in alternative ways as part of value-added services. Equipment may also have additional functions for which other MOPS or Technical Standard Orders (TSOs) may be applicable or it may contain additional functions not defined by any MOPS or TSO and non-TSO function guidance may be applicable.

If the equipment implementation includes a computer software package, the guidelines contained in RTCA document DO-178C/European Organisation for Civil Aviation Equipment (EUROCAE) European Document ED-12C, (or the most current published revision) *Software Consideration in Airborne Systems and Equipment Certification*, should be considered.

1.2 System Overview

The FIS-B service provides meteorological and aeronautical data to the cockpit. The high-level data flows supporting FIS-B are illustrated in Figure 1-1. The FIS-B Ground System Control Station (CS) ingests meteorological and aeronautical data and broadcasts generated sets of products specific to the location of a radio station. These products are broadcast over the UAT radio frequency link so pilots have timely information of regional meteorological and aeronautical information, including National Airspace System (NAS) status/changes that might impact flight.

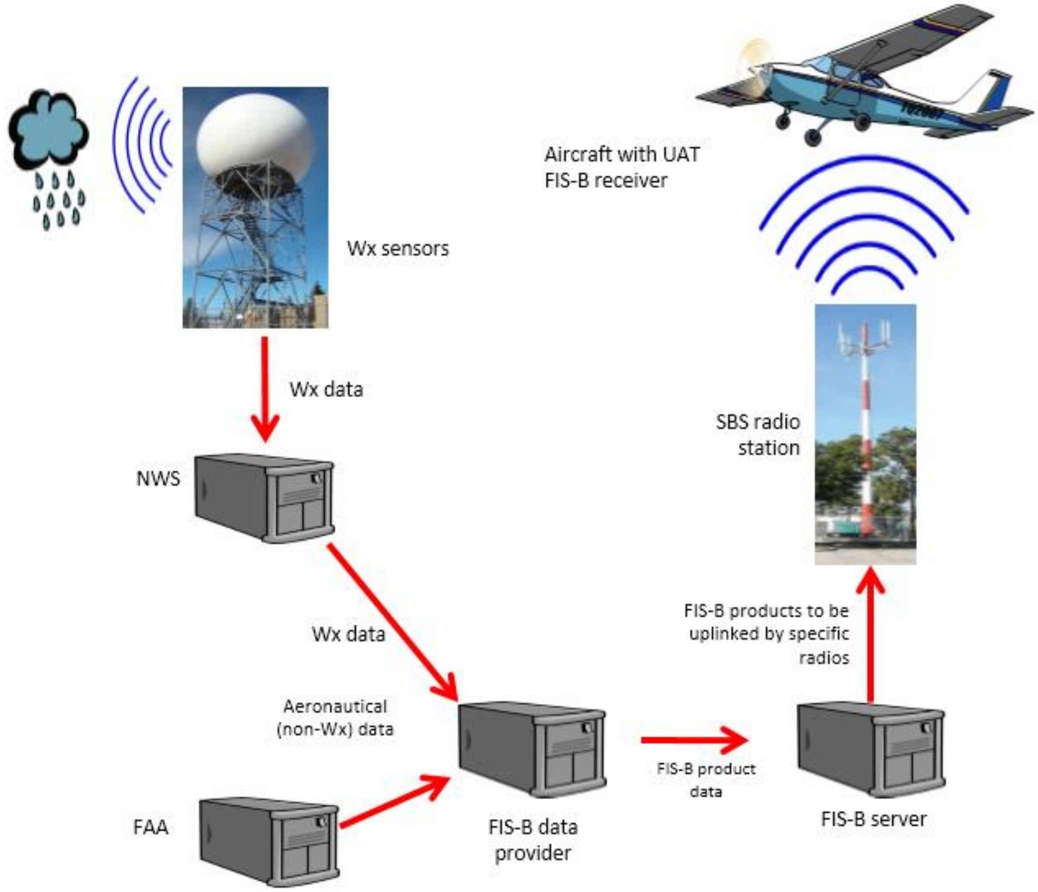

Figure 1-1: High-level Data Flows Supporting FIS-B

1.2.1 Document Hierarchy

Higher-level end-to-end system requirements are described in RTCA DO-267A *Minimum Aviation System Performance Standard (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link*, dated April 29, 2004. RTCA DO-267A documented both MASPS and MOPS for FIS-B. This MOPS was created to separate and update the MOPS portion of RTCA DO-267A for FIS-B with UAT.

1.3 Operational Application(s)

The goal of the FIS-B system codified in this MOPS is to provide weather (Wx) and aeronautical information to pilots in a manner that will enhance their awareness of the flight conditions and enable better strategic route planning consistent with guidance provided by Federal Aviation Regulations (FAR) and corporate policy. The information provided through FIS-B is considered non-binding advice provided to assist in the safe and legal conduct of flight operations. With this information, general aviation (GA) pilots and air carrier flight crews will be better able to assess the need to consider alternative route and altitude selection.

Currently, when adverse Wx conditions are present, the Very High Frequency (VHF) radio frequencies designed to facilitate the exchange of Wx and flight data information become saturated to the point that near real-time exchange of information is troublesome. It is envisioned that FIS-B products will be continuously received and stored to be readily available as needed or when requested by the pilot.

This FIS-B system is not intended to replace existing voice networks, Flight Service Station (FSS) services or usurp any joint duties or responsibilities required by aircraft operators. Loss or non-receipt of FIS-B service would have no regulatory impact.

FIS-B products are to be used only for strategic/planning purposes and not for crew alerting. This is due to the fact that FIS-B products may have significant latency between the observation of a Wx phenomenon, the issuance of a forecast or the change in airspace status and the display of that information in the cockpit. In addition, because their update rates are relatively low, FIS-B products should not be used for tactical maneuvering of the aircraft and should not be the sole basis for immediate corrective action by the pilot. FIS-B products are intended to enable pilots to determine if action should be taken well before it is required and should be used in conjunction with other information sources to support in-flight decisions.

It is expected that FIS-B will offer operational advantages to all types of airspace users. For Part 121 airline operations, the ability of flight crews to access information in-flight previously available only during pre-flight will greatly enhance the collaborative decision making process of pilot-in-command and aircraft dispatcher.

The general aviation community will benefit from FIS-B by having better in-flight access to information on Wx phenomena that may pose a danger to the flight. In addition, because many GA flights are single-pilot operations, FIS-B will enable GA pilots to gain a more comprehensive Wx picture than currently obtainable via voice radio, thereby enabling better in-flight strategic decision-making. Finally, with the creation of Temporary Flight Restrictions (TFRs) becoming more prevalent due to national security concerns, FIS-B offers another means to increase the GA pilot's awareness of the status of airspace.

1.4 Intended Function

The equipment shall perform its intended function, as defined by the manufacturer. The equipment shall process and display the FIS-B products identified in this MOPS.

1.5 Operational Goals

The operational goal is to display the FIS-B products on the flight deck in order to enhance pilot awareness of meteorological conditions and airspace constraints along the route of flight.

1.6 Assumptions

This MOPS is written under the assumption that FIS-B avionics receives its data from a UAT. Reference RTCA DO-282B *Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast (ADS-B)*.

1.6.1 FIS-B Implementation

The requirements in the MOPS are based on the implementation of FIS-B provided by the FAA in the United States (U.S.) and its territories.

It should be noted that the requirements reflect the operational status of the FIS-B Ground System at the time this MOPS was published. Evolution of the FIS-B service and/or the source of the data, such as changes from providers of data input to Surveillance and Broadcast Services System (SBSS) (e.g., National Weather Service (NWS)) may in fact affect these requirements and would need to be addressed. Anticipated near-term updates to FIS-B are described in 0.

1.6.2 Coordinated Universal Time (UTC) Time Access

It is assumed that the FIS-B avionics can access current UTC time including month, day, hour, minute and seconds.

1.7 Test Procedures

The test procedures specified in this document are intended to be used as one means of demonstrating compliance with the performance requirements defined in Section 2.2. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. Users of this document should not infer performance requirements based on Test Procedures.

The order of tests specified suggests that the equipment be subjected to a succession of tests as it moves from design, and design qualification, into operational use. For example, compliance with the requirements of Section 2 shall have been demonstrated as a precondition to satisfactory completion of the installed system tests of Section 3.

1. Environmental Tests

   Environmental test requirements are specified in Section 2.3. The procedures and their associated limits are intended to provide a laboratory means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations.

   Unless otherwise specified, the environmental conditions and test procedures contained in RTCA DO-160G/EUROCAE ED-14G, *Environmental Conditions and Test Procedures for Airborne Equipment,* will be used to demonstrate equipment compliance.

2. Bench Tests

   Bench test procedures are specified in Section 2.4. These tests provide a laboratory means of demonstrating compliance with the requirements of Section 2.2. Test results may be used by equipment manufacturers as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design.

3. Installed Equipment Considerations

   Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

   The installed equipment test procedures and their associated limits are specified in Section 3. Although bench and environmental test procedures are not included in the installed equipment test, their successful completion is a precondition to completion of the installed test. In certain instances, however, installed equipment tests may be used in lieu of bench test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the aircraft, etc. Installed tests are normally performed under two conditions:

a. With the aircraft on the ground and using simulated or operational system inputs.

b. With the aircraft in flight using operational system inputs appropriate to the equipment under test.

Test results may be used to demonstrate functional performance in the intended operational environment.

1.8 Definition of Terms

The terms defined in this section are important terms used in this document.

Decode—When used in this document, the term decode refers to the processing, parsing and translating of the data from its encoded uplink format.

FIS-B Avionics—The avionics components required for the cockpit display of those FIS-B products uplinked by the FIS-B ground system. The FIS-B avionics includes a processor and display and depending on the design, may also encompass the UAT receiver.

FIS-B Ground System—That portion of the FAA's ground network and equipment providing the uplink of FIS-B products within the U.S. and its territories.

FIS-B Latency—The use of the term latency associated with the requirements in this document represents the time interval between reception of a complete FIS-B message, to include reassembled segmented APDUs, by the FIS-B processor and display of the contents of that FIS-B message on the FIS-B display.

FIS-B Product File—When the FIS-B Report cannot be contained in a single UAT Ground Uplink Message, it is segmented into a Product File spanning multiple UAT Ground Uplink Messages.

Look Ahead Range—This relates to the radius for which a given product is provided from a given radio station.

May—The use of this term indicates an implementation characteristic that is permissible and completely left to the vendor's decision.

NEXRAD Display Update

1. Incremental—The *Incremental Display Update* is where NEXRAD imagery is updated on the display as it is received.

2. All-at-once—The *All-At-Once Display Update* is where NEXRAD imagery is updated at a discrete time, ideally when all new data has been received.

Purge—When used in this document, the term purge means to make the referenced item no longer available for display. The referenced item may be kept in avionics memory or storage for later retrieval. However the referenced item should not be easily retrievable on the default display by the pilot once it is purged. The intent of the purge requirements are to remove information that is no longer operationally relevant from the display to avoid clutter and potential confusion to the pilot.

Radio Station—The component of the FIS-B ground system broadcasting the FIS-B information.

Shall—The use of this term indicates a requirement.

Note: *The number contained in [ ] immediately after the term "shall" indicates the requirement number.*

Should—The use of this term indicates a characteristic that is highly recommended but is not required.

Significant Meteorological Information (SIGMET) Product—SIGMET and Convective SIGMET are Wx advisories that contain meteorological information concerning the safety of aircraft. The two products have slightly different scope and criteria. Unless differentiated by the text, the MOPS use of the term SIGMET applies to both products.

Transmission Interval—The interval of time between consecutive broadcasts of a specified FIS-B product from a radio station. This interval depends upon the product type.

Note: *See APPENDIX C for the update and transmission intervals by product type. For most products the Transmission Interval is shorter than the Update Interval.*

UAT Frame—The UAT Frame refers to the data frame that contains the APDUs. The concept of a UAT frame that refers to the frame used for UAT media access will be referred to as UAT media access frame.

Update Interval—The interval of time between updates of the content of the FIS-B products within the FIS-B ground system. This interval depends upon the product type.

1.9 Acronyms/Abbreviations

Table 1-1 lists the acronyms and abbreviations used throughout this MOPS document.

Table 1-1: Acronyms and Abbreviations

Acronym / Abbreviation	Explanation
3D	Three-Dimensional
AC	Advisory Circular
AC	Alternating Current
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-R	Automatic Dependent Surveillance – Rebroadcast
Af	Application Methods Flag Bit
AGL	Above Ground Level
AIRMET	Airman's Meteorological Information
AM	Amendment (for TAF)
APDU	Application Protocol Data Unit
BN	Block Number
C	Celsius
CONUS	Conterminous United States
CRC	Cyclic Redundancy Check

Acronym / Abbreviation	Explanation
CRL	Current Report List
CRLF	End-of-Line
CS	Control Station
CS	Currency Sign
CSV or “*.csv”	Comma-Separated Value
dBZ	Decibels of reflectivity
DAL	Design Assurance Levels
DLAC	Data Link Application Control
DO	Document
ED	European Document
ETX	End-of-Text
EUROCAE	European Organisation for Civil Aviation Equipment
F	Fahrenheit
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FIS-B	Flight Information Services – Broadcast
FMH	Federal Meteorological Handbook
FSS	Flight Service Station
ft	Feet
GA	General Aviation
Gf	Geographic Locator Flag Bit
Hz	Hertz
ICAO	International Civil Aviation Organization
ID	Identifier
INCMPL	Incomplete
INCR	Increment
m	Meter
kPa	kiloPascal
L	Length
LAT	Latitude
LONG	Longitude
LSB	Least Significant Bit

Acronym / Abbreviation	Explanation
MASPS	Minimum Aviation System Performance Standards
METAR	Aviation Routine Weather Report
MOPS	Minimum Operational Performance Standards
MSB	Most Significant Bit
MSL	Mean Sea Level
MSO	Message Start Opportunity
N	North
NAS	National Airspace System
NC	Null Character
NDS	National Weather Service Policy Directive
NEXRAD	Next-Generation Radar
nmi	Nautical mile
NOTAM	Notice to Airmen
NOTAM-D	Notice to Airmen – Distant
NOTAM-FDC	Notice to Airmen – Flight Data Center
NOTAM-TFR	Notice to Airmen – Temporary Flight Restriction
NWS	National Weather Service
Pf	Provider Specific Flag Bit
PIREP	Pilot Report
RF	Radio Frequency
RS	Record Separator
RTCA	RTCA, Inc. formerly Radio Technical Commission for Aeronautics
S	South
SBS	Surveillance and Broadcast Services
SBSS	Surveillance and Broadcast Services System
SC-206	(RTCA) Special Committee 206 - Aeronautical Information and Meteorological Data Link Services
sec	Second
Sf	Segmentation Flag Bit
SIGMET	Significant Meteorological Information
SP	Special Aviation Routine Weather Report
SPECI	Special Aviation Routine Weather Report

Acronym / Abbreviation	Explanation
SUA	Special Use Airspace
TAB	Tabulator
TAF	Terminal Aerodrome Forecast
TAF.AMD	Amended Terminal Aerodrome Forecast
TAF.COR	Corrected Terminal Aerodrome Forecast
TFR	Temporary Flight Restriction
TAF.AMD	Amended Terminal Aerodrome Forecast
TAF.COR	Corrected Terminal Aerodrome Forecast
TIS-B	Traffic Information Services – Broadcast
TSO	Technical Standard Order
TWGO	Text with Graphical Overlay
U.S.	United States
UAT	Universal Access Transceiver
UUT	Unit Under Test
UTC	Coordinated Universal Time
VHF	Very High Frequency
W	West
WGS-84	World Geodetic System-84
WINDS	Winds and Temperatures Aloft Product
WSR-88D	Weather Surveillance Radar 88 Doppler
WST	Convective SIGMET
Wx	Weather
Z	Zulu

1.10 References

1. Federal Aviation Administration Advisory Circular 00-45G, Aviation Weather Services
2. Federal Aviation Administration Order JO 7110.10X, Flight Services
3. Federal Aviation Administration Order JO 7930.2N, Notices to Airmen (NOTAM)
4. Federal Aviation Administration Technical Standard Order C113, Airborne Multipurpose Electronic Displays
5. Federal Aviation Administration Technical Standard Order C154c, Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz

6. Federal Aviation Regulations Part 23, Appendix F
7. Federal Aviation Regulations Part 25 Appendix F
8. Federal Meteorological Handbook No. 1 – Surface Weather Observations and Reports
9. National Weather Service Policy Directive 10-8, Aviation Weather Services
10. RTCA DO-160G/EUROCAE ED-14G, Environmental Conditions and Test Procedures for Airborne Equipment
11. RTCA DO-178C/EUROCAE ED-12C, Software Considerations in Aircraft Systems and Equipment Certification
12. RTCA DO-267A Minimum Aviation System Performance Standard (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link
13. RTCA DO-282B Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast (ADS-B)
14. RTCA DO-317B/EUROCAE ED-194A, Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System

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2 EQUIPMENT PERFORMANCE REQUIREMENTS AND TEST PROCEDURES

2.1 General Requirements

2.1.1 Airworthiness

In the design and manufacture of the equipment, the manufacturer shall provide for installation so as not to impair the airworthiness of the aircraft.

2.1.2 Intended Function

The equipment shall perform its intended function(s), as defined by the manufacturer, and its proper use shall not create a hazard to other users of the NAS.

2.1.3 Federal Communications Commission Rules

This equipment shall comply with the relevant Federal Communications Commission regulations or other requirements, as applicable.

2.1.4 Software Management

If the equipment design is implemented using digital computer techniques, the computer software package(s) shall follow guidelines contained in RTCA DO-178B/EUROCAE ED-12B, *Software Considerations in Aircraft Systems and Equipment Certification.* The equivalent of later editions of RTCA DO-178C/EUROCAE ED-12C may be used with the agreement of the authority.

2.1.5 Fire Protection

All materials used shall be self-extinguishing except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire.

Note: *One means of showing compliance is contained in FAR, Part 25, Appendix F and/or Part 23 Appendix F.*

2.1.6 Operation of Controls

The equipment shall be designed so that controls intended for use during flight cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.1.7 Accessibility of Controls

Controls that do not require adjustment during flight shall not be readily accessible to flight personnel.

2.1.8 Effect of Test

The equipment shall be designed so that the application of specified test procedures shall not be detrimental to equipment performance following the application of the tests, except as specifically allowed.

2.1.9 Design Assurance

Design Assurance Levels (DAL) should be adequate to mitigate the failure classification appropriate to the contribution of the equipment to the aircraft level failure in the aircraft in which it is to be installed. The DAL appropriate for a given hazard classification is not the same for all aircraft types and the contribution of the equipment to an aircraft level failure may vary depending on the aircraft and other installed equipment.

2.2 Equipment Performance—Standard Conditions

This section starts with the low-level communication protocol requirements detailing link layer requirements and header formats. This is followed by sections oriented to each uplink product grouped into three product classes according to how they are encoded for uplink. This is followed by requirements for the FIS-B avionics to integrate and maintain a full set of FIS-B product reports across multiple radio stations and retransmission cycles. Section 2.2 ends with requirements related to loss of access to UTC time, system capacity and providing a reception status indication to the pilot. All shall statements have a number to denote a verification requirement, identified by the requirement number contained within square brackets [XX].

2.2.1 Data Link Layer Interface to UAT Receiver

The requirements of this section apply to installations where the UAT Receiver subsystem is separate from the avionics display subsystem. These requirements ensure integrity in the data transfer between these avionics subsystems.

2.2.1.1 Error Detection

The data link layer **shall** [01] support an error detection capability at least equivalent to that of a 16-bit Cyclic Redundancy Check (CRC).

Note: *Verification for this requirement is left up to the manufacturer.*

2.2.2 FIS-B Data Formats and Decoding

2.2.2.1 UAT Ground Uplink Message

The FIS-B avionics **shall** [02] decode the UAT Ground Uplink Message according to the format in Section A.1 through Section A.1.2.

2.2.2.2 UAT Frame

1. The FIS-B avionics **shall** [03] decode the UAT Frame according to the format in Section A.1.3 through Section A.1.3.4.
2. The FIS-B avionics **shall** [04] discard all UAT Frame Types other than 0 and 14 for the purposes of processing FIS-B information.

Note: *UAT Frame Type 15 refers to the Traffic Information Services – Broadcast (TIS-B)/Automatic Dependent Surveillance – Rebroadcast (ADS-R) Service Status message and is not used in the display or processing of FIS-B products. See RTCA DO-317B/EUROCAE ED-194A, Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System for additional information about UAT Frame Type 15.*

2.2.2.3 FIS-B APDU

The FIS-B avionics **shall** [05] decode the FIS-B APDU according to the format in Section A.2.

2.2.2.4 Current Report List (CRL)

The FIS-B avionics **shall** [06] decode the CRL for each of the products Notice to Airmen – Temporary Flight Restriction (NOTAM-TFR), Airmen’s Meteorological Information (AIRMET) and SIGMET per formats provided in Section A.4 through Section A.4.2.5.

2.2.3 General Display Requirements

The MOPS document does not provide general display requirements. When applicable, product-specific display requirements are provided in Section 2.2.4.

2.2.4 FIS-B Product Requirements

Table 2-1 shows each FIS-B product according to its product class. Requirements for processing and display of each product are provided in this section.

The FIS-B avionics **shall** [07] discard any APDU with a Product Identifier (ID) other than those listed in Table 2-1.

Table 2-1: FIS-B Products According To Product Class

Product Class	Product ID #	Product Name	Recommended Product Title	Product Description Reference
Generic Text	413	METAR	"METAR"	FMH-1
		TAF	"TAF"	NDS 10-8
		PIREP	"PIREP"	NDS 10-8
		WINDS	"WIND & TEMPS"	NDS 10-8
Global Block Representation	63	Regional NEXRAD	"Regional NEXRAD"	APPENDICES A and E
	64	CONUS NEXRAD	"CONUS NEXRAD"	APPENDICES A and E
Text with Graphical Overlay	8	NOTAM-D	"NOTAM-D"	APPENDIX A
		NOTAM-FDC	"NOTAM-FDC"	APPENDIX A
		NOTAM-TFR	"NOTAM-TFR"	APPENDIX A
		FIS-B Product Updates Unavailable	"Unavail FIS-B Prods"	APPENDIX A
	11	AIRMET	"AIRMET"	NDS 10-8
	12	SIGMET	"SIGMET"	NDS 10-8
		WST	"Convective SIGMET"	NDS 10-8

Notes:

1. *Column 3, Product Name, indicates the name that each particular product is referred to throughout the document. Column 4, Recommended Product Title, is the recommended title to use when displaying that particular product on the FIS-B avionics per the product title requirements.*
2. *The Terminal Aerodrome Forecast (TAF) product includes the subset of Amended Terminal Aerodrome Forecast (TAF.AMD) and Corrected Terminal Aerodrome Forecast (TAF.COR).*
3. *The Aviation Routine Weather Report (METAR) product includes the subset of Special Aviation Routine Weather Report (SPECI) products that indicate an unscheduled report issued when specific, established weather criteria are observed.*
4. *Product Description Reference documents include: Federal Meteorological Handbook No. 1 – Surface Weather Observations and Reports (FMH-1) and National Weather Service Policy Directive 10-8, Aviation Weather Services (NDS 10-8).*

2.2.4.1 Generic Text Products

The Generic Text products have only text and possibly special characters. These products do not have any associated graphical records. The Generic Text products (Product ID #413) include the following FIS-B report types: METAR, TAF, Pilot Report (PIREP) and Winds and Temperatures Aloft Product (WINDS). "Generic Text" refers to the fact that all report types under this Product ID use a similar format that allows their formatted display in a consistent manner.

2.2.4.1.1 Decoding

The FIS-B avionics **shall** [08] decode the Generic Text product class per the formats provided in Section A.3.1.

2.2.4.1.2 Product Title

The FIS-B avionics **shall** [09] identify each Generic Text product title on the display.

Notes:

1. *The FIS-B avionics will need to parse the text payload to determine the product title.*
2. *Suggested product titles are given in Table 2-1.*

2.2.4.1.3 Display of Full Report

The broadcasted Generic Text report **shall** [10] be available in its entire decoded text form.

Note: *The decoded form need not be the default display mode. When this is the case, the decoded form is required to be available for display. For example, it may be available as a special display mode for verification purposes.*

2.2.4.1.4 Processing and Display Latency

The FIS-B avionics **shall** [11] make each Generic Text product available for display within the maximum latency shown in Table 2-2.

Table 2-2: Generic Text Product Latency

Generic Text Product	Maximum Latency (minutes)
METAR	2.5
TAF, PIREP and WINDS	5

Notes:

1. *The maximum latency is one-half the transmission interval (Table C-1).*
2. *Times are specified as time since receipt by the FIS-B processor.*

2.2.4.1.5 Report Replacement

The FIS-B avionics **shall** [12] display the newest METAR, and TAF Generic Text reports for a given location.

Note: *This requirement does not preclude making older reports available to the pilot for trend information.*

2.2.4.1.6 Control Characters

The uplinked Generic Text data may contain control characters (such as the end of line character (CRLF) which indicates a break on the display), which should be handled appropriately. See Table A-6 Generic Text Encoding and Section A.3.1.1.1.

2.2.4.2 Graphic Products Using Global Block Representation

The Global Block products include Regional NEXRAD imagery (Product ID #63) and Conterminous United States (CONUS) NEXRAD imagery (Product ID #64). The term “Global Block” refers to the fact that the image units being rendered on the cockpit display are geolocated in a fully qualified global latitude/longitude coordinate system. This makes the resulting image suitable for display on a moving map in a continuous, seamless fashion as the flight progresses.

2.2.4.2.1 Regional NEXRAD

2.2.4.2.1.1 Decoding

The FIS-B avionics **shall** [13] decode the Regional NEXRAD product according to the formats provided in Section A.3.2.

2.2.4.2.1.2 Product Title

The FIS-B avionics **shall** [14] identify the Regional NEXRAD product title on the display.

2.2.4.2.1.3 Product Legend

The FIS-B avionics **shall** [15] provide a legend that indicates the color coding of intensity level and the coding used to indicate “No Data” for the Regional NEXRAD product.

Note: *Legend should be accessible with minimal operator action.*

2.2.4.2.1.4 Indication of Product Age

When UTC time is available, the FIS-B avionics **shall** [16] display time elapsed since the APDU Header time associated with the oldest Regional NEXRAD data on the display.

When UTC time becomes unavailable, the FIS-B avionics **shall** [17] display the APDU Header time associated with the oldest Regional NEXRAD data on the display.

2.2.4.2.1.5 Explicit Indication of Missing Data

The default initial rendering for all Regional NEXRAD global blocks **shall** [18] be the “No Data” condition.

Note: *The "No Data" rendering is distinctive from the color uses specified in Table 2-3.*

Each Regional NEXRAD global block rendering **shall** [19] revert to the “No Data” condition upon reaching 75 minutes of age.

2.2.4.2.1.6 Processing and Display Latency

The FIS-B avionics **shall** [20] make each Regional NEXRAD global block APDU available for display within 100 seconds of receipt of that APDU by the FIS-B processor.

Note: *APPENDIX I contains a sample method to meet this requirement using an all-at-once display update method.*

2.2.4.2.1.7 Time Stamp Variance

The APDU timestamp variance across all Regional NEXRAD global blocks rendered on the display at any given time **shall** [21] be less than 10 minutes.

Notes:

1. *This requirement does not preclude making older global blocks available to the pilot for trend information.*
2. *APPENDIX I contains a sample method to meet this requirement using an all-at-once method.*
3. *The FIS-B Ground System will always uplink Regional NEXRAD based on periodic 5-minute update epochs. So, this requirement limits the data displayed to only two consecutive update epochs.*

2.2.4.2.1.8 Regional Color Use

Color assignments *should* follow the "strategic display philosophy of increasing potential safety hazard" so that the progression from none to green to amber (yellow) to red corresponds to increasing degrees of precipitation intensity.

The use of red, amber (yellow) and green *should* be compatible, although not necessarily identical, across Regional and CONUS NEXRAD displays in order to ensure they maintain their effectiveness and intended functions.

Table 2-3 shows a mapping of the Regional NEXRAD Intensity Encoded Value to its associated dBZ Reflectivity Range and the recommended display of colors for each value.

Table 2-3: Regional NEXRAD Color Use

Intensity Encoded Value	dBZ Reflectivity Range	Recommended Color
0	dBZ < 5	None
1	5 <= dBZ < 20	None
2	20 <= dBZ < 30	Green
3	30 <= dBZ < 40	Amber or Yellow
4	40 <= dBZ < 45	Red
5	45 <= dBZ < 50	Red
6	50 <= dBZ < 55	Red
7	55 <= dBZ	Red

2.2.4.2.2 CONUS NEXRAD

2.2.4.2.2.1 Decoding

The FIS-B avionics **shall** [23] decode the CONUS NEXRAD product according to the formats provided in Section A.3.2.

2.2.4.2.2.2 Product Title

The FIS-B avionics **shall** [24] identify the CONUS NEXRAD product title on the display.

2.2.4.2.2.3 Product Legend

The FIS-B avionics **shall** [25] provide a legend that indicates the color coding of intensity level and the coding used to indicate "No Data" for the CONUS NEXRAD product.

Note: *Legend should be accessible with minimal operator action.*

2.2.4.2.2.4 Indication of Product Age

When UTC time is available, the FIS-B avionics **shall** [26] display time elapsed since the APDU Header time associated with the oldest CONUS NEXRAD data on the display.

When UTC time is not available, the FIS-B avionics **shall** [27] display the APDU Header time associated with the oldest CONUS NEXRAD data on the display.

2.2.4.2.2.5 Explicit Indication of Missing Data

The default initial rendering for all CONUS NEXRAD global blocks **shall** [28] be the "No Data" condition.

Each CONUS NEXRAD global block rendering **shall** [29] revert to the "No Data" condition upon reaching 75 minutes of age.

2.2.4.2.2.6 Processing and Display Latency

The FIS-B avionics **shall** [30] make each CONUS NEXRAD global block APDU available for display within 100 seconds of receipt by the FIS-B processor.

Note: *APPENDIX I contains a sample method to meet this requirement using an all-at-once method.*

2.2.4.2.2.7 Time Stamp Variance

The APDU timestamp across all CONUS NEXRAD global blocks rendered on the display at any given time **shall** [31] be less than 10 minutes.

Note: *This requirement does not preclude making older global blocks available to the pilot for trend information.*

2.2.4.2.2.8 CONUS Color Use

Color assignments *should* follow the "strategic display philosophy of increasing potential safety hazard" so that the progression from none to green to amber (yellow) to red corresponds to increasing degrees of precipitation intensity.

The use of red, amber (yellow) and green *should* be compatible, although not necessarily identical, across Regional and CONUS NEXRAD displays in order to ensure they maintain their effectiveness and intended functions.

The CONUS NEXRAD intensity encoded value of zero (0) **shall** [32] be rendered with a distinctive designation for “No Data.”

Table 2-4 shows a mapping of the CONUS NEXRAD Intensity Encoded Value to its associated dBZ Reflectivity Range and the required and recommended display colors for each value.

Table 2-4: CONUS NEXRAD Color Use

Intensity Encoded Value	dBZ Reflectivity Range	Required Color	Recommended Color
0	No Data	Distinctive Designation for “No Data”	
1	dBZ < 20		None
2	20 <= dBZ < 30		Green
3	30 <= dBZ < 40		Amber or Yellow
4	40 <= dBZ <45		Red
5	45 <= dBZ < 50		Red
6	50 <= dBZ < 55		Red
7	55 <= dBZ		Red

2.2.4.3 Text with Graphical Overlay Products

This class of FIS-B Product includes: Textual and Graphic NOTAMs (Product ID #8), FIS-B Product Updates Unavailable Report (Product ID #8), Textual and Graphic AIRMETs (Product ID #11) and Textual and Graphic SIGMETs (Product ID #12).

2.2.4.3.1 Decoding

The FIS-B avionics **shall** [33] decode the Text with Graphical Overlay (TWGO) product header according to the format provided in Section A.3.3.1.1.

2.2.4.3.2 Product Title

The FIS-B avionics **shall** [34] identify each TWGO product title on the display.

Notes:

1. *FIS-B avionics will need to parse the text payload to determine the product title for the NOTAM products.*
2. *Suggested product titles are given in Table 2-1.*

2.2.4.3.3 Control Characters

The uplinked TWGO data may contain control characters which *should* be handled appropriately (See Section A.3.1.1.1).

2.2.4.3.4 FIS-B Product Updates Unavailable Reports

The broadcasted FIS-B Product Updates Unavailable report **shall** [35] be available in its entire decoded text form for each product displayed.

Note: *The decoded form may not be the default display form of the product, but it should be available to the user. The default display might provide value-added formatting (See Section A.3.3.2.4.1.2).*

2.2.4.3.4.1 Purging of FIS-B Product Update Unavailable Reports

The FIS-B avionics **shall** [37] purge any unique FIS-B Product Update Unavailable report greater than 20 minutes from the last reception.

Note: *See Section A.3.3.2.4.2.2 for uniqueness determination.*

2.2.4.3.5 NOTAM (D, FDC and TFR) Text/Graphic

All requirements referring to the NOTAM product apply to each category of NOTAM (D, FDC, and TFR) unless referred to individually.

Note: *For definition of Notice to Airmen – Distant (NOTAM-D), Notice to Airmen – Flight Data Center (NOTAM-FDC) and NOTAM-TFR, see Section A.3.3.2.4.1.2.*

2.2.4.3.5.1 Text Decoding

The FIS-B avionics **shall** [38] decode NOTAM Text per the formats provided in Section A.3.3.

2.2.4.3.5.2 Graphic Decoding

The FIS-B avionics **shall** [39] decode NOTAM Graphic per the formats provided in Section A.3.3.

2.2.4.3.5.3 Association of NOTAM-D Text and Graphic APDUs

The FIS-B avionics **shall** [40] associate the NOTAM-D Text APDU with the NOTAM-D Graphic APDU.

Note: *The recommended method of association is by using the Report Number, Report Month and Location Identifier (LocID) fields as noted in Section B.3.3.*

A NOTAM-D graphic record received before that of a matching text record **shall** [73] be retained at least 20 minutes awaiting receipt of the matching text record.

Note: *This retention time is twice the transmission interval (Table C-1) for the NOTAM-D records.*

2.2.4.3.5.4 Association of NOTAM-FDC and NOTAM-TFR Text and Graphic APDUs

The FIS-B avionics **shall** [41] associate the NOTAM-FDC/NOTAM-TFR Text APDU with the NOTAM-FDC/NOTAM-TFR Graphic APDU.

Note: *The recommended method of association is by using the Report Number and Report Year fields as noted in Section B.3.3.*

A NOTAM-FDC/NOTAM-TFR graphic record received before that of a matching text record **shall** [74] be retained at least 40 minutes awaiting receipt of the matching text record.

Note: *The transmission interval for NOTAM-TFR and NOTAM-FDC is 10 minutes. However, alternating transmissions of NOTAM-TFR text records only include the header. The entire text records are uplinked then at 20 minute intervals. The 40 minute retention time is twice the transmission interval for the entire NOTAM-TFR text records.*

2.2.4.3.5.5 NOTAM Display

The FIS-B avionics **shall** [42] only display graphical NOTAMs that have an associated text NOTAM.

The FIS-B avionics **shall** [43] make available for display the entire decoded text from all received NOTAMs.

Notes:

1. *The FIS-B Ground System currently has no way to assure completeness of NOTAM-D and NOTAM-FDC due to the potentially large numbers of these reports.*
2. *While the intent of the requirement is to make all NOTAMs available on the default display, it is recognized that different vendor implementations may not be able to efficiently provide such an interface. If the intent cannot be met, requirement [10] ensures the full text of the NOTAM is available elsewhere within the interface. If a given vendor implementation limits the number of NOTAMs provided on the default display, a statement indicating as much should be provided.*

2.2.4.3.5.6 Latency

NOTAM text records **shall** [44] be available for display within 5 minutes of receipt by the FIS-B processor.

NOTAM graphical records **shall** [77] be available for display within 5 minutes of receipt by the FIS-B processor of that graphical record or its associated text record, based on whichever arrives later

Note: *This maximum latency is one half the shortest transmission interval (Table C-1) for this product.*

2.2.4.3.5.7 Displaying Special Use Airspace NOTAMs

For those NOTAMs conveying the status of SUA, the FIS-B avionics *should* associate the airspace name in the NOTAM text with its graphic depiction available to the FIS-B avionics through a published dataset, if available to the FIS-B avionics.

Notes:

1. *A NOTAM-D with SUA information does not have an uplinked graphical record. The FIS-B avionics are required to display the textual information for a NOTAM-D. The FIS-B avionics can optionally associate the uplinked Airspace ID with that in an onboard database to display the area associated with a NOTAM-D indicating an active SUA outside its published time.*
2. *FAA Order JO 7930.2N Paragraph 6-1-2 shows the construction of NOTAMs related to Special Activity Airspace, which should be helpful in parsing and isolating those NOTAMs with a published graphic depiction.*

2.2.4.3.5.8 Report Purging

The FIS-B avionics **shall** [45] purge any unique NOTAM report with expiration date prior to the current UTC time.

Note: *This does not apply to text-only NOTAMs, "Until further notice" NOTAMs or if lacking current UTC time.*

The FIS-B avionics may purge any unique NOTAM report greater than 60 minutes from the last reception.

Notes:

1. *In the case of a NOTAM that is segmented, the NOTAM may be purged 60 minutes after receipt of the last segment.*
2. *See Section B.3.3 for uniqueness determination.*

2.2.4.3.6 AIRMET Text/Graphic

2.2.4.3.6.1 Text Decoding

The FIS-B avionics **shall** [46] decode AIRMET Text per the formats provided in Section A.3.3.

2.2.4.3.6.2 Graphic Decoding

The FIS-B avionics **shall** [47] decode AIRMET Graphic per the formats provided in Section A.3.3.

2.2.4.3.6.3 Association of AIRMET Text and Graphic APDUs

The FIS-B avionics **shall** [48] associate the AIRMET Text APDU with the AIRMET Graphic APDU.

Note: *The recommended method of association is by using the Report Number and Report Year fields as noted in Section B.3.2.*

An AIRMET graphic record received before that of a matching text record **shall** [75] be retained at least 10 minutes awaiting receipt of the matching text record.

Note: *This retention time is twice the transmission interval (Table C-1) for the AIRMET text records.*

2.2.4.3.6.4 AIRMET Display

The FIS-B avionics **shall** [49] only display the graphical AIRMETs that have an associated text AIRMET.

The FIS-B avionics **shall** [50] make available for display the entire decoded text from all received AIRMETs.

Note: *An AIRMET graphic that does not have an associated text record should not be displayed.*

2.2.4.3.6.5 Latency

AIRMET text records **shall** [51] be available for display within 2.5 minutes of receipt by the FIS-B processor.

AIRMET graphical records **shall** [78] be available for display within 2.5 minutes of receipt by the FIS-B processor of that graphical record or the associated text record, based on whichever arrives later.

Note: *This maximum latency is one half the shortest transmission interval (Table C-1) for this product.*

2.2.4.3.6.6 Report Purging

The FIS-B avionics **shall** [52] purge any unique AIRMET report with expiration date prior to the current UTC time.

Notes:

1. *See Section B.3.2.2 for uniqueness determination.*
2. *This does not apply to text-only AIRMETs or if lacking current UTC time.*

2.2.4.3.7 SIGMET Text/Graphic

2.2.4.3.7.1 Text Decoding

The FIS-B avionics **shall** [53] decode SIGMET Text per the formats provided in Section A.3.3.

2.2.4.3.7.2 Graphic Decoding

The FIS-B avionics **shall** [54] decode SIGMET Graphic per the formats provided in Section A.3.3.

2.2.4.3.7.3 Association of SIGMET Text and Graphic APDUs

The FIS-B avionics **shall** [55] associate the SIGMET Text APDU with the SIGMET Graphic APDU.

Note: *The recommended method of association is by using the Report Number and Report Year fields as noted in Section B.3.2.*

A SIGMET graphic record received before that of a matching text record **shall** [76] be retained at least 10 minutes awaiting receipt of the matching text record.

Note: *This retention time is twice the transmission interval (Table C-1) for the SIGMET text records.*

2.2.4.3.7.4 SIGMET Display

The FIS-B avionics **shall** [56] only display the graphical SIGMETs that have an associated text SIGMET.

The FIS-B avionics **shall** [57] make available for display the entire decoded text from all received SIGMETs.

Note: *A SIGMET graphic that does not have an associated text record should not be displayed.*

2.2.4.3.7.5 Latency

SIGMET text records **shall** [58] be available for display within 2.5 minutes of receipt by the FIS-B processor.

SIGMET graphical records **shall** [79] be available for display within 2.5 minutes of receipt by the FIS-B processor of that graphical record or its associated text record, based on whichever arrives later.

Note: *This maximum latency is one half the shortest transmission interval (Table C-1) for this product.*

2.2.4.3.7.6 Report Purging

The FIS-B avionics **shall** [59] purge any unique SIGMET report with expiration date prior to the current UTC time.

Notes:

1. *This does not apply to text-only SIGMETs or if lacking current UTC time.*
2. *See Section B.3.2.2 for uniqueness determination.*

2.2.5 Current Report List

The FIS-B avionics **shall** [60] determine if the CRL contains a report for each Report ID associated with the following product cases:

- All NOTAM-TFRs (i.e., those identified as TFR by the FIS-B ground system)
- All AIRMETs
- All SIGMETs

The FIS-B avionics **shall** [61] provide an indication that the product report set is complete when a report is available for every Report ID contained in the CRL, for each of the cases below, as they are selected for display by the user:

- All NOTAM-TFRs
- All AIRMETs
- All SIGMETs

The FIS-B avionics **shall** [62] remove the indication of completeness, for a given product if the CRL is not received within twice the transmission interval (Table C-1) for the cases above.

2.2.6 Requirements for Reassembly of Segmented APDUs into a Complete Product File

2.2.6.1 Identification

The FIS-B avionics **shall** [63] generate a Product File composed of APDU segments with the same Product File ID.

2.2.6.2 Completeness of Received Sequence

All APDU segments **shall** [64] be present in order to assemble the segmented APDU.

2.2.6.3 Time Integration of Segments Received

The FIS-B avionics **shall** [65] use any Product File ID-associated APDU segment received for up to 60 minutes in the process of assembling a complete segmented APDU sequence.

Notes:

1. *This allows for some retransmission redundancy to fill in any missing segments.*
2. *Any associated collection of APDU segments that have not been reassembled within 60 minutes from receipt of the first in that collection should all be deleted.*
3. *This time integration, when needed, will add delay in the FIS-B avionics acquiring the full FIS-B report. This acquisition delay is not part of the latency requirement for NOTAMs in [44].*

2.2.6.4 Spatial Integration of Segments Received

The FIS-B avionics **shall** [66] use any APDU segment received from any radio station in the process of assembling a complete segmented APDU sequence.

Notes:

1. *Adjacent radio stations, within CS geographic boundaries, will be coordinated in their use of the Product File ID and segmentation pattern for a given FIS-B report requiring segmentation.*
2. *Within CONUS, there are three FIS-B CS areas. Each CS is assigned its own block of "Product File ID" codes used for reassembly of segmented APDUs uplinked within that CS area. Avionics manufacturers should be aware that an aircraft that is receiving radio stations on both sides of a CS boundary could receive segmented ADPUs for the same FIS-B report with a different Product File ID. This forces the FIS-B avionics to decode the same segmented APDU twice with different Product File IDs. These would then need to be processed at the FIS-B report level as described in Section 2.2.7 to eliminate the FIS-B report redundancy.*

2.2.7 Requirements for FIS-B Avionics Maintenance of Complete FIS-B Report Unique Set

The FIS-B avionics **shall** [67] use any report received from any radio station to create a single set of FIS-B reports that are made available for display.

Note: *See Section B.3 for guidance on how each type of FIS-B report can be uniquely identified.*

2.2.8 Dependence on UTC Time

The FIS-B avionics **shall** [69] make available entire decoded text reports and Regional and CONUS NEXRAD in the event that UTC time is inaccessible.

The FIS-B avionics **shall** [70] provide an indication when operating without access to UTC time. This condition is further described in RTCA DO-282B Section 2.2.5.2, Non-UTC Coupled Condition.

2.2.9 Capacity

The FIS-B avionics **shall** [71] be capable of receiving, processing and making available to display UAT Ground Uplink Messages from 31 time slots within the same clock second (Time slots are described in APPENDIX G).

Note: *The rationale for this ability to receive "all in view" is for the robustness offered by the radio station diversity and to avoid complex requirements for determining* *a "best" radio station in the dynamic flight environment. At the time of this MOPS, the maximum, "all-in-view," number of slots utilized is 31.*

2.2.10 System Status

The FIS-B avionics **shall** [72] be capable of displaying real time radio station reception status each second that includes the following for each Radio Station being received:

1. The latitude and longitude of the radio station as encoded in the UAT Header of the Ground Uplink Message.

Note: *Range and magnetic direction to the station may additionally be provided if ownship position is available.*

2. The Reception Success Rate is the fraction of all Ground Uplink Messages transmitted from that radio station that were received over the past 10 seconds.
3. The product completeness status for NOTAM-TFRs, AIRMETs and SIGMETs, per Section 2.2.5 to include the look ahead range from the Radio Station that is encoded in the CRL.

Notes:

1. *Each radio station is assigned from 1 to 4 Data Channels (reference APPENDIX G for discussion of UAT Data Channels and Transmission time slots). Each second, a radio station will transmit a Ground Uplink Message during its allocated time slot(s). The examination of the Latitude and Longitude fields of the UAT Ground Uplink Header in the Ground Uplink Message associates it to a unique radio station.*
2. *For each Ground Segment interval of the UAT media access frame (1 second), the FIS-B avionics will determine how many Ground Uplink Messages were received from each radio station. For each radio station, the number observed will update a Peak/Hold number as required, which is assumed as the number of channels allocated to it. The Peak number will be retained while the radio station remains in range.*

2.3 Equipment Performance—Environmental Conditions

The environmental tests and performance requirements described in this section provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operations.

Some of the environmental tests contained in this section need not be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase "When required." If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these "When required" tests **shall** be performed.

The test set-up procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA DO-160G/EUROCAE ED-14G, *Environmental Conditions and Test Procedures for Airborne Equipment*, December 8, 2010.

Some of the performance requirements in Section 2.1 and Section 2.2 are not tested by the test procedures herein. Moreover, not all tests are required to be done at each of the environmental conditions in RTCA DO-160G/EUROCAE ED-14G. Judgment and experience have indicated that these particular performance parameters are not susceptible to certain environmental conditions and that the level of performance specified in Section 2.1 and Section 2.2 will not be measurably degraded by exposure to these environmental conditions.

Additional tests may have to be performed in order to determine performance of particular design requirements that are not specified in this document. It is the responsibility of the manufacturer to determine appropriate tests for these functions.

Specific FIS-B performance tests have been included in this section for use in conjunction with the environmental procedures of RTCA DO-160G/EUROCAE ED-14G. These tests have been judiciously chosen as a subset of the performance tests of Section 2.4. Normally, a MOPS document does not provide specific equipment performance tests to be used in conjunction with the environmental procedures of RTCA DO-160G/EUROCAE ED-14G. However, there is a sufficiently large number of FIS-B performance tests in Section 2.4 that it would be impractical to repeat all of those tests in conjunction with all of the appropriate environmental procedures.

2.3.1 Environmental Test Conditions

Note: If the appliance includes UAT receiver functions, then test conditions in TSO-C154c also apply. If the appliance includes additional display functions, then the test conditions in TSO-C113 also apply. Otherwise, use the test conditions listed below.

Table 2-5 lists all of the environmental conditions and test procedures (hereafter referred to as environmental procedures) that are documented in RTCA DO-160G/EUROCAE ED-14G. Table 2-6 lists the sets of FIS-B performance tests that are specified in detail in this section and which are intended to be run subject to the various environmental procedures of RTCA DO-160G/EUROCAE ED-14G. In order to simplify the process of relating the environmental procedures to the FIS-B performance tests,

Table 2-5 divides the environmental procedures into groups. All of the procedures in a given group are carried out in conjunction with the same set of FIS-B performance tests. Using this approach, the environmental procedures fall into three groups. The environmental procedures that apply to all of the sets of FIS-B performance tests fall into Group 1. Group 2, which applies to none of the FIS-B performance tests, only requires that the equipment is powered and functioning normally. Group 2 is identified for environmental procedures that are intended to determine the effect of the FIS-B functions on rack mounting hardware, compass needles, explosive gasses and other radio frequency (RF) hardware. Group 3 is identified for environmental procedures that are intended to determine FIS-B equipment effects on mechanical aspects or fire safety.

Table 2-6 indicates which of the groups of environmental procedures is related to each set of FIS-B performance tests. Each FIS-B performance test **shall** be validated under all of the environmental procedures in the groups required for that test as indicated in Table 2-6.

<u>Table 2-5:</u> Environmental Test Groups

RTCA DO-160G Test #	Environmental Conditions	RTCA DO-160G/ EUROCAE ED-14G Paragraph	Groups	Remarks
4a	Temperature	4.5	1	
4b	Altitude	4.6.1	1	
4c	Decompression & Overpressure	4.6.2-4.6.3	2	When required
5	Temperature Variation	5.0	1	
6	Humidity	6.0	1 & 3	3 During, 1 After
7a	Operational Shock	7.2	2	When required
7b	Crash Safety	7.3	3	
8	Vibration	8.0	1	During and After
9	Explosion	9.0	2	When required
10	Waterproofness	10.0	2	When required
11	Fluids Susceptibility	11.0	2	When required
12	Sand and Dust	12.0	2	When required
13	Fungus Resistance	13.0	2	When required
14	Salt Spray	14.0	2	When required
15	Magnetic Effect	15.0	2	
16	Power Input	16.0	1	
	Momentary Interruptions All Others		1 & 2	2 During, 1 after
17	Voltage Spike	17.0	1	After
18	Audio Freq. Conducted Susceptibility	18.0	1	
19	Induced Signal Susceptibility	19.0	1	
20	RF Susceptibility	20.0	1	
21	Emission of RF Energy	21.1	2	

RTCA DO-160G Test #	Environmental Conditions	RTCA DO-160G/ EUROCAE ED-14G Paragraph	Groups	Remarks
22	Lightning Induced Transient Susceptibility	22.0	1	
23	Lightning Direct Effects	23	N/A	
24	Icing	24	N/A	
25	Electrostatic Discharge	25	2	When required
26	Fire/Flammability	26	3	

Notes:

1. *Tests in Group 3 determine the effects of the FIS-B equipment on other equipment (mounts, compass needles, explosive gasses and other RF equipment) and therefore do not involve the FIS-B performance requirements of this document.*
2. *"When required" in Table-2-5 means when necessary to support installation issues and is not specifically required by these MOPS.*

Table 2-6: Performance Test Requirements during Environmental Tests

Test Procedure Paragraph	Description	Required Environment Test Groups (See Table 2-5)		
		1	**2**	**3**
2.3.2.1	Verification of Capacity	X		N/A
2.3.2.2	Verification of System Status	X		N/A
As required	Equipment powered-on		X	N/A

2.3.2 Detailed Environmental Procedures

The environmental procedures set forth below are considered satisfactory for use in determining equipment performance under environmental conditions. Although specific environmental procedures are cited, it is recognized that other methods may be preferred. These alternative procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternative procedures. These environmental procedures do not include specific pass fail criteria. It is intended that those criteria be obtained from the transponder performance requirements presented in the referenced paragraphs in Section 2.2.

2.3.2.1 Verification of Capacity

Step 1: Perform the test procedure of Section 2.4.3.6, with the exception of starting the FIS-B message playback at t=7980 seconds and continuing to the end of the stimulus (8782 seconds).

Step 2: Verify that the radio reception status page indicates the following Radio Stations with the corresponding reception success rates as shown in Table 2-7.

Table 2-7: Expected Radio Station Reception Success Rate during Environmental Tests

Tier of Radio Station	City, State	Latitude	Longitude	Expected Success Rate for Previous 10 sec*
High	Cameron, TX	31.20321	-97.0512	68% (27/40)
High	New Madrid, MO	36.67045	-89.5408	100% (40/40)
High	St Paul, MN	44.91471	-92.9465	100% (40/40)
Medium	Fitzgerald, GA	31.7527	-83.339	27% (8/30)
Medium	Fairview, OK	36.2175	-98.618	100% (30/30)
Medium	Owosso, MI	42.9497	-84.108	93% (28/30)
Low	Holly Springs, MS	34.64925	-89.6512	10% (2/20)
Low	Stockton, MO	37.63034	-93.6393	85% (17/20)
Low	Owensboro, KY	37.9073	-87.0538	95% (19/20)
Surface	Louisville, KY	38.1694	-85.7332	10% (1/10)
Surface	Louisville, KY	38.17011	-85.7352	30% (3/10)

**A tolerance of +/- 10% is allowed for a 1-second timing offset in the 10-second interval.*

Step 3: Repeat Steps 1 and 2 continually for the duration of the environmental test exposure.

2.3.2.2 Verification of System Status

No test required. Validation of this requirement is provided by the test procedure of Section 2.3.2.1.

2.4 Equipment Test Procedures

The test procedures set forth in the following sub-paragraphs are considered satisfactory for use in determining required performance under standard and stressed conditions. Although specific test procedures are cited, it is recognized that other methods may be preferred by the testing facility. These alternate procedures may be used if the equipment manufacturer can show they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

2.4.1 Test Approach

All tests in this section are based on the injection of a prescribed stimuli, provided as a set of binary source files, to the Unit Under Test (UUT) that should result in an expected display response. Each binary source file provided as part of this MOPS contains one (1) UAT Ground Uplink Message. These files are aggregated into a stimulus through a Comma-Separated Values (CSV or "*.csv") file that associates each binary source file with a time. Those Ground Uplink Messages with the same time can be replayed in any order.

The test procedures in this section are based on 18 "Test Groups" where each Test Group verifies all the requirements from Section 2.2 that are covered by a common stimulus. Each requirement maps to one Test Group. Each Test Group section identifies those Section 2.2 requirements verified.

Note: *These 18 Test Groups are specific to Section 2.4 of this MOPS and are not to be confused with the three (3) groupings of the environmental procedures discussed in Section 2.3.*

2.4.2 Definitions of Terms and Conditions of Test

The following are definitions of terms and the conditions under which the tests described in this section should be conducted.

1. Power Input Voltage—Unless otherwise specified, all tests shall be conducted with the power input voltage adjusted to design voltage, plus or minus 2%. The input voltage shall be measured at the input terminals of the equipment under test.
2. Power Input Frequency
    a. In the case of equipment designed for operation from an alternating current (AC) source of essentially constant frequency (e.g., 400 Hz), the input frequency shall be adjusted to design frequency, plus or minus 2%.
    b. In the case of equipment designed for operation from an AC source of variable frequency (e.g., 300 to 1000 Hz), unless otherwise specified, tests shall be conducted with the input frequency adjusted to within 5% of a selected frequency and within the range for which the equipment is designed.
3. Each UAT Ground Uplink Message is stored in its own "*.bin" file. Each bin file contains 432 byte uplink in its native encoding format starting at the UAT Ground Uplink Header.
4. Test Functionality—There are three basic test functions needed for the conduct of these tests.
    a. A playback function for the injection of the stimulus files.
    b. A timing function that allows for the ability to control time as provided in the test case.
    c. A location function that allows for geo-locating the unit under test, if necessary.

    Additionally, if the FIS-B processing and display functions are tightly coupled with the UAT receiver, a test point will be required for injection of the stimulus data at the output receiver. An alternative would be for the manufacturer to playback the stimulus files into a test transmitter built for that purpose, thus allowing the stimulus to flow "end-to-end." See Figure 2-1.

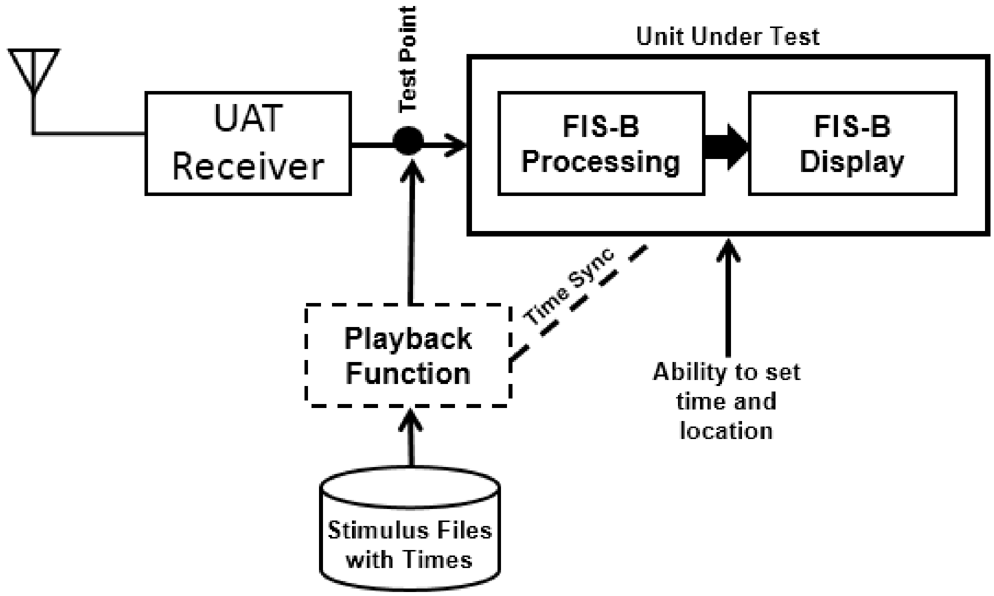

Figure 2-1: Basic Test Setup

1. Ambient Conditions—Unless otherwise specified, all tests shall be made within the following ambient conditions:
   a. Temperature: +15 to +35 degrees C (+59 to +95 degrees F).
   b. Relative Humidity: Not greater than 85%.
   c. Ambient Pressure: 84 to 107 kPa (equivalent to +5000 to -1500 ft) (+1525 to -460 m).
2. Connected Loads—Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.

2.4.3 Detailed Test Procedures

The test procedure overviews below provide a brief description of what will be tested and the requirements associated with those elements. Manufacturers may decide to create their own test stimulus to verify requirements. In those cases, the compliance to each Section 2.2 requirement must be defined by the manufacturer.

2.4.3.1 Test Group 1

This is the test for the TWGO product class to ensure textual decoding is done properly.

Table 2-8 lists the requirements covered under this test group.

Table 2-8: Test Group 1 Requirements

Req. #	Section 2.2 Requirement Statement
33	The FIS-B avionics **shall** [33] decode the TWGO product header according to the format provided in Section A.3.3.1.1.
34	The FIS-B avionics **shall** [34] identify each TWGO product title on the display.
35	The broadcasted FIS-B Product Updates Unavailable report **shall** [35] be available in its entire decoded text form for each product displayed.
38	The FIS-B avionics **shall** [38] decode NOTAM Text per the formats provided in Section A.3.3.
43	The FIS-B avionics **shall** [43] display text-only NOTAMs.
46	The FIS-B avionics **shall** [46] decode AIRMET Text per the formats provided in Section A.3.3.
50	The FIS-B avionics **shall** [50] make available for display the entire decoded text from all received AIRMETs.
53	The FIS-B avionics **shall** [53] decode SIGMET Text per the formats provided in Section A.3.3.
57	The FIS-B avionics **shall** [57] make available for display the entire decoded text from all received SIGMETs.

See supplemental file "Test Group 1 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.2 Test Group 2

This is the test for the Generic Text product class to verify textual decoding. It also tests for proper updating of the display upon reception of new Generic Text products. Table 2-9 lists the requirements covered under this test group.

Table 2-9: Test Group 2 Requirements

Req. #	Section 2.2 Requirement Statement
8	The FIS-B avionics **shall** [08] decode the Generic Text product class per the formats provided in Section A.3.1.
9	The FIS-B avionics **shall** [09] identify each Generic Text product title on the display.
10	The broadcasted Generic Text report **shall** [10] be available in its entire decoded text form.
12	The FIS-B avionics **shall** [12] display the newest METAR, and TAF Generic Text reports for a given location.

See supplemental file “Test Group 2 Procedures.docx” for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.3 Test Group 3

This test verifies the latency requirements are met for each textual product. Table 2-10 lists the requirements covered under this test group.

Table 2-10: Test Group 3 Requirements

Req. #	Section 2.2 Requirement Statement
11	The FIS-B avionics **shall** [11] make each Generic Text product available for display within the maximum latency shown in Table 2-2.
44	The FIS-B avionics **shall** [44] make a NOTAM available for display within 5 minutes of receipt by the FIS-B processor.
51	The FIS-B avionics **shall** [51] make an AIRMET available for display within 2.5 minutes of receipt by the FIS-B processor.
58	The FIS-B avionics **shall** [58] make a SIGMET available for display within 2.5 minutes of receipt by the FIS-B processor.

See supplemental file “Test Group 3 Procedures.docx” for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.4 Test Group 4

This test is designed to exercise and ensure the proper decoding, display and labeling of the Regional NEXRAD product and confirm proper display of the Regional NEXRAD legend. Table 2-11 lists the requirements covered under this test group.

Table 2-11: Test Group 4 Requirements

Req. #	Section 2.2 Requirement Statement
13	The FIS-B avionics **shall** [13] decode and process the Regional NEXRAD product according to the formats provided in Section A.3.2.
14	The FIS-B avionics **shall** [14] identify the Regional NEXRAD product title on the display.
15	The FIS-B avionics **shall** [15] provide a legend that indicates the color coding of intensity level and the coding used to indicate “No Data” for the Regional NEXRAD product.
18	The default initial rendering for all Regional NEXRAD global blocks **shall** [18] be the “No Data” condition.

See supplemental file “Test Group 4 Procedures.docx” for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.5 Test Group 5

This test is designed to exercise and ensure the proper display of Regional NEXRAD product age and the removal of Regional NEXRAD products at specified relative or absolute ages. Table 2-12 lists the requirements covered under this test group.

Table 2-12: Test Group 5 Requirements

Req. #	Section 2.2 Requirement Statement
16	When UTC time is available, the FIS-B avionics **shall** [16] display time elapsed since the APDU Header time associated with the oldest Regional NEXRAD data on the display.
17	When UTC time becomes unavailable, the FIS-B avionics **shall** [17] display the APDU Header time associated with the oldest Regional NEXRAD data on the display.
19	Each Regional NEXRAD global block rendering **shall** [19] revert to the "No Data" condition upon reaching 75 minutes of age.
21	The APDU timestamp variance across all Regional NEXRAD global blocks rendered on the display at any given time **shall** [21] be less than 10 minutes.

See supplemental file "Test Group 5 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.6 Test Group 6

This test is designed to load the avionics to ensure it has the capacity to process all Radio Stations in view in order to ensure minimal acquisition time and to maximize robustness. Since this test uses a large set of actual operational uplink data, it also verifies requirements for FIS-B avionics purging of redundant data and verifies the following are decoded correctly by the FIS-B avionics: UAT Ground Uplink Message, UAT Frame and the FIS-B APDU. Table 2-13 lists the requirements covered under this test group.

Table 2-13: Test Group 6 Requirements

Req. #	Section 2.2 Requirement Statement
2	The FIS-B avionics **shall** [02] decode the UAT Ground Uplink Message according to the format in Sections A.1 through A.1.2.
3	The FIS-B avionics **shall** [03] decode the UAT Frame according to the format in Sections A.1.3 through A.1.3.4.
5	The FIS-B avionics **shall** [05] decode the FIS-B APDU according to the format in Sections A.2 through A.2.2.
67	The FIS-B avionics **shall** [67] utilize reports received from all FIS-B radio stations in range to create a single set of FIS-B reports that are made available for display.
71	The FIS-B avionics **shall** [71] be capable of receiving, processing and

Req. #	Section 2.2 Requirement Statement
	making available to display UAT Ground Uplink Messages from 31 time slots within the same clock second (Time slots are described in APPENDIX G).
72	The FIS-B avionics **shall** [72] be capable of displaying real time radio station reception status each second that includes the following for each radio station being received: a. The latitude and longitude of the radio station as encoded in the UAT Header of the Ground Uplink Message; b. The Reception Success Rate, which is the fraction of all Ground Uplink Messages transmitted from that radio station that were received over the past 10 seconds; and, c. The product completeness status for NOTAMs, AIRMETs and SIGMETs, per Section 2.2.5.

See supplemental file "Test Group 6 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.7 Test Group 7

This test is designed to load the avionics with data from multiple radio stations using operational data followed immediately by uplink of a specific Regional NEXRAD test pattern from a single radio station. This test verifies the test pattern appears in the required time after it is transmitted to the UUT. Table 2-14 lists the requirements covered under this test group.

Table 2-14: Test Group 7 Requirements

Req. #	Section 2.2 Requirement Statement
20	The FIS-B avionics **shall** [20] make each Regional NEXRAD global block APDU available for display within 100 seconds of receipt by the FIS-B processor.

See supplemental file "Test Group 7 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.8 Test Group 8

This test is designed to load the avionics with data from multiple radio stations using operational data followed immediately by uplink of a specific CONUS NEXRAD test pattern from a single radio station. This test verifies the test pattern appears in the required time after it is transmitted to the UUT. Table 2-15 lists the requirements covered under this test group.

Table 2-15: Test Group 8 Requirements

Req. #	Section 2.2 Requirement Statement
30	The FIS-B avionics **shall** [30] make each CONUS NEXRAD global block APDU available for display within 100 seconds of receipt by the FIS-B processor.

See supplemental file "Test Group 8 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.9 Test Group 9

This test is designed to exercise and ensure the proper decoding, display and labeling of the CONUS NEXRAD product and confirm proper display of the CONUS NEXRAD legend. Table 2-16 lists the requirements covered under this test group.

Table 2-16: Test Group 9 Requirements

Req. #	Section 2.2 Requirement Statement
23	The FIS-B avionics **shall** [23] decode the CONUS NEXRAD product according to the formats provided in Section A.3.2.
24	The FIS-B avionics **shall** [24] identify the CONUS NEXRAD product title on the display.
25	The FIS-B avionics **shall** [25] provide a legend that indicates the color coding of intensity level and the coding used to indicate "No Data" for the CONUS NEXRAD product.
28	The default initial rendering for all CONUS NEXRAD global blocks **shall** [28] be the "No Data" condition.

See supplemental file "Test Group 9 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.10 Test Group 10

This test is designed to exercise and ensure the proper display of CONUS NEXRAD product age and the removal of CONUS NEXRAD products at specified relative or absolute ages. Table 2-17 lists the requirements covered under this test group.

Table 2-17: Test Group 10 Requirements

Req. #	Section 2.2 Requirement Statement
26	When UTC time is available, the FIS-B avionics **shall** [26] display time elapsed since the APDU Header time associated with the oldest CONUS NEXRAD data on the display.
27	When UTC time becomes unavailable, the FIS-B avionics **shall** [27] display the APDU Header time associated with the oldest CONUS NEXRAD data on the display.

Req. #	Section 2.2 Requirement Statement
29	Each CONUS NEXRAD global block rendering **shall** [29] revert to the “No Data” condition upon reaching 75 minutes of age.
31	The APDU timestamp variance across all CONUS NEXRAD global blocks rendered on the display at any given time **shall** [31] be less than 10 minutes.

See supplemental file “Test Group 10 Procedures.docx” for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.11 Test Group 11

This test addresses the requirements for decoding and displaying the graphical records of the TWGO products. It also ensures the UUT correctly associates the text and graphical records while keeping a graphical record for the required time. The test is not designed to cover every variation of encoding, but instead cover the typical encoding of graphics with multiple records and multiple geometries. Table 2-18 lists the requirements covered under this test group.

Table 2-18: Test Group 11 Requirements

Req. #	Section 2.2 Requirement Statement
39	The FIS-B avionics **shall** [39] decode NOTAM Graphic per the formats provided in Section A.3.3.
40	The FIS-B avionics **shall** [40] associate the NOTAM-D Text APDU with the NOTAM-D Graphic APDU.
41	The FIS-B avionics **shall** [41] associate the NOTAM-FDC/NOTAM-TFR Text APDU with the NOTAM-FDC/NOTAM-TFR Graphic APDU.
42	The FIS-B avionics **shall** [42] only display graphic NOTAMs that are associated with a text NOTAM.
47	The FIS-B avionics **shall** [47] decode AIRMET Graphic per the formats provided in Section A.3.3.
48	The FIS-B avionics **shall** [48] associate the AIRMET Text APDU with the AIRMET Graphic APDU.
49	The FIS-B avionics **shall** [49] only display the graphical AIRMETs that have an associated text AIRMET.
54	The FIS-B avionics **shall** [54] decode SIGMET Graphic per the formats provided in Section A.3.3.
55	The FIS-B avionics **shall** [55] associate the SIGMET Text APDU with the SIGMET Graphic APDU.
56	The FIS-B avionics **shall** [56] only display the graphical SIGMETs that have an associated text SIGMET.

Req. #	Section 2.2 Requirement Statement
73	A NOTAM-D graphic record received before that of a matching text record **shall** [73] be retained at least 20 minutes awaiting receipt of the matching text record.
74	A NOTAM-FDC/NOTAM-TFR graphic record received before that of a matching text record **shall** [74] be retained at least 40 minutes awaiting receipt of the matching text record.
75	An AIRMET graphic record received before that of a matching text record **shall** [75] be retained at least 10 minutes awaiting receipt of the matching text record.
76	A SIGMET graphic record received before that of a matching text record **shall** [76] be retained at least 10 minutes awaiting receipt of the matching text record.

See supplemental file “Test Group 11 Procedures.docx” for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.12 Test Group 12

This test addresses the requirements for decoding and reassembling segmented APDUs. Table 2-19 lists the requirements covered under this test group.

Table 2-19: Test Group 12 Requirements

Req. #	Section 2.2 Requirement Statement
63	The FIS-B avionics **shall** [63] generate a Product File composed of APDU segments with the same Product File ID.
64	All APDU segments **shall** [64] be present in order to assemble the segmented APDU.
65	The FIS-B avionics **shall** [65] use any Product File ID-associated APDU segment received for up to 60 minutes in the process of assembling a complete segmented APDU sequence.
66	The FIS-B avionics **shall** [66] use any APDU segment received from any radio station in the process of assembling a complete segmented APDU sequence.

See supplemental file “Test Group 12 Procedures.docx” for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.13 Test Group 13

This test is designed to load the FIS-B avionics with data from multiple Radio Stations using operational data in order to test latency requirements are met for graphical records. In addition to the operational data, two (2) specially created test reports are added for NOTAM, AIRMET and SIGMET each containing a text and graphic record with different uplink timing in order to verify latency. Table 2-20 lists the requirements covered under this test group.

Table 2-20: Test Group 13 Requirements

Req. #	Section 2.2 Requirement Statement
77	NOTAM graphical records **shall** [77] be available for display within 5 minutes of receipt by the FIS-B processor of that graphical record or its associated text record, based on whichever arrives later.
78	AIRMET graphical records **shall** [78] be available for display within 2.5 minutes of receipt by the FIS-B processor of that graphical record or its associated text record, based on whichever arrives later.
79	SIGMET graphical records **shall** [79] be available for display within 2.5 minutes of receipt by the FIS-B processor of that graphical record or its associated text record, based on whichever arrives later.

See supplemental file "Test Group 13 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.14 Test Group 14

This tests the CRL functionality. The test will verify requirements for using the CRL to annunciate product completeness. Table 2-21 lists the requirements covered under this test group.

Table 2-21: Test Group 14 Requirements

Req. #	Section 2.2 Requirement Statement
6	The FIS-B avionics **shall** [06] decode the CRL for each of the products NOTAM-TFR, AIRMET and SIGMET per formats provided in Section A.4.
60	The FIS-B avionics **shall** [60] determine if the CRL contains a report for each Report ID associated with the following product cases: • all NOTAM-TFRs (i.e., those identified as TFR by the FIS-B Ground System) • all AIRMETs • all SIGMETs.
61	The FIS-B avionics **shall** [61] provide an indication that the product report set is complete when a report is available for every Report ID contained in the CRL, for each of the cases below, as they are selected for display by the user: NOTAM-TFR, AIRMET and SIGMET.
62	The FIS-B avionics **shall** [62] remove the indication of completeness, for a given product if the CRL is not received within twice the transmission interval for the cases above.

See supplemental file "Test Group 14 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.15 Test Group 15

This test is designed to verify that invalid UAT Frame Types and invalid APDU Product IDs are discarded by the avionics. Table 2-22 lists the requirements covered under this test group.

Table 2-22: Test Group 15 Requirements

Req. #	Section 2.2 Requirement Statement
4	The FIS-B avionics **shall** [04] discard all UAT Frame Types other than 0 and 14 for the purposes of processing FIS-B information.
7	The FIS-B avionics **shall** [07] discard any APDU with a Product ID other than those listed in Table 2-1.

See supplemental file "Test Group 15 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.16 Test Group 16

This test is designed to verify that FIS-B Product Update Unavailable reports will be purged by the FIS-B avionics when 20 minutes elapses with no reception of that report. Table 2-23 lists the requirements covered under this test group.

Table 2-23: Test Group 16 Requirements

Req. #	Section 2.2 Requirement Statement
37	The FIS-B avionics **shall** [37] purge the FIS-B Product Update Unavailable report after 20 minutes from the last received FIS-B Product Update Unavailable report.

See supplemental file "Test Group 16 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.17 Test Group 17

This test is designed to verify that NOTAMs will be purged by the FIS-B avionics when 60 minutes elapses with no reception of that NOTAM. Table 2-24 lists the requirements covered under this test group.

Table 2-24: Test Group 17 Requirements

Req. #	Section 2.2 Requirement Statement
45	The FIS-B avionics **shall** [45] purge any unique NOTAM report with expiration date prior to the current UTC time.

See supplemental file "Test Group 17 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

2.4.3.18 Test Group 18

This test is designed to ensure a minimum FIS-B display capability exists when UTC time is unavailable to the FIS-B avionics. Table 2-25 lists the requirements covered under this test group.

Table 2-25: Test Group 18 Requirements

Req. #	Section 2.2 Requirement Statement
69	The FIS-B avionics **shall** [69] at a minimum, make available entire decoded text reports and Regional and CONUS NEXRAD in the event that UTC time is inaccessible.
70	The FIS-B avionics **shall** [70] provide an indication when operating without access to UTC time.

See supplemental file "Test Group 18 Procedures.docx" for the detailed procedures. DO-358 Supplements available as electronic zip file.

Requirements Verification Summary

Table 2-26 lists all numbered (shall) requirements of Section 2.2 along with their verification.

Table 2-26: Requirements Verification Summary

Section 2.2 Req. #	Requirement Verification Method		Section 2.2 Req. #	Requirement Verification Method
1	Verification determined by manufacturer		41	Test Group 11
2	Test Group 6		42	Test Group 11
3	Test Group 6		43	Test Group 1
4	Test Group 15		44	Test Group 3
5	Test Group 6		45	Test Group 17
6	Test Group 14		46	Test Group 1
7	Test Group 15		47	Test Group 11
8	Test Group 2		48	Test Group 11
9	Test Group 2		49	Test Group 11
10	Test Group 2		50	Test Group 1
11	Test Group 3		51	Test Group 3
12	Test Group 2		52	Test Group 17
13	Test Group 4		53	Test Group 1
14	Test Group 4		54	Test Group 11
15	Test Group 4		55	Test Group 11
16	Test Group 5		56	Test Group 11
17	Test Group 5		57	Test Group 1
18	Test Group 4		58	Test Group 3
19	Test Group 5		59	Test Group 17
20	Test Group 7		60	Test Group 14
21	Test Group 5		61	Test Group 14
22	Requirement # Not Used		62	Test Group 14
23	Test Group 9		63	Test Group 12

Section 2.2 Req. #	Requirement Verification Method		Section 2.2 Req. #	Requirement Verification Method
24	Test Group 9		64	Test Group 12
25	Test Group 9		65	Test Group 12
26	Test Group 10		66	Test Group 12
27	Test Group 10		67	Test Group 6
28	Test Group 9		68	Requirement # Not Used
29	Test Group 10		69	Test Group 18
30	Test Group 8		70	Test Group 18
31	Test Group 10		71	Test Group 6
32	Test Group 9		72	Test Group 6
33	Test Group 1		73	Test Group 11
34	Test Group 1		74	Test Group 11
35	Test Group 1		75	Test Group 11
36	Requirement # Not Used		76	Test Group 11
37	Test Group 16		77	Test Group 13
38	Test Group 1		78	Test Group 13
39	Test Group 11		79	Test Group 13 (Last requirement number used)
40	Test Group 11			

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3 MANUFACTURER CONSIDERATIONS FOR INSTALLED EQUIPMENT

This section states the minimum acceptable level of performance for the equipment when installed in the aircraft. Generally, installed performance requirements are the same as those contained in Section 2, which are verified through bench and environmental tests. However, certain requirements may be affected by the physical installation (e.g., antenna patterns, receiver sensitivity, etc.) and can only be verified after installation. The installed performance limits stated below take into consideration these situations.

3.1 Equipment Installation

3.1.1 Accessibility

Controls and monitors provided for in-flight operations shall be readily accessible from the pilot's normal seated position. The appropriate operator/crew member(s) shall have an unobstructed view of displayed data when in the normal seated position.

3.1.2 Aircraft Environment

Equipment shall be compatible with the environmental condition present in the specific location in the aircraft where the equipment is installed.

3.1.3 Display Visibility

Display intensity shall be suitable for data interpretation under all cockpit ambient light conditions ranging from total darkness to reflected sunlight.

Note: *Visors, glare-shields or filters may be an acceptable means of obtaining daylight visibility.*

3.1.4 Dynamic Range

Operation of the equipment shall not be adversely affected by aircraft maneuvering or changes in attitude encountered in normal flight conditions.

3.1.5 Failure Protection

Any probable failure of the equipment shall not degrade the normal operation of equipment or systems connected to it. Likewise, the failure of interfaced equipment or systems shall not degrade normal operation of this equipment.

3.1.6 Interference Effects

The equipment shall not be the source of harmful conducted or radiated interference nor be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

Note: *Electromagnetic compatibility problems noted after installation of this equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installing facility will be responsible for resolving any incompatibility between this equipment and previously installed equipment in the aircraft. The various factors contributing to the incompatibility shall be considered.*

3.1.7 Inadvertent Turnoff

Appropriate protection shall be provided to avert the inadvertent turnoff of the equipment.

3.1.8 Power Input

Unless otherwise specified, all aircraft electronically operated equipment and systems shall be turned ON before conducting interference testing.

3.1.9 Other Considerations

3.2 Installed Equipment Performance Considerations

The installed equipment shall meet the requirements of Section 2.1 and Section 2.2. In order to meet these requirements, test results supplied by the equipment manufacturer may be accepted in lieu of tests performed by the equipment installer. However, performance characteristics such as interaction with other installed equipment and power sources, which cannot be tested by the equipment manufacturer, shall be tested by the installer.

3.3 Test Procedures for Installed Equipment Performance

The following sections define conditions under which tests, specified in Section 3.3.4, shall be conducted

Standard safety precautions (best industry practices, in addition to those outlined in RTCA DO-160G/EUROCAE ED-14G) should be observed.

3.3.1 Environment

During testing, the equipment shall not be subjected to environmental conditions that exceed those specified by the equipment manufacturer.

3.3.2 Adjustment of Equipment

Circuits of the equipment under test shall be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.

3.3.3 Warm-up Period

Unless otherwise specified, tests shall be conducted after a warm-up (stabilization) period of not more than 15 minutes.

The following test procedures provide one means of determining installed equipment performance. Although specific test procedures are cited, it is recognized that other methods may be preferred by the installing activity. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. The equipment shall be tested to determine compliance with the minimum requirements stated in Section 2.2. In order to meet this requirement, test results supplied by the equipment manufacturer or other proof of conformity may be accepted in lieu of bench tests performed by the installing activity.

3.3.4 Ground Test Procedures

3.3.4.1 Conformity Inspection

Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices. Verify that proper mechanical and electrical connections have been made and that the equipment has been located and installed in accordance with the manufacturer's recommendations.

3.3.4.2 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer's instruction and that each control performs its intended function.

3.3.4.3 Interference Effects

With the equipment energized, individually operate each of the other electrically operated aircraft equipment and systems to determine that significant conducted or radiated interference does not exist. Evaluate all reasonable combinations of control settings and operating modes. Operate communication and navigation equipment on the low, high and at least one, but preferably four, mid-band frequencies. Make note of system or modes of operation that should also be evaluated during flight. If appropriate, repeat tests using emergency power with the aircraft's batteries alone and the inverters operating.

3.3.4.4 Power Supply Fluctuations

Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings and verify proper operation of the equipment as specified by the equipment manufacturer.

3.3.4.5 Equipment Accessibility

Determine that all equipment controls and displayed data are readily accessible and easily interpreted.

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4 MEMBERSHIP

Special Committee 206

Aeronautical Information Services Data Link

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APPENDIX A FORMAT AND ENCODING OF FIS-B UPLINK PRODUCTS

A.1 UAT Ground Uplink Message Format

The UAT Ground Uplink Message payload consists of two components: the first eight bytes comprise the UAT Ground Uplink Header[2] and bytes 9 through 432 comprise the Application Data. Figure A-1 shows the byte-level format of the UAT Ground Uplink Message. The most significant bit (MSB) is the leftmost bit and the least significant bit (LSB) is the rightmost bit in Figure A-1.

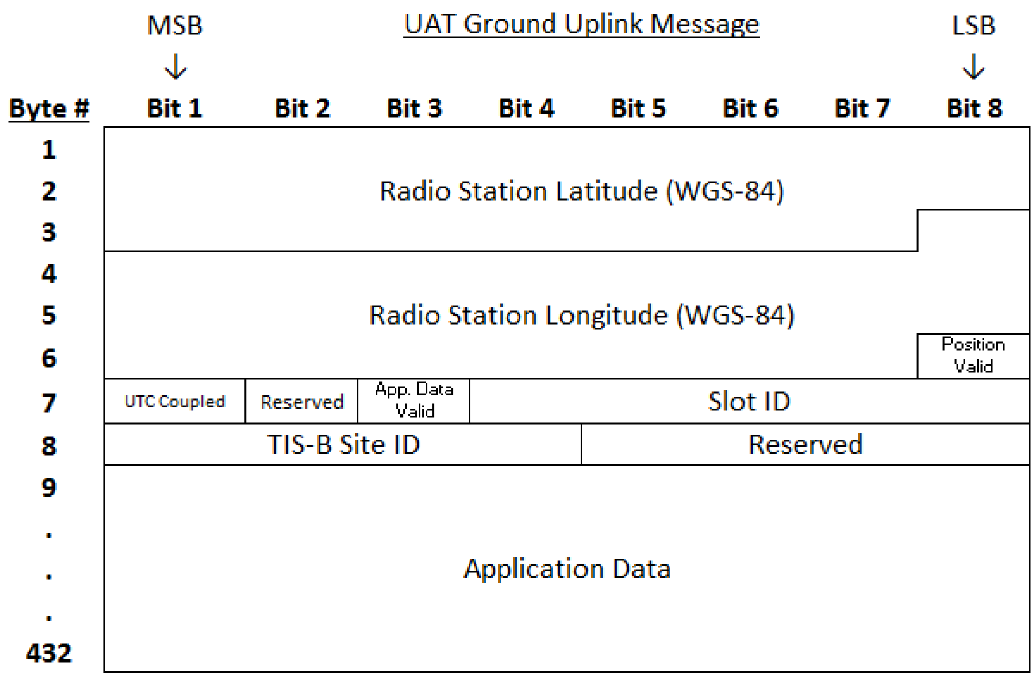


Figure A-1: UAT Ground Uplink Message Byte-Level Format

A.1.1 UAT Ground Uplink Header Format

The byte-level format of the UAT Ground Uplink Header is provided in Figure A-1. The header is eight (8) bytes long and is comprised of the Radio Station Latitude/Longitude, Position Valid, UTC Coupled, Application Data Valid, Slot ID, TIS-B Site ID and Reserved fields.

A.1.1.1 Radio Station Latitude/Longitude Field Encoding

The Radio Station Latitude field is a 23-bit field used to encode the latitude according to World Geodetic System-84 (WGS-84) coordinate system. Refer to Table A-1.

The Radio Station Longitude field is a 24-bit field used to encode the longitude according to WGS-84. Refer to Table A-1.

Figure A-2 gives a graphic depiction of the angular weighted binary encoding used for latitude and longitude.

[2] This is referred to as the UAT-Specific Uplink Header in RTCA DO-282B.

Note: *In RTCA DO-282B the term "Ground Station" is used rather than the term "Radio Station" used in this MOPS.*

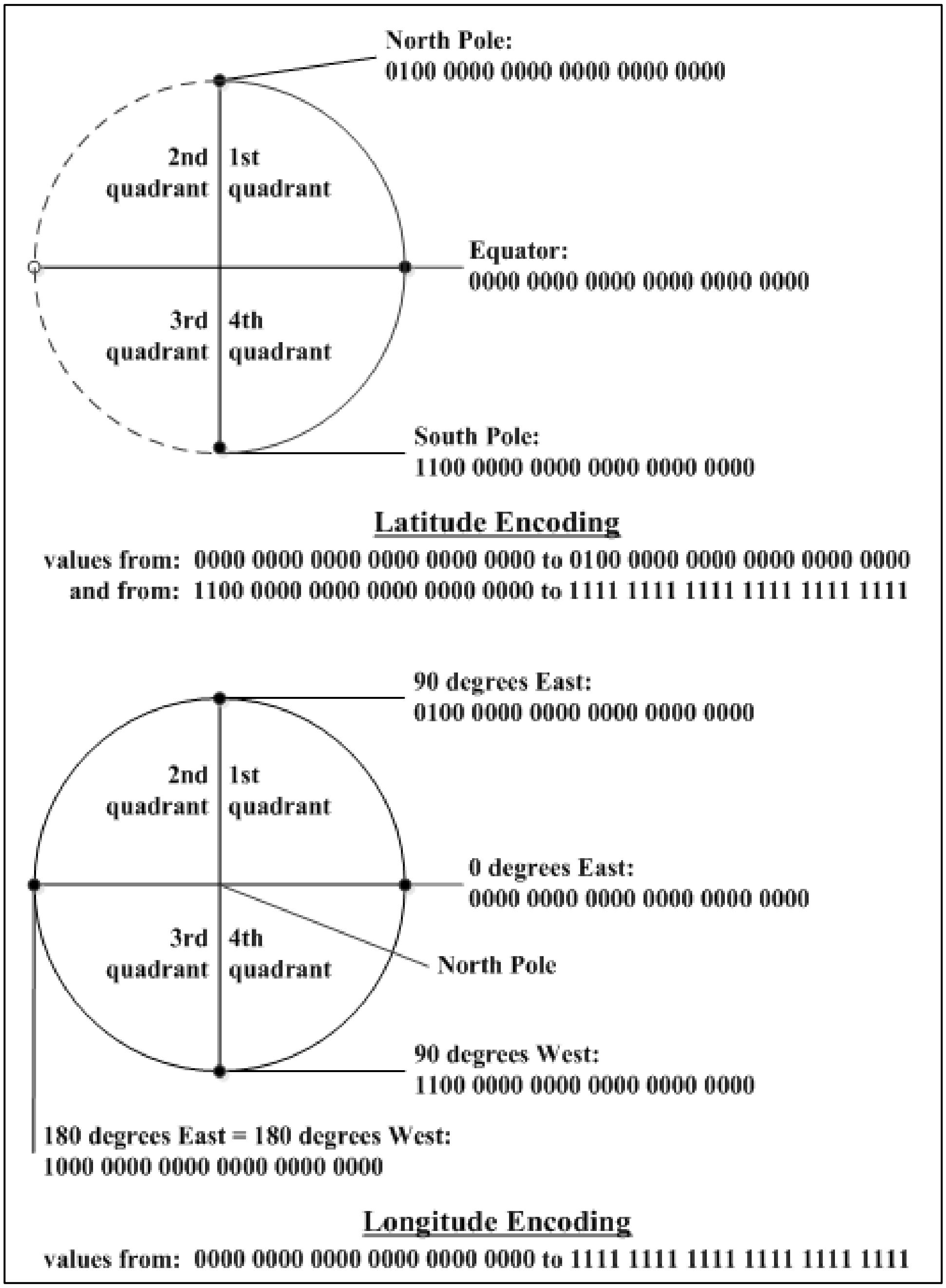
Table A-1: Angular Weighted Binary Encoding of Latitude and Longitude

Quadrant	"Latitude" or "Longitude" bits	Meaning ($LSB = 360/2^{24} = 2.1457672 \times 10^{-5}$ degrees)	
	MSB ... LSB	Latitude	Longitude
1st quadrant	0000 0000 0000 0000 0000 0000	ZERO degrees (Equator)	ZERO degrees (Prime Meridian)
	0000 0000 0000 0000 0000 0001	*LSB* degrees North	*LSB* degrees East
	. . .	. . .	. . .
	0011 1111 1111 1111 1111 1111	(90-*LSB*) degrees North	(90-*LSB*) degrees East
2nd quadrant	0100 0000 0000 0000 0000 0000	90 degrees (North Pole)	90 degrees East
	0100 0000 0000 0000 0000 0001	<Illegal Values>	(90+*LSB*) degrees East
	. . .	<Illegal Values>	. . .
	0111 1111 1111 1111 1111 1111	<Illegal Value>	(180-*LSB*) degrees East
3rd quadrant	1000 0000 0000 0000 0000 0000	<Illegal Value>	180 degrees East or West
	1000 0000 0000 0000 0000 0001	<Illegal Value>	(180-*LSB*) degrees West
	. . .	<Illegal Values>	. . .
	1011 1111 1111 1111 1111 1111	<Illegal Values>	(90+*LSB*) degrees West
4th quadrant	1100 0000 0000 0000 0000 0000	90 degrees (South Pole)	90 degrees West
	1100 0000 0000 0000 0000 0001	(90-*LSB*) degrees South	(90-*LSB*) degrees West
	. . .	. . .	. . .
	1111 1111 1111 1111 1111 1111	*LSB* degrees South	*LSB* degrees West

Notes:

1. The MSB of the angular weighted binary latitude is omitted from the transmitted message. This is because all valid latitudes, other than the latitude of the North Pole (exactly 90 degrees north), have the same value in their two MSBs. The application using the FIS-B reports has the responsibility to differentiate the North and South Poles.

2. Raw data used to establish the Latitude or Longitude fields will normally have more resolution (i.e., more bits) than is required by the Latitude or Longitude fields. When converting such data to the Latitude or Longitude subfields, the accuracy of the data is *maintained such that it is not worse than ±½ the LSB where the LSB is that of the Latitude or Longitude field.*



<u>Figure A-2:</u> Angular Weighted Binary Encoding of Latitude and Longitude

A.1.1.2 Position Valid Field Encoding

The Position Valid field is a 1-bit flag used to indicate whether or not the position in the header is valid.

<u>Note:</u> *This field should be ignored for the purpose of this MOPS.*

A.1.1.3 UTC Coupled Field Encoding

The UTC Coupled flag is a 1-bit flag used to indicate whether or not the radio station 1 Pulse Per Second timing is valid. An encoding of one (1) represents that the radio station is UTC-Coupled. An encoding of zero (0) represents that the radio station is not UTC-Coupled.

Note: *The radio station must be UTC time synchronized to transmit. If sufficient time precision cannot be assured, the radio station does not transmit (i.e., the not-UTC-Coupled case would never be broadcast).*

A.1.1.4 Reserved Bit

Bit 2 of byte 7 is reserved for future use and should be ignored for the purpose of this MOPS.

A.1.1.5 Application Data Valid Field Encoding

The Application Data Valid field is a 1-bit flag used to indicate whether or not the Application Data is valid for operational use. An encoding of one (1) represents VALID Application Data. An encoding of zero (0) represents INVALID Application Data.

Notes:

1. *Equipment conforming to this MOPS should discard the Application Data when this bit is set to INVALID.*
2. *This flag will allow testing and demonstration of new products without impact to operational airborne systems.*

A.1.1.6 Slot ID Field Encoding

The Slot ID field is a 5-bit field used to identify the time slot within which the Ground Uplink Message transmission took place. This field is encoded as a 5-bit unsigned binary numeral.

Notes:

1. *The Slot ID for UAT Ground Uplink Messages is continually shifted for maximum interference tolerance to other users sharing the band. Airborne receivers do not need a priori knowledge of this shifting scheme; this is for ground service providers to coordinate. APPENDIX G of this document contains more detail.*
2. *Equipment conforming to this MOPS has no minimum requirement to react to the setting of this field.*
3. *The Slot ID is related to the Transmission Time Slot discussed in APPENDIX G. The Slot ID is the Transmission Time Slot minus 1.*

A.1.1.7 TIS-B Site ID Field Encoding

The TIS-B Site ID field is a 4-bit field used to identify the tier and data channels used by the radio station.

A.1.1.8 Reserved Bits

Bits 5 through 8 of byte 8 are reserved for future use and should be ignored for the purpose of this MOPS.

A.1.2 Application Data Format

The Application Data consists of one or more variable length UAT Frames and always consists of an integral number of bytes. The UAT Frames are organized sequentially inside the payload of a UAT Ground Uplink Message with any remaining space, of the 424-byte payload, filled with all zeros. Figure A-3 shows the decomposition of the Application Data.

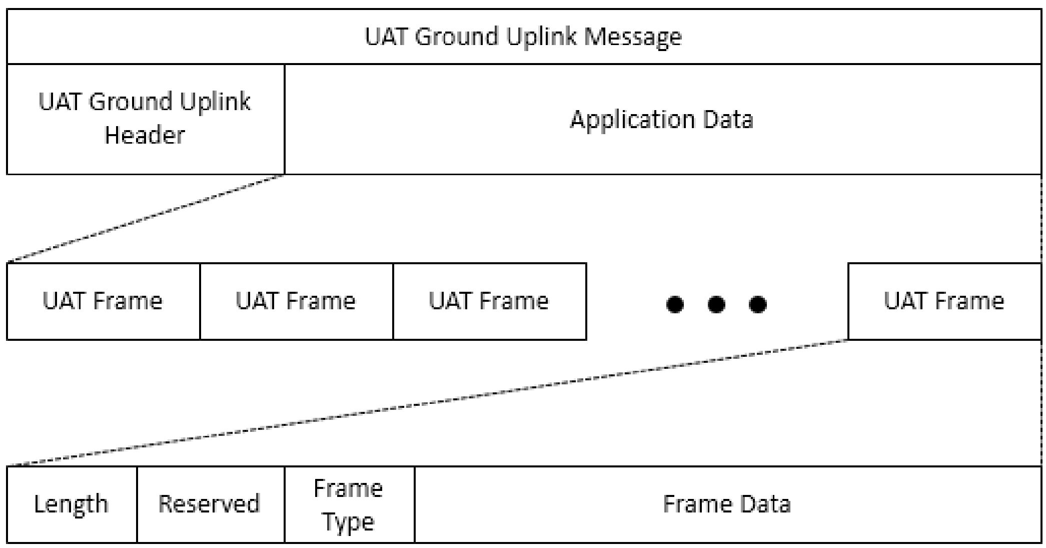


Figure A-3: Decomposition of the Application Data

Note: *Figure A-3, and others, that illustrate the decomposition of the UAT Uplink Message do not show the possible zero fill padding that may be required.*

A.1.3 UAT Frame Format

Each variable length UAT Frame consists of "N" bytes, comprising a Length field, a Reserved field, a Frame Type field and a Frame Data field. Figure A-4 shows the byte-level format of the UAT Frame.

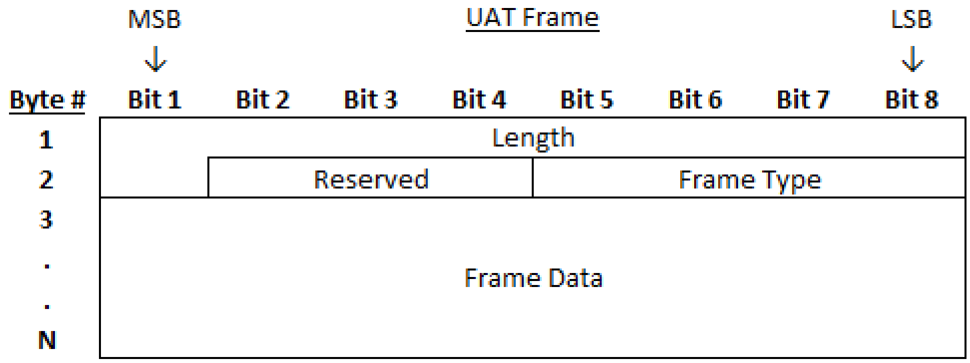


Figure A-4: UAT Frame Byte-Level Format

Note: *The Byte numbers in this figure are relative to the beginning of the current UAT Frame.*

A.1.3.1 Length Field Encoding

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

A.1.3.2 Reserved Field

Bits 2 through 4 of byte 2 are reserved and should be ignored.

A.1.3.3 Frame Type Field Encoding

The Frame Type field is a 4-bit field that contains the indication for the format of the Frame Data field. The encoding of Frame Type field is shown in Table A-2.

Table A-2: Frame Type Field Encoding

Coding (binary) **MSB LSB**	**Coding (decimal)**	**Frame Data Format**
0000	0	FIS-B APDU
0001	1	Reserved for Developmental Use
0010	2	Reserved for Future Use
through	through	
1101	13	
1110	14	CRL
1111	15	TIS-B/ADS-R Service Status

Note: *Frame Type 1 is intended for developmental use, such as to support on-air flight testing of new Ground Uplink Message Frame Types, prior to their adoption in future MOPS versions.*

A.1.3.3.1 Frame Type 0—FIS-B APDU

When the Frame Type is zero (binary 0000), the Frame Data contains an APDU Header, followed by the APDU Data, as described in Section A.2.

A.1.3.3.2 Frame Type 14—CRL

When the Frame Type is 14 (binary 1110), the Frame Data contains a CRL Header followed by the CRL Payload as described in Section A.4.

A.1.3.3.3 Frame Type 15—TIS-B/ADS-R Service Status

Frame Type 15 (binary 1111) is not used for FIS-B. Section H.9 of RTCA DO-317B/EUROCAE ED-194A describes the encoding of this frame.

A.1.3.3.4 Other Potential Future Frame Data Content

Thirteen reserved values remain for future and developmental use. Any frame types not currently defined in this appendix should be ignored.

A.1.3.4 Frame Data Field Encoding

A.1.3.4.1 FIS-B Product Frame Data

The Frame Data field is comprised of an APDU Header and APDU Payload or a CRL Header and CRL Payload. Note that if the Frame Data field contains a CRL Header and CRL Payload than those terms would replace the APDU Header and APDU Payload fields, respectively, in Figure A-5.

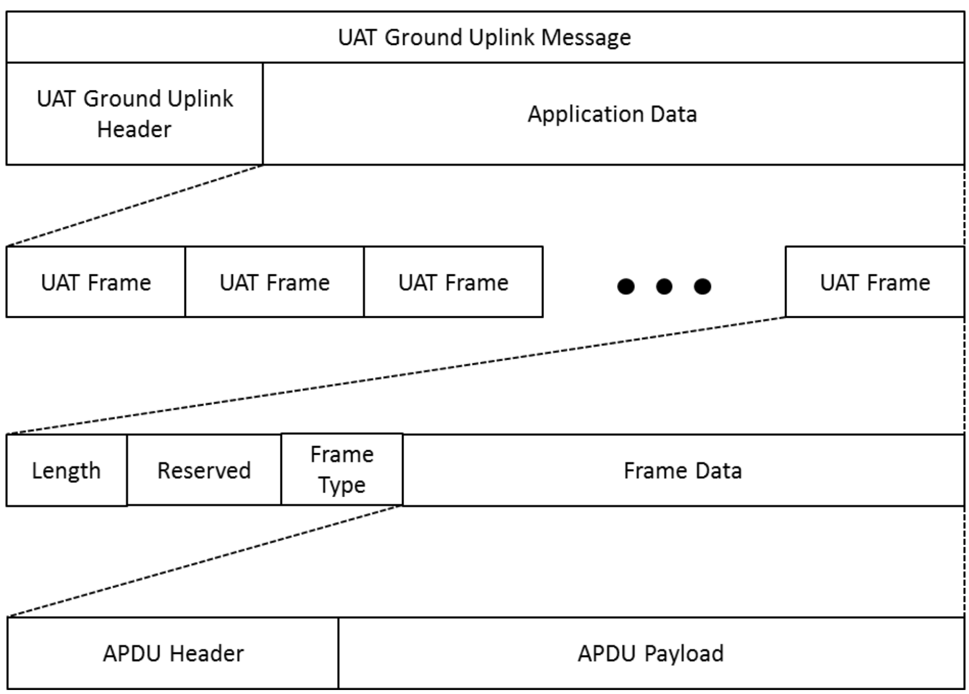


Figure A-5: Decomposition of the Frame Data

A.2 APDU Header and Payload Encoding

The fields contained in the APDU Header are determined by the type of product and whether the report requires segmentation. The type of product will determine the Time Option and the specific time fields included in the APDU Header. Figure A-6 shows graphically the APDU Header format at the bit level for a Product Type where the Time Option calls for Month/Day/Hours/Minutes and when there is no APDU segmentation. Figure A-7 shows the APDU Header format at the bit level for a Product Type where the Time Option calls for Month/Day/Hours/Minutes and when there is APDU segmentation. A variable amount of padding is added, as required, in order to make the APDU Header align with the nearest byte boundary

← APDU Header 40 bits) →										
Product Descriptor (14 bits)				S f	Header Time (22 bits)					Pad (3 bits)
A f	G f	P f	Product ID (11 bits)		T opt	Month (4 bits)	Day (5 bits)	Hours (5 bits)	Minutes (6 bits)	

Figure A-6: APDU Header Bit Level Format—No Segmentation

← APDU Header (72 bits) →										
Product Descriptor (14 bits)				S f	Header Time (22 bits)					
A f	G f	P f	Product ID (11 bits)		T opt	Month (4 bits)	Day (5 bits)	Hours (5 bits)	Minutes (6 bits)	•••

•••	Segmentation Block (28 bits)			Pad (7 bits)
	Product File ID (10 bits)	Product File Length (9 bits)	APDU Number (9 bits)	

Figure A-7: APDU Header Bit Level Format when Segmentation Block Present

Table A-3 gives a breakdown of the APDU Header elements with Section reference.

Table A-3: APDU Header Breakdown

Name	Section Name	Section Number
APDU Header	APDU Header	A.2.1
Product Descriptor	Product Descriptor	A.2.1.1
Af	Application Methods Flag Bit	A.2.1.1.1
Gf	Geographic Locator Flag Bit	A.2.1.1.2
Pf	Provider Specific Flag Bit	A.2.1.1.3
Product ID	Product Identifier	A.2.1.1.4
Sf	Segmentation Flag Bit	A.2.1.2
APDU Header Time	Header Time	A.2.1.3
T opt	Time Options	A.2.1.3.1
Month	Month (optional)	A.2.1.3.2
Day	Day (optional)	A.2.1.3.3
Hours	Hours	A.2.1.3.4
Minutes	Minutes	A.2.1.3.5
Segmentation Block	Segmentation Block	A.2.1.4
Product File ID	Product File ID	A.2.1.4.1
Product File Length	Product File Length	A.2.1.4.2
APDU Number	APDU Number	A.2.1.4.3
Pad	Pad	A.2.1.5

A.2.1 APDU Header

The APDU Header consists of the following data fields: Product Descriptor, Segmentation Flag, Header Time, an optional Segmentation Block and a variable length Pad.

A.2.1.1 Product Descriptor

The Product Descriptor field contains the flag bits for the optional Application Methods, Geographic Locator and Provider Specific fields. It also contains the Product ID field which indicates the type of product within that particular APDU. See Table 2-1 for the mapping of Product ID to Product Title.

A.2.1.1.1 Application Methods Flag Bit

The Application Methods Flag Bit (Af) is reserved and should be ignored by equipment conforming to this MOPS.

A.2.1.1.2 Geographic Locator Flag Bit

The Geographic Locator Flag Bit (Gf) is reserved and should be ignored by equipment conforming to this MOP.

A.2.1.1.3 Provider Specific Flag Bit

The Provider Specific Flag Bit (Pf) is reserved and should be ignored by equipment conforming to this MOP.

A.2.1.1.4 Product Identifier

The Product ID identifies the FIS-B product contained in the APDU Payload. Only the Product ID values in Table 2-1 are recognized by equipment conforming to this MOPS.

A.2.1.2 Segmentation Flag Bit

The Segmentation Flag bit (Sf) indicates whether the optional Segmentation Block is present (Sf = 1) or omitted (Sf = 0). Product Files that are too large for transmission in a single APDU are segmented into multiple APDUs. In this event, the Segmentation Flag is set (i.e., Sf = 1) to indicate use of the Segmentation Block with resulting Product File segments individually numbered and sequenced. Section A.2.1.4 provides more detail on the Segmentation Block.

A.2.1.3 Header Time

The Header Time may be the specific time the APDU(s) are created or generated or it may be some other time established by the FIS-B provider such as the date/time of the Product File. Note that the Header Time will be the same/identical for all linked APDU segments.

The Header Time will use up to 22 bits (Month, Day, Hours and Minutes, as shown in Table A-4). The use of these fields for specific products will be explained in the product specific notes for each product in Section A.3.

Table A-4: Header Time

APDU Field	Binary Length
Time Option (T opt)	2 bits
Month of Year (Optional)	4 bits
Day of Month (Optional)	5 bits
Hours	5 bits
Minutes	6 bits

A.2.1.3.1 Time Options

Table A-5 provides the Time Option states.

Table A-5: Time Options

Options	Day of Month (5 bits) and Month of Year (4 bits)	Hours (5 bits) and Minutes (6 bits)
00	Omitted	Included
01	Reserved	Reserved
10	Included	Included
11	Reserved	Reserved

A.2.1.3.2 Month of Year (Optional)

The Month field gives the month value derived from UTC (Z) time and corresponds to the month number within the year.

A.2.1.3.3 Day of Month (Optional)

The Day field gives the day value from UTC (Z) time and corresponds to the day within the month.

A.2.1.3.4 Hours

The Hours field gives the hours value from UTC (Z) time.

A.2.1.3.5 Minutes

The Minutes field gives the minutes value from UTC (Z) time.

A.2.1.4 Segmentation Block

The Segmentation Block will be included in the APDU Header if the Segmentation Flag Bit is set to one (1). It will be omitted if the Segmentation Flag Bit is cleared to zero (0). The purpose of the Segmentation Block is to provide information for the reassembly of a FIS-B Product File that has been segmented into multiple APDUs. Those FIS-B Product Files conveyed by independent APDUs will not use the Segmentation Block mechanism. If present, the Segmentation Block will consist of three components, the Product File ID field, the Product File Length field and the APDU Number field.

A.2.1.4.1 Product File ID

The Product File ID field identifies the specific individual segments of a FIS-B product that are associated with one another. This identifier is consistent across all radio stations contained within the same FIS-B CS area.

A.2.1.4.2 Product File Length

The Product File Length field indicates the number of linked APDUs comprising the FIS-B Product File identified by the Product File ID. The Product File Length field remains constant for all APDUs comprising a Product File.

A.2.1.4.3 APDU Number

The APDU Number field identifies a specific APDU in a series of linked APDUs. The APDU Number field is incremented by one for each transmitted APDU of a Product File. For example, if the Product File Length field is eight and the APDU Number field is three, then the APDU is the third of eight total APDUs contained in the Product File.

Note: *A value of zero (0) for the APDU Number is invalid and the enclosing APDU should be ignored for the purpose of this MOPS.*

A.2.1.5 Pad

The APDU Header will be padded with up to seven (7) zero-valued padding bits in order to make the APDU Header align with the nearest byte boundary (i.e., to make the total number of bits in the APDU Header a multiple of eight). The number of padding bits (if any) required for a given APDU will vary depending on the particular use of APDU Header options.

A.2.2 APDU Payload

The APDU Payload is composed of the encoded FIS-B products described in Section A.3. The Frame Data field is always an integral number of bytes in length.

A.3 FIS-B Products

FIS-B products are broken down into three classes: Generic Text products, Global Block Representation products and TWGO products. Generic Text products are always assigned a Product ID of 413 and use the Data Link Application Control (DLAC) 6-bit alphabet (see Table A-6). These products are represented as strings of characters in a format that is independent of the type of text product itself. Generic Text products include METAR, PIREP, TAF and WINDS. Global Block Representation products are assigned a Product ID of 63 for Regional NEXRAD encoding and a Product ID of 64 for CONUS NEXRAD encoding. These products are represented as graphical images of precipitation without a base map. TWGO products are assigned Product IDs ranging from 8 through 12 depending on the product. These products include a textual portion and an optional graphical portion. TWGO products consist of NOTAMs (Product ID #8), FIS-B Product Updates Unavailable Reports (Product ID #8), AIRMETS (Product ID #11), SIGMETs (Product ID #12) and Convective SIGMETs (WST) (Product ID #12). See Table 2-1 for the breakdown of Product Title by Product Class and ID number.

A.3.1 Generic Text (Product ID #413)

A.3.1.1 Generic Text Encoding

The DLAC 6-bit alphabet, given in Table A-6, will be used to encode Generic Text products. Since a DLAC character does not use an entire byte in its representation, multiple DLAC characters can be packed together such that four characters can be carried in three bytes of data. In the event there are an insufficient number of characters to fill a three-byte sequence, the last byte containing a character is padded with zeroes. The DLAC character alphabet does not include lowercase characters.

Table A-6: Generic Text Encoding

Bit Encoding	Character	Bit Encoding	Character
000000	ETX	100000	space
000001	A	100001	!
000010	B	100010	“
000011	C	100011	#
000100	D	100100	CS
000101	E	100101	%
000110	F	100110	&
000111	G	100111	‘
001000	H	101000	(
001001	I	101001	)
001010	J	101010	*
001011	K	101011	+
001100	L	101100	,
001101	M	101101	-
001110	N	101110	.
001111	O	101111	/
010000	P	110000	0
010001	Q	110001	1
010010	R	110010	2
010011	S	110011	3
010100	T	110100	4
010101	U	110101	5
010110	V	110110	6
010111	W	110111	7
011000	X	111000	8
011001	Y	111001	9
011010	Z	111010	:
011011	NC	111011	;
011100	TAB	111100	<
011101	RS	111101	=

Bit Encoding	Character	Bit Encoding	Character
011110	CRLF	111110	>
011111	|	111111	?

A.3.1.1.1 Data Link Applications Coding (DLAC) Control Characters

The International Civil Aviation Organization (ICAO) DLAC character set contains control characters that govern the appearance and formatting of the text report. The following control characters are specified for the DLAC character set.

- CRLF—This is the End-of-Line character, which indicates a line break on the display.
- RS—This is the Record Separator character. This character also implies a display line break and can replace an End-of-Line character.
- ETX—This is the End-of-Text character, which denotes both a display line break as well as the end of the text report. It can also replace End-of-Line and Record Separator characters in the last line of a multiple-report APDU.
- NC—The Null Character should be used to represent any characters not available using DLAC encoding (e.g., underscore or backslash).
- TAB—Tabulator (the binary value of the six bits following the TAB character define the number of Space characters to be inserted).
- Currency Sign—This is the Currency Sign (e.g., $).
- Space—This is the Space character.

A.3.1.2 Text Record Formatting

Text records for Generic Text products are formatted as shown in the syntax below.

<Type>< space ><LocID>< space ><Time>[SP|AM]< space ><Text report>
<RS><Fill bits>

Table A-7 gives the meanings for each component of the text record shown above.

Table A-7: Text Record Elements

Syntax Element	Description
<>	Denotes a required text string.
[]	Denotes an optional field.
space	Denotes a single space character (bit encoding of 100000).
RS	Denotes the record separator character (bit encoding of 011101).
Type	One or more characters not containing the <space> or <RS>. Limited to “METAR” and “TAF” initially.

Syntax Element	Description
LocID	One or more characters that cannot contain <space> or <RS>, required.
Time	One or more characters that cannot contain <space> or <RS>.
SP or AM	SP denotes special METAR as a subset of METAR or AM denotes amendments (AMEND) as a subset of TAF.
Text report	One or more characters that cannot contain <RS>. This is the actual text of the World Meteorological Organization report that may be displayed exactly as received without additional formatting or interpretation.
Fill bits	0, 2, 4 or 6 bits added as required.

A.3.1.3 APDU Header

The format of the APDU Header used for Generic Text products is shown in the Figure A-8. It follows the APDU Header format as outlined in Section A.2 with no APDU segmentation. The last four zeroes show the pad that is required to round out the APDU Header to end on a byte boundary. Section A.3.1.5.1 describes what the time field indicates for each different Generic Text product.

<table>
<tr><td colspan="32">← APDU Header (32 Bits) →</td></tr>
<tr><td colspan="14">Product Descriptor (14 bits)</td><td rowspan="2">S
f</td><td colspan="13">Header Time (13 bits)</td><td colspan="4" rowspan="2">Pad
(4 bits)</td></tr>
<tr><td>A
f</td><td>G
f</td><td>P
f</td><td colspan="11">Product ID (11 bits)</td><td colspan="2">T
opt</td><td colspan="5">Hours
(5 bits)</td><td colspan="6">Minutes
(6 bits)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Figure A-8: APDU Header Bit Level Format—Generic Text

A.3.1.4 APDU Payload

The Generic Text product APDU Payload is filled with DLAC encoded text. Since this product does not support APDU segmentation, a maximum of 418 bytes of DLAC encoded text can fit within the payload. If the text message is greater than 418 bytes, the message will be truncated as indicated in Section A.3.1.5.3. Figure A-9 shows the byte-level format for the text record.

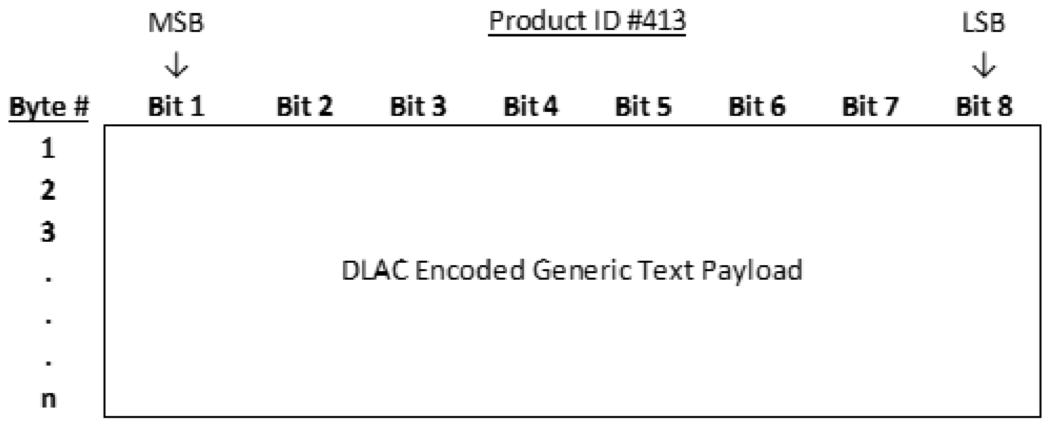


Figure A-9: Generic Text Record Byte-Level Format

A.3.1.5 Product Specific Notes

A.3.1.5.1 APDU Timestamp Rules

The time value provided in the APDU Header Time field for the Product #413 Generic Text products represents the following: For the observation-based products (i.e., METAR and PIREP), the APDU Header Time value is the time of observation in UTC time. For the forecast and advisory products (i.e., TAF and WINDS), the APDU Header Time value is the time these products are issued at their source in UTC time.

A.3.1.5.2 APDU Header Time

For METAR, TAF, PIREP and WINDS, only day, hour and minute are provided by the FIS-B Data Source. However, there is no such format in the Time Options field (see Figure A-5). Since these observation-based products do not exist for more than 24 hours, only the Hours and Minutes fields are used, as shown in Figure A-10:

T Opt 2 bits		Hours 5 bits					Minutes 6 bits					
0	0											

Figure A-10: APDU Header Time Bit Level Format

A.3.1.5.3 Truncation of Long Product #413s

Truncation is required because APDU segmentation does not support Product ID #413.

A.3.1.5.3.1 Description of Truncation

There are a total of 422 bytes available for the FIS-B APDU. Subtracting four bytes for the APDU Header, as configured for Product ID #413, and an additional one byte for the required DLAC Record Separator leaves a total of 417 bytes available for the APDU

Payload. Therefore, if the report totals 417 bytes or less, after being DLAC-encoded, the entire report will be sent.

If the report is greater than 417 bytes after DLAC encoding, truncation will be performed. After the 4-byte header is constructed the following parts are added to complete the remainder of the FIS-B APDU:

- The first 411 bytes of the DLAC-encoded payload will be retained with all further bytes discarded.
- The next six bytes of the payload will be filled with the 8-character terminator text "(INCMPL)," after it is DLAC-encoded. This text 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      )
```

- A Record Separator DLAC character and two (2) Pad bits will comprise the last byte of the APDU.

The resultant 422 bytes of the APDU with truncation is shown in Table A-8.

Table A-8: Generic Text Product Truncation Example

<table>
<tr><td rowspan="7">4 bytes</td><td rowspan="7">APDU Header</td><td>1 bit</td><td>Application Methods Flag</td></tr>
<tr><td>1 bit</td><td>Geographic Locator Flag</td></tr>
<tr><td>1 bit</td><td>Provider Specific Flag</td></tr>
<tr><td>11 bits</td><td>Product ID</td></tr>
<tr><td>1 bit</td><td>Segmentation Flag</td></tr>
<tr><td>13 bits</td><td>Header Time</td></tr>
<tr><td>4 bits</td><td>Pad</td></tr>
<tr><td>411 bytes</td><td>DLAC-encoded report text</td><td colspan="2">…DLAC-encoded report text…</td></tr>
<tr><td>6 bytes</td><td>DLAC-encoded terminator "(INCMPL)"</td><td colspan="2">101000001001001110000011001101010000001100101001</td></tr>
<tr><td rowspan="2">1 byte</td><td>DLAC-encoded Record Separator</td><td>6 bits</td><td>011101</td></tr>
<tr><td>Pad</td><td>2 bits</td><td>00</td></tr>
</table>

A.3.1.5.4 Winds and Temperatures Aloft

A single WINDS report is uplinked by the FIS-B Ground System for each individual reporting location and forecast period. Therefore each reporting location will have three active reports corresponding to the 6, 12 and 24 hour forecast. As generated by the NWS, the WINDS header contains the "For Use" time period. This information is omitted in the report as uplinked by the FIS-B Ground System but can be inferred by the avionics based on the "Valid" time and "Product Available" time that appear in each report. Specifically, the Product Available time is encoded in the APDU Header and the Valid time appears in the uplinked text report.

Figure A-11 shows a sample uplinked text report with the Valid time in bold text.

WINDS ABI	**201800Z**	FT	6000	9000	12000	18000	24000	30000	34000	39000	2417+20
2417+14	2229+07	2437-11	2540-23	255039	266247	267255					

Figure A-11: Example of Wind and Temperature Text Report as Uplinked

Table A-9 is taken from Advisory Circular (AC) 00-45G showing the Wind and Temperature Aloft forecast periods and should be useful in inferring the “For Use” time based on the “Valid” and “Product Available” times.

Table A-9: Timing of the Wind and Temperatures Aloft Forecast Periods

Model Run	Product Available	6-Hour Forecast		12-Hour Forecast		24-Hour Forecast	
		Valid	For Use	Valid	For Use	Valid	For Use
0000Z	~0200Z	0600Z	0200-0900Z	1200Z	0900-1800Z	0000Z	1800-0600Z
0600Z	~0800Z	1200Z	0800-1500Z	1800Z	1500-0000Z	0600Z	0000-1200Z
1200Z	~1400Z	1800Z	1400-2100Z	0000Z	2100-0600Z	1200Z	0600-1800Z
1800Z	~2000Z	0000Z	2000-0300Z	0600Z	0300-1200Z	1800Z	1200-0000Z

Note: *There may be a small variance between the APDU Header time and the Product Available time listed in Table 7-11 of AC 00-45G.*

In order to reduce end-user confusion of Winds and Temperature Aloft products when forecasts for individual altitude bands are not provided, a one-row header has been added above the Winds and Temperatures Aloft forecast data to specify the altitudes for the product. This helps to make it obvious to users when a specific altitude data point is missing. If a specific altitude data point is missing, the corresponding altitude is also missing in the header.

Figure A-12 is an example (as it may appear on the cockpit display) with ‘FT’ (feet) indicating the dimension of altitude values and ‘JAN’ indicating the airport identifier for this report:

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
JAN	2026	2030+06	2329+00	2338-04	2546-17	2561-30	257546	710851	750657

Figure A-12: Wind and Temp Aloft Report Example as it May Appear on Display

Figure A-13 is an example when missing the 3000 ft and 6000 ft forecasts (as it may appear on the cockpit display).

FT			9000	12000	18000	24000	3000	34000	39000
PRC			2340-04	2548-06	2564-15	2567-26	243441	237852	258060

Figure A-13: Wind and Temp Aloft Report Example When Altitudes are Missing as it May Appear on Display

A.3.1.5.5 METAR Cutoff Time

In cases where METAR updates are not available from their source, the FIS-B system will retransmit the last available METAR from that reporting station for 120 minutes.

A.3.1.5.6 PIREP With No Airport Identifier

A.3.1.5.6.1 Background

The syntax of Wx PIREPs is defined in FAA Order JO7110.10X, "Flight Services." Section 9-2-15 of the FAA Order states that the location field (/OV) of a PIREP is to contain either:

- Location in reference to a VHF Navigation Aid or an airport, using the three- or four-letter identifier.
  1. Example: /OV KJFK
  2. Example: /OV KJFK107080
- Route segment. Two or more fixes.
  1. Example: /OV KSTL-KMKC

Those are the only two options for syntax of the /OV parameter and both of them are supposed to contain a three- or four-letter LocID.

A.3.1.5.6.2 FIS-B Ground System Response When No Airport Identifier Provided

In contradiction to the PIREP location syntax described in FAA Order JO7110.10X, PIREPs have been received which do not contain a three- or four-letter identifier in their location field, but instead a latitude/longitude.

- Example: /OV 3934N 7732W

In order for cockpit avionics to properly decode and display a PIREP, they expect each to have a LocID. Therefore, in cases of a PIREP which does not have a three- or four-letter identifier in its /OV field, the value NIL= will be sent as the LocID value.

A.3.2 Global Block Representation Products

A.3.2.1 General Formatting

A.3.2.1.1 Background

A Global Block Representation will be used for encoding the NEXRAD images. This geo reference method is based on a global grid of "blocks" and "bins." It was developed to support uplink of common base image products from multiple origins (i.e., radio stations) simultaneously in a globally seamless manner with independent APDUs.

A.3.2.1.2 The Use of Bins and Blocks

The Global Block Representation approach employs a global grid of bins, which represent the smallest granularity of uplink image data to be rendered on the cockpit display. For purposes of bandwidth efficient transmission, bins are run length encoded. To simplify and optimize run length encoding, bins are grouped into blocks.

The coordinate system for bins is oriented to the axes of latitude and longitude. The relationship between bins and blocks are shown in Figure A-14. In the latitude axis, bins always have a dimension of 1 arc minute or 1 nautical mile (nmi). In the longitude axis, bin width is constant in minutes, which results in a variable distance proportional to the cosine of the bin's latitude. In order to prevent unnecessary over-sampling of image data at high latitude, the longitudinal bin width is increased from 1.5 minutes below 60 degrees, to 3 minutes above 60 degrees. These bin dimensions are designed to match the maximum resolution of the NEXRAD source data as closely as possible, on average.

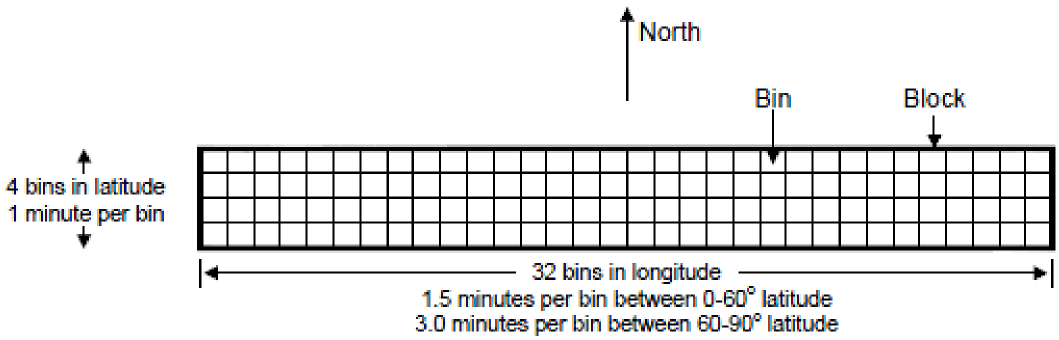
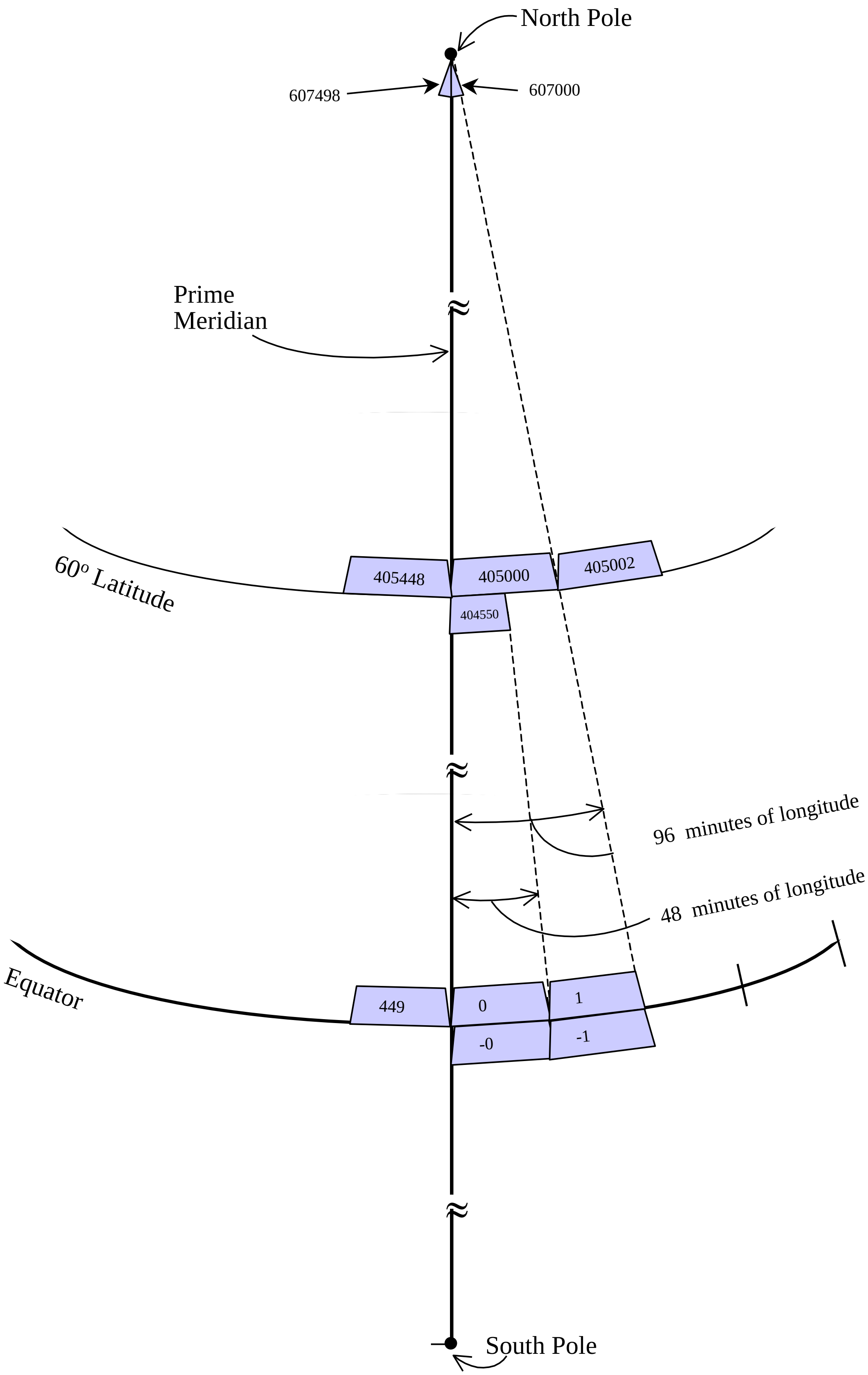


Figure A-14: Run Length Encoding Blocks Showing Constituent Bins

A.3.2.1.3 Global Block Numbering Plan

A.3.2.1.3.1 Grid Layout

The origin of the block numbering plan is at the prime meridian and the equator. Numbering is symmetric about the equator; northern and southern hemispheres are distinguished with a sign bit. Positive block numbering begins with the block just east and north of the prime meridian and equator (block number 0). Block numbers increment in an easterly direction until the entire "ring" of blocks is closed back at the prime meridian. Each ring will consist of 450 blocks below 60 degrees latitude and 225 blocks above 60 degrees. Block numbers continue to increment in each successive ring in the direction of the poles. Note that above 60 degrees latitude, only even block numbers are assigned. This is to maintain a globally consistent relationship of 48 minutes of longitude per block increment. See Figure A-15 for a graphic representation of the assignment of block numbers.



<u>Figure A-15:</u> Global Block Numbering Plan

A.3.2.2 Global Block Frame Formatting

The Application Data for a Global Block Representation product is usually broken into numerous UAT Frames since the payload is usually much smaller than 424 bytes. Each Global Block UAT Frame consists of an APDU Payload that is broken down into a 3-byte Block Reference Indicator and a variable length global block encoding field as shown in Figure A-16. The Application Data may consist of both Empty Block Encoded elements and Run-Length Encoded elements in any order. Bit and byte transmission order is as described with the encoding description of each element.

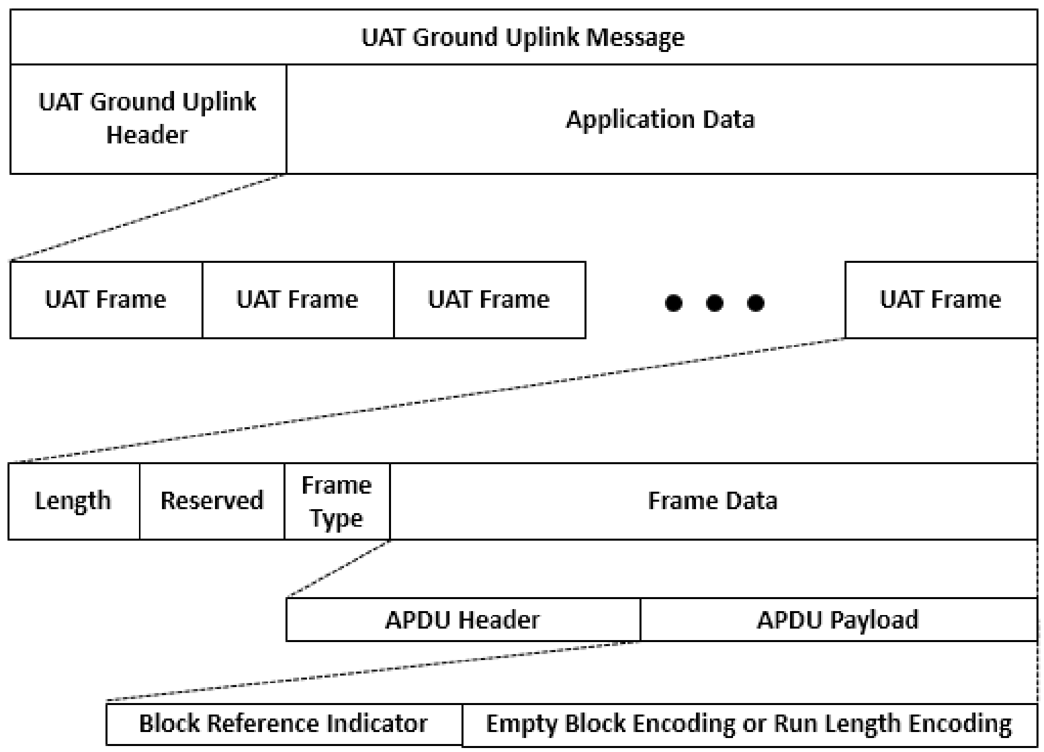


Figure A-16: Decomposition Showing Global Block Product Formatting

A.3.2.2.1 The Block Reference Indicator

Three bytes are used to encode the Block Reference Indicator as depicted in Figure A-17. The Block Reference Indicator contains an Element Identifier bit, the Hemisphere (N/S) bit, a Scale Factor and the Block Number.

A.3.2.2.1.1 Element Identifier

This indicates the type of image data element that is represented relative to the block location identified. The data elements are one of two types:

- A value of one (1) is a Run Length Encoded element: the encoded information associated with the Block Number provided is a run length encoding of all bins within the identified block.

- A value of zero (0) is the Empty Block Encoded element: the encoded information represents multiple empty blocks with the identified Block Number representing both a reference point and the location of the first empty block.

A.3.2.2.1.2 Hemisphere N/S

For blocks in the Northern Hemisphere this bit will be set to zero (0). For blocks in the Southern Hemisphere this bit will be set to one (1).

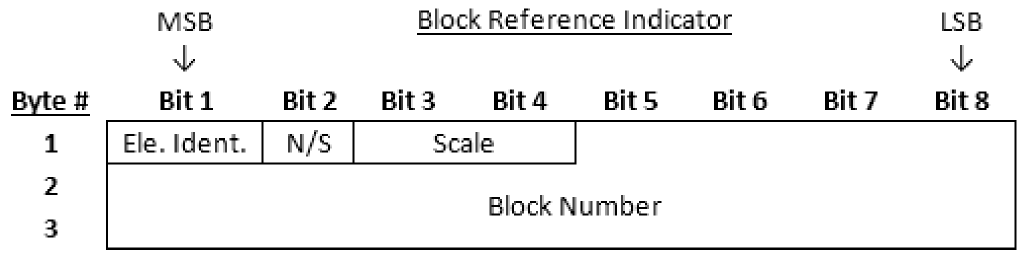


Figure A-17: Block Reference Indicator Byte-Level Format

A.3.2.2.1.3 Scale Factor

The meaning of the Scale Factor encoding is shown in Table A-10.

Table A-10: Scale Factor Encoding

Bit Number			
3	**4**	**Usage Label**	**Meaning**
0	0	High Resolution	Base encoding; each bin 1 min (LAT), 1.5 min (LONG) 0-60 deg LAT or 3 min (LONG) 60-90 deg LAT
0	1	Medium Resolution	5X encoding; each bin 5 min (LAT), 7.5 min (LONG) 0-60 deg LAT or 15 min (LONG) 60-90 deg LAT
1	0	Low Resolution	9X encoding; each bin 9 min (LAT), 13.5 min (LONG) 0-60 deg LAT or 27 min (LONG) 60-90 deg LAT
1	1		Reserved

A.3.2.2.1.4 Block Number

Twenty-one bits are required to uniquely identify all blocks on the globe with the numbering plan defined above. Figure A-18 shows the size of the low-, medium- and high-resolution global blocks. The numbers represent the block number of each high-resolution block. The darker outlines represent the size of the low-, medium- and high-resolution global blocks. High-resolution global blocks are always divisible by one (1), medium-resolution global blocks are always divisible by five (5) and low-resolution blocks are always divisible by nine (9). The medium- and low-resolution blocks are anchored to and numbered to the high-resolution blocks that align with its northwest corner. For example, the first northern hemisphere medium-resolution block is numbered 1800 and continues numbering with 1805, 1810, etc. The first northern hemisphere low-resolution block is numbered 3600 and continues numbering with 3609, 3618, etc. The next row of northern hemisphere medium-resolution blocks starts numbering at 4050 and the next row of low-resolution blocks starts numbering at 7650.

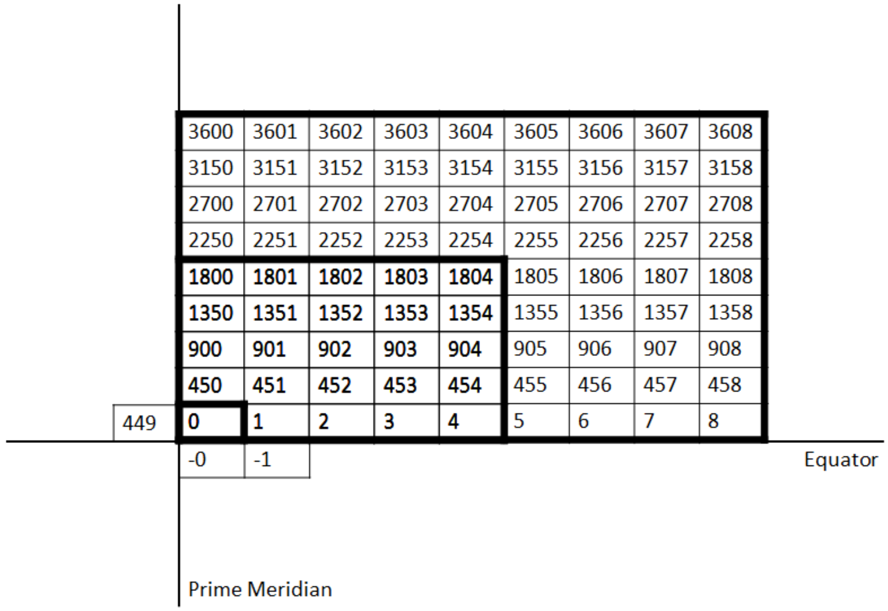


Figure A-18: Global Block Numbering Scheme by Scale Factor

A.3.2.2.2 Run Length Encoded Element

The complete encoding of a Run Length Encoded element is shown in Figure A-19. Note that there is no explicit length field since the receiving application interprets each successive byte as an encoded run until all 128 bins of the Run Length Encoded block are accounted for.

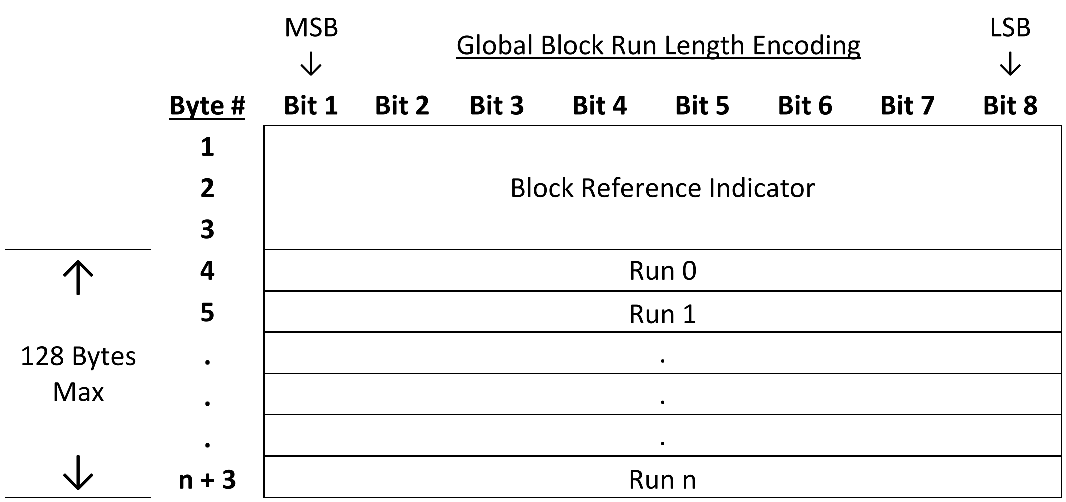


Figure A-19: Run Length Encoded Element Byte-Level Format

Bytes are transmitted in sequence beginning with byte 1. Within each byte, bits are transmitted in sequence beginning with bit 1.

A.3.2.2.2.1 Run Length Encoding of Cells within the Block

Creating “runs” of bins of identical precipitation intensity (or reflectivity) within a single block forms a Run Length Encoded element. A run is represented by one (1) byte as shown in Figure A-20. Data is run-length encoded in west-to-east rows starting in the northwest corner of the block. Runs may span rows of bins within the block. The maximum run allowed is 32 bins. Encoding this maximum amount can be represented in only five (5) bits if one considers that every run is greater than or equal to one (1). We therefore subtract the value of one (1) from this maximum amount yielding an adjusted maximum value of 31, which can be delivered in five (5) bits. A maximum of eight (8) levels of intensity can be conveyed.

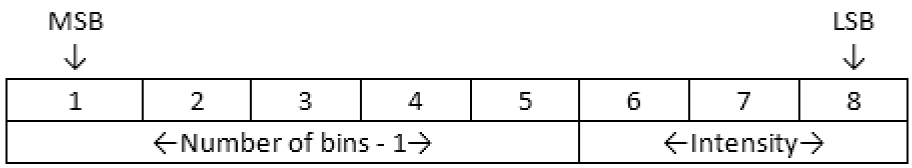


Figure A-20: Individual Run Encoding

Figure A-21 shows a block containing 10 runs of varying intensities. The run length encoding information for this block is contained in Table A-11. The total number of bins encoded per block will always be 128. In the worst case—minimum compression—scenario there would be 128 runs of length 1 bin each.

Figure A-21: Example Block Containing 12 Runs

Table A-11: Run Encoding for Example Block

Run Length	Intensity	Cumulative Bins	Encoded Run (binary)
9	0	9	01000 000
15	1	24	01110 001
7	2	31	00110 010
1	3	32	00000 011
8	0	40	00111 000
18	1	58	10001 001
6	2	64	00101 010

Run Length	Intensity	Cumulative Bins	Encoded Run (binary)
6	0	70	00101 000
32	1	102	11111 001
26	1	128	11001 010

A.3.2.2.3 The Empty Element

Most uplink images of any size will almost always contain large areas void of detectable precipitation. Unfortunately, the run encoding on a bin basis described above will not fully exploit this fact and would result in inefficient bandwidth use for these large areas void of precipitation. This is because with this approach even "empty" blocks would require a run length encoded block with four (4) runs of 32 bins each. A better, more compact approach for the special case of empty blocks is to use an Empty Block Encoded element. The Empty Block Encoded element uses a bitmap encoding of all empty blocks that are contained in a row of blocks. The Block Number encoded in the Block Reference Indicator identifies the Starting Block Number (i.e., the first empty block) within a row of blocks. Figure A-22 shows the format. Each row of blocks will require uplink of a separate Empty Element.

Global Block Empty Element Encoding

Byte #	Bit 1 (MSB)	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8 (LSB)
1	Block Reference Indicator							
2								
3								
4	Bitmap				Bitmap Length (L)			
5	Bitmap							
.	Bitmap							
.	Bitmap							
.	Bitmap							
L+4	Bitmap							

Figure A-22: Empty Element Byte-Level Format

Bytes are transmitted in sequence beginning with byte 1. Within each byte, bits are transmitted in sequence beginning with bit 1.

A.3.2.2.3.1 Length and Bitmap Bytes

A.3.2.2.3.1.1 Length

In the Global Block encoding of an Empty Block Encoded element, bits 5-8 of byte 4 represent Length (L) in Figure A-22. This value, L, represents the integer number of bitmapped bytes to follow. Bits 1-4 of byte 4 are described in the bitmap section below.

A.3.2.2.3.1.2 Bitmap

The value of the bits in the bitmap bytes determines the "emptiness" of the block it represents. The block is empty when the bit is set to one (1). Each block represented by a zero will also be conveyed in a separate Run Length Encoded element.

Bitmap bytes begin at byte 4 and extend to the end of the Empty Block Encoded element as shown in Figure A-22. There are a total of L additional bytes in the bitmap, per the Length field described above.

A.3.2.2.3.2 Number of Potential Empty Blocks

Number of potential empty blocks = (8 * L) + 4 + 1.

Since the Length field is four bits, the maximum value for L is binary 1111 or decimal 15. Substituting, the maximum row size that can potentially be encoded: (8 * 15) + 4 + 1 = 125 blocks.

A.3.2.2.3.3 Mapping Bits to Blocks

The emptiness of the blocks following the Block Number (BN) given in the Block Reference Indicator is determined from the bit locations shown in Table A-13. The bitmap bits are set according to the emptiness of the blocks following the Block Number. The Block Number value associated with each bitmap depends on the Scale Factor and latitude location of the row of the Block Number (see Section A.3.2.1.3.1 for a discussion on latitude location effects). The Scale Factor and latitude location combine to create an increment (INCR) multiplier that is used to derive block numbers. Table A-12 shows how the INCR value is determined.

Table A-12: Determining the Increment

Description	Increment (INCR)
High Resolution Below 60 Degrees Latitude	1
High Resolution Above 60 Degrees Latitude	2
Medium Resolution	5
Low Resolution	9

Note: *Medium and Low resolution formatted blocks are not provided above 60 degrees latitude and, therefore, do not have Increment values given in the table.*

Table A-13: Bit Map Blocks

Byte	Bit	L	Empty Block Number
4	4	-	BN + 1 x INCR
4	3	-	BN + 2 x INCR
4	2	-	BN + 3 x INCR
4	1	-	BN + 4 x INCR
5	8	1	BN + 5 x INCR

Byte	Bit	L	Empty Block Number
5	7	1	BN + 6 x INCR
5	6	1	BN + 7 x INCR
5	5	1	BN + 8 x INCR
5	4	1	BN + 9 x INCR
5	3	1	BN + 11 x INCR
5	2	1	BN + 11 x INCR
5	1	1	BN + 12 x INCR
6	8	2	BN + 13 x INCR
6	7	2	BN + 14 x INCR
6	6	2	BN + 15 x INCR
6	5	2	BN + 16 x INCR
6	4	2	BN + 17 x INCR
6	3	2	BN + 18 x INCR
6	2	2	BN + 19 x INCR
6	1	2	BN + 20 x INCR
…	…	…	…
L+4	8	L	BN + (L x 8 - 3) x INCR
L+4	7	L	BN + (L x 8 - 2) x INCR
L+4	6	L	BN + (L x 8 - 1) x INCR
L+4	5	L	BN + (L x 8 - 0) x INCR
L+4	4	L	BN + (L x 8 + 1) x INCR
L+4	3	L	BN + (L x 8 + 2) x INCR
L+4	2	L	BN + (L x 8 + 3) x INCR
L+4	1	L	BN + (L x 8 + 4) x INCR

Note: *When a row of blocks spanning the Prime Meridian is encoded by the FIS-B Ground System, Empty Element encoding will include all blocks of the row on both sides of the Prime Meridian. FIS-B avionics processing needs to account for this case and properly identify the block numbers on the East side of the meridian using modulo arithmetic.*

A.3.2.3 Regional NEXRAD (Product #63)

A.3.2.3.1 APDU Header

The format of the APDU Header used for this product is shown in Figure A-23. It follows the APDU Header format as outlined in Section A.2 with none of the optional fields used for this product; specifically, no Product Descriptor options and no APDU segmentation are used. Four bits are needed to get to a byte boundary. The time field encoded in the APDU Header is the time of mosaic creation.

<table>
<tr><td colspan="32">← APDU Header (32 Bits) →</td></tr>
<tr><td colspan="14">Product Descriptor (14 bits)</td><td rowspan="2">S
f</td><td colspan="13">Header Time (13 bits)</td><td rowspan="2" colspan="4">Pad
(4 bits)</td></tr>
<tr><td>A
f</td><td>G
f</td><td>P
f</td><td colspan="11">Product ID (11 bits)</td><td colspan="2">T
opt</td><td colspan="5">Hours
(5 bits)</td><td colspan="6">Minutes
(6 bits)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<u>Figure A-23:</u> Regional NEXRAD APDU Header Bit Level Format

A.3.2.3.2 Product Specific Notes

A.3.2.3.2.1 Background on the NEXRAD Information Uplinked

See <u>APPENDIX E</u>.

A.3.2.4 CONUS NEXRAD (Product #64)

A.3.2.4.1 APDU Header

The format of the APDU Header used for this product is shown in <u>Figure A-24</u>. It follows the APDU Header format as outlined in <u>Section A.2</u> with none of the optional fields used for this product; specifically, no Product Descriptor options and no APDU segmentation are used. Four bits are needed to get to a byte boundary. The time field encoded in the APDU Header is the mosaic cutoff time.

<table>
<tr><td colspan="32">← APDU Header (32 bits) →</td></tr>
<tr><td colspan="14">Product Descriptor (14 bits)</td><td rowspan="2">S
f</td><td colspan="13">Header Time (13 bits)</td><td rowspan="2" colspan="4">Pad
(4 bits)</td></tr>
<tr><td>A
f</td><td>G
f</td><td>P
f</td><td colspan="11">Product ID (11 bits)</td><td colspan="2">T
opt</td><td colspan="5">Hours
(5 bits)</td><td colspan="6">Minutes
(6 bits)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<u>Figure A-24:</u> CONUS NEXRAD APDU Header Bit Level Format

A.3.2.4.2 Product Specific Notes

A.3.2.4.2.1 Background on the NEXRAD Information Uplinked

See <u>APPENDIX E</u>.

A.3.2.4.2.2 Product Update Timing and Latency

The CONUS NEXRAD product is uplinked once every 15 minutes. Every third Regional NEXRAD product described in <u>APPENDIX E</u> will be used to update the CONUS NEXRAD uplinked image. The time that is encoded in the APDU Header is the mosaic cutoff time.

The CONUS NEXRAD product is generated independently by each of the FIS-B Ground System Control Stations. The Control Stations can be expected to vary as to which of the 5 minute Regional NEXRAD epochs they sync with. The radios in the domain of a one Control Station may uplink CONUS NEXRAD based mosaics with cutoffs on the hour and at :15, :30 and :45 minutes after the hour. The radios in the domain of another Control Station may uplink CONUS NEXRAD based mosaics with cutoffs at :05, :20, :35 and :50 minutes after the hour.

A.3.2.4.2.3 Scaling of Global Blocks

The CONUS NEXRAD run length encoding uses the medium scale factor for the bins as described in Table A-10 in Section A.3.2.2.1. The CONUS NEXRAD product is derived from the high-resolution source composite Regional NEXRAD mosaic. The intensity of each medium scale bin of the CONUS NEXRAD is the maximum bin intensity present in the 25 corresponding high resolution bins.

A.3.3 Text with Graphical Overlay FIS-B Products

This section describes the encoding format used for the TWGO product class.

Note: *This class of FIS-B products employs an encoding framework that contains flexibility to represent graphic objects not currently present in FIS-B uplink products. Many fields documented here contain states that do not presently occur. Where this occurs, these states are marked Future Use within this appendix. The encoding framework also includes some optional fields that were not used at the time the MOPS was developed. These currently unused optional fields are omitted in this appendix.*

A.3.3.1 General Formatting

The APDU Payload for TWGO FIS-B Products supports textual and graphical overlay representations within the same payload construct. The payload consists of a header and one or more records. The APDU Payload will contain either graphical records or text records. It will not contain both a text record and a graphical record within the same payload. See Figure A-25.

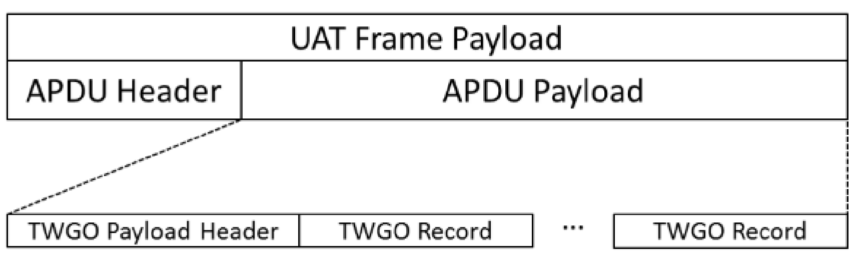


Figure A-25: Decomposition Showing TWGO FIS-B Payload

A.3.3.1.1 TWGO Payload Header

The TWGO Payload Header is composed of Record Format, Product Version, Record Count, Reserved, LocID and Record Reference Point fields. The reserved field is reserved for future use. The TWGO Payload Header information appears once in an

APDU and always is at the beginning of the APDU Payload field. In the case of segmentation, the TWGO Payload Header appears in each segmented APDU. The Payload Header stipulates the format and number of the records to follow and the version of the format being used.

The organization of the TWGO Header fields is shown in Figure A-26.

Text with Graphical Overlay Header

Byte #	Bit 1 (MSB)	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8 (LSB)
1	Record Format				Product Version			
2	Record Count				Reserved			
3	Location Identifier							
4								
5								
6	Record Reference Point							

Figure A-26: TWGO Header Byte-Level Format

A.3.3.1.1.1 Record Format

The Record Format field described in Table A-14 indicates what type of product report is contained in the TWGO Record. There are two basic types of product reports, textual and graphical overlay. This is the only place in the format that the report type is identified.

The Record Format field allows text reports that are organized in various forms to support existing report formats used in the NAS today, but also to support the transition to ICAO standardized formats.

Graphical overlay records are organized in only one form. The encoding of overlays is defined in Section A.3.3.1.3.

Table A-14: Record Format Options

Meaning	Value
Unformatted DLAC Text	2
Graphical Overlay	8
Future Use	0, 1, 3-7, 9-15

FIS-B avionics should ignore all Record Format values associated with a future use.

A.3.3.1.1.2 Product Version

This field should be ignored by FIS-B avionics conforming to this MOPS. The Product Version field is a one byte sequentially ordered number (1-15) used to maintain configuration control of changes to the product definitions.

A.3.3.1.1.3 Record Count

The Record Count field indicates the number of records using the same Record Format that can be grouped together. Up to 15 (binary 0001 to 1111) Text or Graphical Overlay records can be grouped with each TWGO product.

A.3.3.1.1.4 Reserved Bits

The Reserved field is reserved for future use and should be ignored by FIS-B avionics conforming to this MOPS.

A.3.3.1.1.5 Location Identifier

The LocID references the location or facility that the report applies to or the overlay has originated from, such as an air traffic facility (e.g., airports, navigation aids or control facilities). The 3-byte field contains four DLAC characters (See Section A.3.1.1 for DLAC format). In cases when less than four characters are needed for the identifier or no identifier is present, the unused characters are set to ETX.

A.3.3.1.1.6 Record Reference Point

A value in this field of all zeros (0) or all ones (1) should cause this field to be ignored by FIS-B avionics conforming to this MOPS. Any other value should cause FIS-B avionics conforming to this MOPS to discard the TWGO Record.

A.3.3.1.2 TWGO Text Record

The Text Record fields provide a framework to support the communication of text reports. Figure A-27 gives the byte-level format of the Text Record fields.

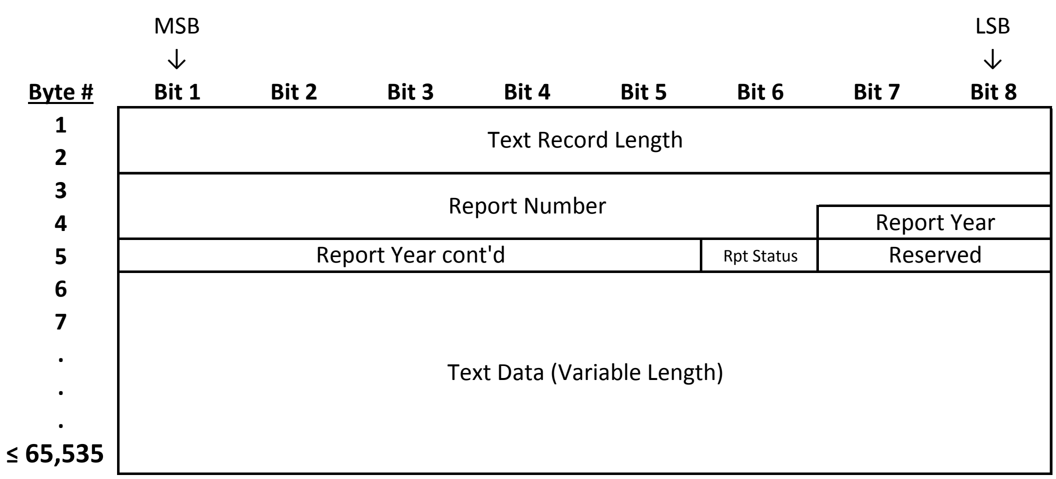


Figure A-27: Text Record Byte-Level Format

A.3.3.1.2.1 Text Record Length

The Text Record Length field (2 bytes) indicates the number of bytes (5..65,535) contained in a single text record. The length includes all the fields contained in the 5-byte header.

Note: *All Text Records for this product class are subject to truncation if necessary to 1500 DLAC characters by the FIS-B ground system. The last eight characters of a truncated Text Record will contain "(INCMPL)" consistent with the truncation approach used for the Generic Text product class (see Section A.3.1.5.3.1). Pilots should be instructed to contact Flight Service for more information.*

A.3.3.1.2.2 Report Number

The Report Number field (14 bits) is one of the fields used to determine report uniqueness. This field can accommodate a number in the range of 0 to 16,383 used to identify each report. See Section B.3 for information on where this Report Number comes from for each product and for guidance on what fields must be used to uniquely identify a report for each product type.

A.3.3.1.2.3 Report Year

The Report Year field (7 bits) indicates the last two digits of the year the report originated (e.g., 2014 is represented as "14"). Exceptions are NOTAM-TFR and NOTAM-FDC where the year the report originated is represented by a single digit. (e.g., 2014 is represented as "4"). In cases when the source report does not contain a year value, this value will be provided by the FIS-B Ground System.

A.3.3.1.2.4 Report Status

The use of the Report Status enables the FIS-B Ground System to confirm or update the status of any previously uplinked report (text and associated overlay) and quickly purge those records that are terminated prematurely (i.e., not in accordance with the period of validity that may be provided in the record itself). Generally, reports reaching the end of their valid time are no longer transmitted. As shown in Table A-15, the Report Status is either Cancelled or Active.

Note: *Reports with Active status may not necessarily have reached their Valid Time and should not be confused with the Valid Times in the report.*

When the Report Status field is represented as "Cancelled" the report should be immediately purged from the FIS-B avionics. A cancellation overrides the period of validity contained in the original records. As long as a report remains valid, the Report Status will be represented as "Active."

Table A-15: Report Status

Meaning	Value
Cancelled Report	0
Active Report	1

A key feature of the Report Status is that it enables the status of all records associated with a previously uplinked report (including overlay records) to be updated without having to retransmit the entire record or set of records. This is accomplished by only transmitting the first five (5) bytes of the text record (see Section A.3.3.1.2), which includes only those fields necessary to reference the record(s) and status.

A.3.3.1.2.5 Reserved Bits

Bits 7 through 8 of byte 5 are reserved for future use and should be ignored.

A.3.3.1.2.6 Text Data Field

The Text Data Field contains the DLAC encoded text for a single report.

A.3.3.1.3 TWGO Graphical Overlay Record

The Graphical Overlay Record contains the fields for the graphical depictions of NAS Status information (e.g., NOTAM-TFR and SIGMET reports). A byte-level format of the Graphical Overlay Record is shown in Figure A-28.

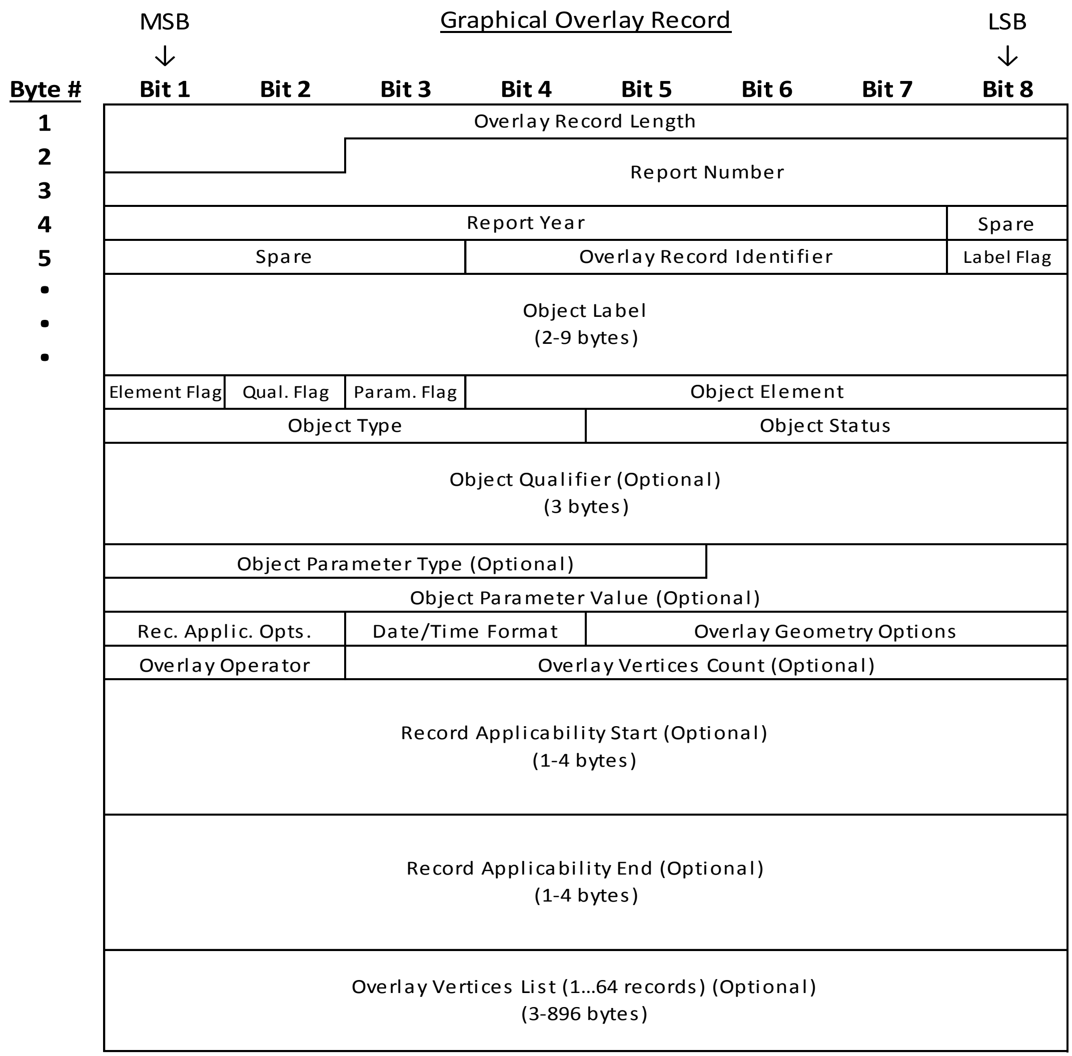


Figure A-28: Graphical Record Byte-Level Format

A.3.3.1.3.1 Overlay Record Length

The Overlay Record Length field (10 bits) indicates the number of bytes in a single overlay record. The length includes the Overlay Record Length field.

A.3.3.1.3.2 Report Number

The Report Number field (14 bits) is one of the fields used to determine report uniqueness. This field can accommodate a number in the range of (0 to 16,383) used to identify each report. See Section B.3 for information on where this Report Number comes from for each product and for guidance on what fields must be used to uniquely identify a report for each product type.

A.3.3.1.3.3 Report Year

The Report Year field (7 bits) indicates the last two digits of the year the report originated (e.g., 2014 is represented as "14"). Exceptions are NOTAM-TFR and NOTAM-FDC reports where the year the report originated is represented by a single digit (e.g., 2014 is represented as "4"). In cases when the source report does not contain a year value, this value will be provided by the FIS-B Ground System.

A.3.3.1.3.4 Spare Bits

Bit 8 of byte 4 and bits 1 through 3 of byte 5 are reserved for future use and should be ignored.

A.3.3.1.3.5 Overlay Record Identifier

The Overlay Record Identifier is a 4-bit sequence number (0..14) identifying each, of potentially several, overlay records. There may be up to 15 related overlay records. The decoding of this field requires that a one (1) be added to the Overlay Record Identifier value to get the decimal value. For example, a binary value of 0000 corresponds to Record ID of 1 (decimal) and a binary value of 0001 corresponds to a Record ID of 2 (decimal).

A.3.3.1.3.6 Object Label Flag

The Object Label Flag controls the approach used to represent the Object Label. This field is a binary field indicating whether the Object Label field is numeric (0) or alphanumeric (1).

For FIS-B avionics conforming to this version of the MOPS, a value of 0 indicates there is no Object Label and a 1 indicates the text label is an airport LocID.

A.3.3.1.3.7 Object Label

FIS-B avionics conforming to this MOPS should interpret the Object Label field as follows:

1. When the Object Label Flag is zero (0) this field is two (2) bytes in length and the Graphical Overlay record should be processed ignoring the Object Label field.
2. When the Object Label Flag is one (1), this field is nine (9) bytes in length and represents a LocID (e.g., airport or airspace) using the DLAC character set (see Table

A-6). If there are less than 12 letters in the field, the least significant DLAC characters are filled with ETX.

A.3.3.1.3.8 Object Type

The Object Type field provides the notable parts of an airport or airspace environment. These airport/airspace objects comprise the collection of regions or things that can have an impact on flight operations if they become hazardous, if they fail or if they are unavailable for some reason. FIS-B avionics conforming to this MOPS should interpret only two values for this field as shown in Table A-16. The presence of any other values should result in FIS-B avionics conforming to this MOPS discarding the Graphical Overlay Record.

Table A-16: Object Types

Object Type	Value
Aerodrome (airport, heliport, helipad)	0
Airspace	14
Future Use	1-13, 15

A.3.3.1.3.9 Object Element Flag

The Object Element Flag field is a binary field used to indicate whether the Object Element field is used (1) or not (0).

A.3.3.1.3.10 Object Element

The Object Element field provides a particular feature or element of an Object Type of interest. FIS-B avionics conforming to this MOPS should discard any Object Element associated with an Aerodrome Object Type. An Object Element associated with the Airspace Object Type is represented by the feature in Table A-17.

Table A-17: Airspace Object Elements

Object Element	Contraction	Value
Temporary Flight Restriction	TFR	0
Future Use		1-15

A.3.3.1.3.11 Object Status

The Object Status field provides the state of an object. Possible values are listed in Table A-18. Graphical Overlay records indicating any value other than 15 for this field should be discarded by FIS-B avionics conforming to this MOPS.

Table A-18: Object Status

Object Status	Value
In Effect	15
Future Use	0-14

A.3.3.1.3.12 Object Qualifier Flag

The Object Qualifier Flag field is a binary field used to indicate whether the Object Qualifier field is used (1) or not (0). FIS-B avionics conforming to this MOPS should discard any Graphical Overlay records that invoke the optional Object Qualifier field.

A.3.3.1.3.13 Object Parameter Flag

The Object Parameter Flag field is a binary value indicating whether the Object Parameter Type and Object Parameter Value fields are present (1) or absent (0). FIS-B avionics conforming to this MOPS should discard any Graphical Overlay records that invoke the optional Object Parameter Type and Object Parameter Value fields.

A.3.3.1.3.14 Record Applicability Options

The Record Applicability Options provide information about the timing of the reported event. Some events will have both beginning and ending times that the reported event is applicable. Other reports will be valid as long as they are being reported. Table A-19 lists the options to cover possible reporting approaches.

Note that the Record Applicability field (Section A.3.3.1.3.16) is specific to the contents of the report and is independent of the product transmission time.

Table A-19: Record Applicability Options

Meaning	Value
No times given	0
Start time only	1
End time only	2
Both start and end times	3

A.3.3.1.3.15 Date/Time Format

The Date/Time Format field provides format used in the Record Applicability fields (Section A.3.3.1.3.16) enabling a subset of date/time information to be sent. Table A-20 provides the format options available for tailoring the Record Applicability fields. The selected format applies to both the start and end times (if both exist in the record).

Table A-20: Date/Time Format

Meaning	Value
No Date/Time Used	0

Meaning	Value
Month, Day, Hours, Minutes	1
Day, Hours, Minutes	2
Hours, Minutes	3

A.3.3.1.3.16 Record Applicability

The Record Applicability fields include a starting time and ending time field that indicate the period the data in the overlay record are in effect. The Record Applicability Options field controls the inclusion of the Record Applicability Start and End fields in the record. The format for each field is stipulated in the Date/Time Format field. When the Date/Time Format field is set to zero (0) the Record Applicability field can be ignored by equipment conforming to this MOPS. When the Date/Time Format field is set to one (1) the Record Applicability field is broken down into four one-byte sub-fields to represent month, day, hour and minute. When the Date/Time format is set to two (2) or three (3), the Record Applicability field contains only the specified fields associated with each respective encoded value. (Note: The sub-field data can be represented in fewer bits, but to preserve the byte boundary with subsequent fields, there would be marginal savings and there would be additional complexity in the format encoding/decoding processing.) Figure A-29 shows the byte-level format of the Record Applicability field.

Record Applicability

	MSB ↓							LSB ↓
Byte #	**Bit 1**	**Bit 2**	**Bit 3**	**Bit 4**	**Bit 5**	**Bit 6**	**Bit 7**	**Bit 8**
1	Month (optional)							
2	Day (optional)							
3	Hours (optional)							
4	Minutes (optional)							

Figure A-29: Record Applicability Byte-Level Format

A.3.3.1.3.17 Overlay Geometry Options

The Overlay Geometry Options indicates whether or not there is a geometry explicitly defined in the record. The geometry option provides the geometry type, resolution and vertex encoding to be used. Table A-21 presents the geometry types and possible number of vertices. Each vertex is defined by the set of coordinates required to define a geometric point in space (e.g., x, y, z). Table A-22 shows the vertex coordinates and the corresponding encoding for each geometry.

The encoding and decoding for each geometry is different due to the number and type of coordinates and the resolution (LSB) for each coordinate. When encoding a coordinate into binary form, the decimal coordinate value may need to be rounded toward zero to a value that is a multiple of the resolution value. The procedure is necessary to ensure both encoding and decoding are performed consistently. The procedure for rounding toward zero is to modulus the magnitude of the coordinate value with the resolution and subtract the result from the magnitude of the coordinate value. Then perform the encoding specified by each geometry in the following sections.

The following is an example of the rounding procedure for any given geometry in Table A-21:

*Y = sign(X) * (floor|X|/R) * R), where:*

X = original coordinate value in decimal

Y = rounded coordinate value in decimal

R = coordinate resolution as specified in Table A-22

FIS-B avionics conforming to this MOPS should discard the Graphical Overlay record when any fields or states from Table A-16, Table A-17, Table A-18, Table A-19, Table A-20 and Table A-21 indicated as "*Future Use*" are encountered.

Table A-21: Overlay Geometry Options

Geometry Type	Value	Vertices Count Range
Extended Range 3D Polygon (MSL)	3	1-64
Extended Range 3D Polygon (AGL)	4	1-64
Extended Range Circular Prism (MSL)	7	1-64
Extended Range Circular Prism (AGL)	8	1-64
Extended Range 3D Point (AGL)	9	1-64
Extended Range 3D Point (MSL)	10	1-64
Future Use	0-2, 5-6, 11-15	

A.3.3.1.3.17.1 Extended Range 3D Polygon

The Extended Range three-dimensional (3D) Polygon provides a connect-the-dot geometry independent of the Record Reference Point. This option is useful in defining various airspace objects in the airport terminal or en route domains. The definition of this geometry should be consistent with SUA objects defined for non-Aerodrome applications (e.g., en route airspace) to simplify avionics processing requirements.

The location of each vertex in this geometry is defined using latitude and longitude and is not tied to the Record Reference Point. The latitude and longitude coordinate field values are each encoded using a 19-bit unsigned integer providing 0.000687 degrees of position resolution. These fields are encoded using the Angular Weighted Binary Encoding, which is described in Table A-1.

The altitude (z) coordinate is encoded using a 10-bit unsigned integer providing 100 ft of resolution and representing a range of 0 to 102,300 ft Mean Sea Level (MSL) or Above Ground Level (AGL). The Overlay Geometry Option selected indicates the altitude reference used. Each z coordinate is decoded by multiplying the field value by 100. See Table A-22 for encoding details. If this geometry is describing a range of altitudes (e.g., 3000 ft to 17,999 ft), start with the higher altitude and complete its geometry. After the first geometry is closed, move down to the lower altitude and complete its geometry.

See Section A.3.3.1.3.18 for further encoding rules for this geometry.

A.3.3.1.3.17.2 Extended Range Circular Prism

The Extended Range Circular Prism provides a singular geometry. The Extended Range Circular Prism geometry is intended to describe airspace objects in the terminal or en route domain. A circular prism provides the flexibility to define a basic cylinder or a more complex parallelepiped with an elliptical cross-section. The top and bottom ellipsoids are the same shape and orientation, but the two centroids may not be aligned. The vertical boundaries of the prism are always parallel. The definition of this geometry should be consistent with SUA objects defined for non-Aerodrome applications (e.g., en route airspace) to simplify avionics processing requirements.

Figure A-30 shows graphically how the Extended Range Circular Prism is specified. The left side shows the plan and profile view of a basic cylinder, where the radii are the same and the α parameter is 0. The right side shows the plan and profile view of a parallelepiped with an elliptical cross-section, where the radius in the North/South direction happens to be larger than the radius in the East/West direction – before rotation. The α parameter then indicates a rotation 45 degrees around magnetic North in a clockwise direction. In both examples, there happens to be no offset in the center location between the top and bottom of the volumes, but an offset is supported via separate “LAT” and “LONG” for both top and bottom.

The location of this geometry is defined using latitude and longitude and is not tied to the Record Reference Point. The latitude and longitude coordinate field values are each encoded using an 18-bit unsigned integer providing 0.001373 degrees of position resolution (~150 meters positional accuracy). These fields are encoded using the Angular Weighted Binary Encoding, which is described in Table A-1.

The radii, r_{LONG} and r_{LAT}, are each encoded using a 9-bit unsigned integer providing a fifth of a nautical mile (0.20 nmi) of position resolution. The radii have a range of up to approximately 102.2 nmi from the center of the ellipse. The r_{LONG} and r_{LAT} coordinates are each decoded by dividing the field value by 5 to yield the coordinate in nautical miles.

The orientation of the elliptical cross-section is specified by a rotation angle, α, that originates at magnetic North and increments in a clockwise direction between 0 and 179 degrees. The α coordinate is represented by an 8-bit unsigned integer and has a resolution of 1 degree. The rotation angle is obtained from the field value directly (i.e., no conversion necessary).

There are two altitude coordinates (z_{bot} and z_{top}), one for the bottom of the parallelepiped and one for the top. Each z coordinate is encoded using a 7-bit unsigned integer providing 500 ft of resolution and representing a range of 0 to 63,500 ft MSL or AGL. The Overlay Geometry Option (Table A-21) selected indicates the altitude reference used. Each z coordinate is decoded by multiplying the field value by 500. See Table A-22 for encoding details.

See Section A.3.3.1.3.18 for further encoding rules for this geometry.

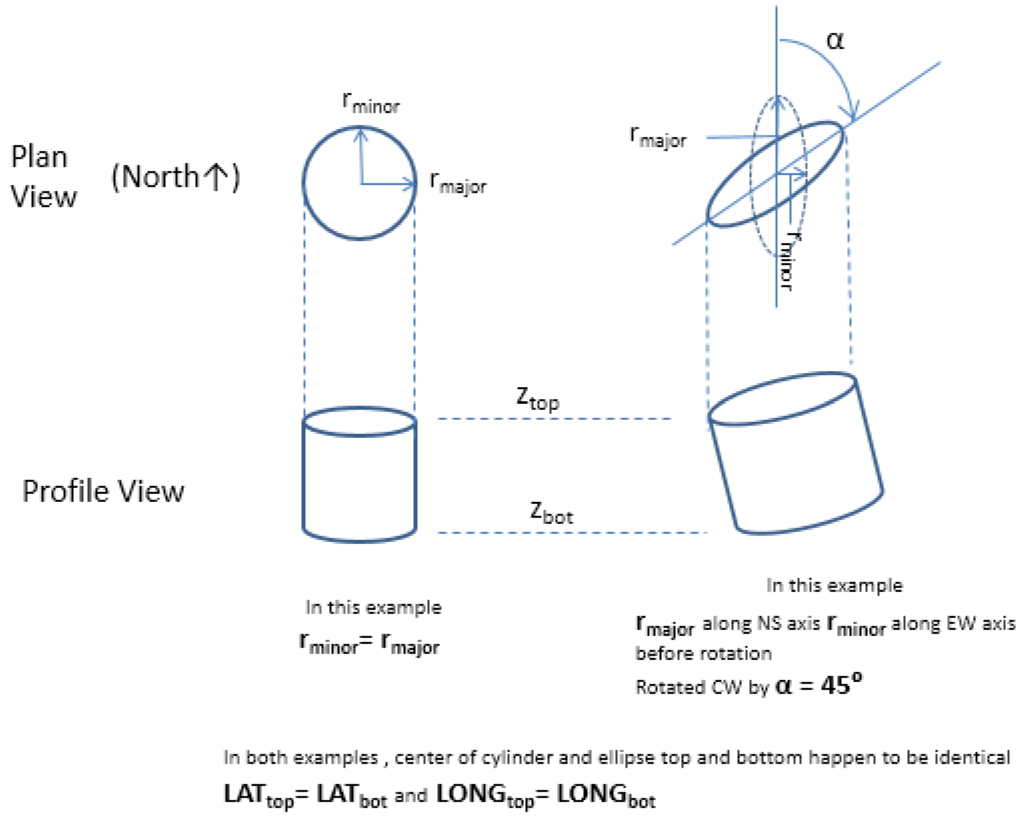


Figure A-30: Extended Range Circular Prism

A.3.3.1.3.17.3 Extended Range 3D Point

The Extended Range 3D Point provides a singular geometry. This option is useful in defining locations within the airspace to identify or reference points of interest to pilots. The definition of this geometry should be consistent with SUA objects defined for non-Aerodrome applications (e.g., en route airspace) to simplify avionics processing requirements.

The location the vertex in this geometry is defined using latitude and longitude and altitude. The latitude and longitude coordinate field values are each encoded using a 19-bit unsigned integer providing 0.000687 degrees of position resolution. These fields are encoded using the Angular Weighted Binary Encoding, which is described in Table A-1.

The altitude (z) coordinate is encoded using a 10-bit unsigned integer providing 100 ft of resolution and representing a range of 0 to 102,300 ft MSL or AGL. The Overlay Geometry Option selected indicates the altitude reference used. Each z coordinate is decoded by multiplying the field value by 100. See Table A-22 for encoding details.

When multiple Extended Range 3D Point geometries are packed in a single record, each is by definition independent of each other. When multiple Extended Range 3D Point geometries are packed across multiple records, each individual geometry is also independent.

See Section A.3.3.1.3.18 for further encoding rules for this geometry.

Table A-22: Overlay Geometry Encoding

Geometry	Vertex Coordinate	Resolution (LSB)	Value Range
Extended Range 3D Polygon	LONG: LAT: z:	19 bits (0.000687 deg) 19 bits (0.000687 deg) 10 bits (100 ft)	(0..±180) (0..±90) (0..102,300)
Extended Range Circular Prism	$LONG_{bot}$: LAT_{bot}: $LONG_{top}$: LAT_{top}: z_{bot}: z_{top}: r_{major}: r_{minor}: α:	18 bits (0.001373 deg) 18 bits (0.001373 deg) 18 bits (0.001373 deg) 18 bits (0.001373 deg) 7 bits (500 ft) 7 bits (500 ft) 9 bits (0.2 nmi) 9 bits (0.2 nmi) 8 bits (1 deg)	(0..±180) (0..±90) (0..±180) (0..±90) (0..63, 500) (0..63, 500) (0..102.2) (0..102.2) (0..179)
Extended Range 3D Point	LONG: LAT: z:	19 bits (0.000687 deg) 19 bits (0.000687 deg) 10 bits (100 ft)	(0..±180) (0..±90) (0..102,300)

A.3.3.1.3.18 Overlay Operators

This version of the MOPS is limited to interpreting the Overlay Operators field set to zero, indicating geometries are independent across records as shown in Table A-23. Any other value encountered by FIS-B avionics conforming to this MOPS should cause the record to be discarded.

Table A-23: Overlay Operators

Operator	Value	Meaning
No Operator	0	Graphical Overlay Records are independent
Future Use	1-3	

A.3.3.1.3.19 Rules for Encoding and Rendering Overlay Geometries

For Polygon Geometries:

- Vertices can span multiple records.
- Pen stays down to connect vertices within a record.
- Pen lifts between records, however, the FIS-B Ground System will repeat last vertex of the previous record into the first vertex of the subsequent record to effectively keep the pen down—unless starting a new geometry.

- All polygons will be closed by the FIS-B Ground System (at least as it appears to the pilot) and each polygon is a "geometry."

For 3D point and Circular Prism Geometries:

- Each vertex point corresponds to a "geometry."
- Each geometry/vertex is independent of others within a record and across records.
- Multiple geometries/vertices can be packed multiple per record.

A.3.3.1.3.20 Overlay Vertices Count

The Overlay Vertices Count field indicates the number of vertices listed in the Overlay Vertices List field. The Overlay Count field is an optional field that is only present when the Overlay Geometry Option field is non-zero. The Overlay Vertices List can contain up to 64 polygon vertices. Since the ellipse and circular prism geometries have a single vertex, up to 64 of these geometries can be included in the Overlay Vertices List. The decoding of this field requires that one be added to the Overlay Vertices Count value to get the decimal value.

A.3.3.1.3.21 Overlay Vertices List

The Overlay Vertices List field is a variable length field containing a list of vertices for the geometry specified in the Overlay Geometry Options. Only one geometry type can be included in each overlay record (e.g., polygon and prism geometries cannot exist in the same record). The Overlay Vertices List field is optional and is only present when the Overlay Geometry Option field is non-zero. The number of vertices in the list is specified in the Overlay Vertices Count field.

A.3.3.2 NOTAM (Product #8)

Within the scope of Product #8 is the set of current, valid NOTAMs issued from the FAA's NOTAM system plus special notification reports generated within the FIS-B Ground System to notify pilots when any FIS-B product updates may be unavailable. This latter category does not exist as NOTAMs within the FAA's NOTAM system but exist only within the FIS-B Ground System and will be referred to subsequently as the "FIS-B Product Updates Unavailable" report.

The FAA-issued NOTAMs are categorized into TFR NOTAMs, D NOTAMs and FDC NOTAMs by the FIS-B Ground System.

A.3.3.2.1 APDU Header

An example of the APDU Header for one possible NOTAM is shown in the

Table A-24. It follows the APDU Header Format as outlined in Section A.2. In this example, the Product Descriptor options are not used. The segmentation capability is also not used in this example; therefore, the Segmentation Flag is set to zero (0). If this were a long enough NOTAM, the Segmentation Flag would have been set to one (1) and the APDU Header format would be much more detailed according to Section A.2.

Table A-24: NOTAM APDU Header Example

Field	Decimal Value	Binary APDU Encoding
Application Methods Flag Bit	0	0
Geographic Locator Bit Flag	0	0
Provider Specific Bit Flag	0	0
Product ID	8	00000001000
Segmentation flag	0	0
T option	2	10
Month of Year	10	1010
Day of Month	15	01111
Hours	10	01010
Minutes	54	110110
Pad	0	000

NOTAMs can be uplinked using either a single text record or a text record with a corresponding graphical component. The textual information for a NOTAM is uplinked in a separate record from the graphical information of the same NOTAM. It is up to the FIS-B avionics to match the textual NOTAM to its corresponding graphical content. Section B.3.3 provides some guidance on using tags within a text and graphical record to identify matching reports.

A.3.3.2.2 Text Record Payload Example

An example of the formatting of the Text Record Payload can be found in the test vectors supplied with this MOPS.

A.3.3.2.3 Graphical Record Payload Example

An example of the formatting of the Graphical Record Payload can be found in the test vectors supplied with this MOPS.

A.3.3.2.4 Product Specific Notes

A.3.3.2.4.1 FAA-Issued NOTAMs

A.3.3.2.4.1.1 APDU Time Stamp

For NOTAMs that contain a specific start time, that time is used in the APDU Time, for NOTAMs with no explicit start time, the time the NOTAM is first received by the ground system is used. The time option bits in the APDU Header Time are set to a value of 2 meaning the Month, Day, Hour and Minute are encoded.

A.3.3.2.4.1.2 Format of NOTAMs Received from FAA NOTAM System

The FIS-B Ground System classifies NOTAMs provided by the FAA's NOTAM system as either "NOTAM-TFR," "NOTAM-FDC" or "NOTAM-D" and includes this label at the front of the text record. FDC and D NOTAMs are identified as such at the FAA source. The FIS-B Ground System further identifies the subset of FDC NOTAMs that are TFRs if they meet any of the following criteria:

- Any NOTAM which is present on the http://tfr.faa.gov website.
- Any FDC NOTAM with the following phrases in the text:
  - FLIGHT RESTRICTION
  - FLIGHT RESTRICTIONS
  - SPECIAL NOTICE…PURSUANT TO

The ". . ." indicates any text in between them, not a literal set of periods. A NOTAM will be TEXT ONLY until the graphical portion is provided to the FIS-B Ground System. In general there is less than an hour between the issuance and the addition to the web site. A TFR may of course also remain TEXT ONLY if a graphical definition is never provided on the web site. The TFR is removed according to the NOTAM cancel time, but the NOTAM may remain on tfr.faa.gov for a short period beyond that (also generally less than an hour).

The FIS-B Ground System formats the NOTAM text record report in the following syntax.

<Product Type> space <Location ID> space <Timestamp> space <Text Report>

Table A-25 provides descriptions of each component of the text record shown above.

Table A-25: NOTAM Text Record Elements

Syntax Element	Description
<>	Denotes a required text string
space	Denotes a single space character (bit encoding of 100000)
RS	Denotes the record separator character (bit encoding of 011101)
Product Type	NOTAM-D or NOTAM-FDC or NOTAM-TFR
Location ID	XXXX.MM/### for NOTAM-D where XXXX is the four-letter airport identifier, MM is the report month as indicated in the APDU header, and ### is the last three digits of the NOTAM-D report number.
	XXXX.Y/#### for NOTAM-FDC where XXXX is the four-letter airport identifier, Y is the second digit of the report year, and #### is the four-digit NOTAM-FDC report number.
	Y/#### for NOTAM-TFR where Y is the second digit of the report year and #### is the four-digit NOTAM-TFR report number.

Syntax Element	Description
Timestamp	UTC time in the format DDhhmm, where: DD = day of the month hh = hour of the day mm = minutes of the hour
Text report	One or more characters that cannot contain <RS>.

A.3.3.2.4.1.3 NOTAM Numbering

NOTAM-FDC and NOTAM-TFR are assigned four-digit report numbers ranging from 0001 to 9999. The report numbering sequence resets to 0001 on January 1 of each year. NOTAM-D will have a report number in the range 12000 to 12999 with the last three-digits representing the source number assigned to each NOTAM-D.

A.3.3.2.4.1.4 NOTAM Years

NOTAM-FDC and NOTAM-TFR use a one-digit value for the year field (0-9) to represent the last digit of the current year. For example an FDC NOTAM created in 2013 will have a year value of 3. NOTAM-D uses a two-digit value for the year field (0-99). For example, a NOTAM-D created in 2013 will have a year value of 13. These values are consistent with the year scheme used when the NOTAM is initially created.

A.3.3.2.4.1.5 Retransmit Schedule for Text Record of NOTAM-TFR

NOTAM-TFRs do not change rapidly, therefore, to conserve bandwidth utilization a special retransmit pattern is used for the text record. APPENDIX C indicates that the transmission interval for NOTAMs is 10 minutes. For text NOTAM-TFRs every other retransmission uses an abbreviated form of the product encoding which identifies the NOTAM-TFR by Record Number and indicates its status as Active (see Table A-16) but does not contain the body text of the product. This abbreviated form of the product encoding indicates a length of five bytes even though the Text Data field is NULL to account for the length of the Text Record Length, Report Identifier and Report Status fields (see Table A-26).

This modified transmit schedule does not affect the uplink of Graphical NOTAMs, which are transmitted in their entirety every 10 minutes.

A.3.3.2.4.1.6 Purging of NOTAMs by the FIS-B Ground System

The following describes how and when NOTAMs are purged by the FIS-B Ground System:

- For NOTAM-D and NOTAM-TFR: if the expiration time is available, the NOTAM is purged at the expiration time.
- For NOTAM-D and NOTAM-FDC: If the FIS-B Ground System received a NOTAM Cancellation, the NOTAM text record header will be uplinked with the status bit set to Cancelled for a configurable time interval, then purged.
- For NOTAM-TFR: If the FIS-B Ground System receives no refreshes for a particular NOTAM-TFR for a configurable period, FIS-B Ground System will purge the NOTAM-TFR.

A.3.3.2.4.2 FIS-B Product Updates Unavailable Report

A.3.3.2.4.2.1 Purpose

The FIS-B Product Updates Unavailable Report provides notification to users of outage of individual FIS-B Products updates or the entire FIS-B service. It is transmitted as FIS-B Product ID #8 (the same ID used for NOTAMs) and is a text-only report (i.e., it does not contain a graphical component). Although this signifies a FIS-B data outage of updates to FIS-B products, transmissions of pre-outage data will continue until the respective product data expires. FIS-B Product Updates Unavailable Reports are broadcast from all radio stations within the geographic scope of the Product Update Unavailable Report (see description of geographic scope below).

Note that this notification is intended to cover outages of the upstream FIS-B data or outages involving the FIS-B server - it is not intended to provide notification of outages of the RF link itself.

A.3.3.2.4.2.2 Format of FIS-B Product Updates Unavailable Report Text

The format of the FIS-B Product Updates Unavailable Report is given below. If more than one product below is unavailable, individual reports for each product will be sent. However, if all products are unavailable a single report stating all products are unavailable is uplinked.

A FIS-B Product Update Unavailable Report is uniquely identified by the start time, geographic scope and product affected.

The FIS-B Product Update Unavailable Report is formatted as shown in the syntax below.

FIS-B <start time> <geographic scope> <product affected> UPDATES UNAVAILABLE

The following is an example of a FIS-B Product Update Unavailable Report:

```
FIS-B 111223Z ZMA, ZJX, ZTL NEXRAD IMAGERY PRODUCT UPDATES UNAVAILABLE
```

Table A-26 describes each component of the report shown above.

Table A-26: FIS-B Product Update Unavailable Report Text Elements

Syntax Element	Description
<>	Denotes a required text string
space	Denotes a single space character (bit encoding of 100000)
start time	UTC time in the format DDhhmm, where: DD = day of the month hh = hour of the day mm = minutes of the hour
geographic scope	List of Location Identifiers affected, deliminated by ",". Examples: ZBW,ZDC,ZJX,ZMA,ZME,ZNY,ZSU,ZTL
product affected	Identifies which FIS-B product is unavailable: AIRMET PRODUCT

Syntax Element	Description
	TAF PRODUCT PIREP ICING PRODUCT PIREP TURBULENCE PRODUCT PIREP WIND SHEAR PRODUCT PIREP URGENT PRODUCT ROUTINE PIREP PRODUCT D-NOTAM PRODUCT FDC-NOTAM PRODUCT METAR PRODUCT NEXRAD IMAGERY PRODUCT SIGMET / CONVECTIVE SIGMET PRODUCT TFR NOTAM PRODUCT SUA PRODUCT WINDS AND TEMPERATURE ALOFT PRODUCT NOTAM-FDC-CANCEL PRODUCT NOTAM-D-CANCEL PRODUCT SAN JUAN NEXRAD PRODUCT HAWAII NEXRAD PRODUCT ALASKA NEXRAD PRODUCT GUAM NEXRAD PRODUCT

Notes:

1. *A separate Product Update Unavailable Report will be issued for each product. However when all products are unavailable a single report containing the term `ALL PRODUCT` is used.*
2. *Since display of the SUA product is ignored, the FIS-B Product Updates Unavailable Report referring to SUA PRODUCT should also be ignored.*

A.3.3.3 AIRMET (Product #11)

A.3.3.3.1 APDU Header

An example of the APDU Header for one possible AIRMET is shown in

Table A-27. It follows the APDU Header Format as outlined in Section A.2. In this example, the Product Descriptor options are not used. The segmentation capability is also not used in this example; therefore, the Segmentation Flag is set to zero (0). If this were a long enough AIRMET, the Segmentation Flag would have been set to one (1) and the APDU Header format would be much more detailed according to Section A.2.

Table A-27: AIRMET APDU Header Example

Field	Decimal Value	Binary APDU Encoding
Application Methods Flag Bit	0	0
Geographic Locator Bit Flag	0	0
Provider Specific Bit Flag	0	0
Product ID	11	00000001011
Segmentation flag	0	0
T option	2	10
Month of Year	10	1010
Day of Month	15	01111
Hours	10	01010
Minutes	54	110110
Pad	0	000

AIRMETs are uplinked using a single text record and a corresponding graphical record. The textual information for an AIRMET is uplinked in a separate record from the graphical information of the same AIRMET. It is up to the FIS-B avionics to match the textual AIRMET to its corresponding graphical content. Section B.3.2 provides some guidance on using tags within a text and graphical record to identify matching reports.

A.3.3.3.2 Text Record Payload Example

An example of the formatting of the Text Record Payload can be found in the test vectors supplied with this MOPS.

A.3.3.3.3 Graphical Record Payload Example

An example of the formatting of the Graphical Record Payload can be found in the test vectors supplied with this MOPS.

A.3.3.3.4 Product Specific Notes

A.3.3.3.4.1 APDU Time Stamp

The time the AIRMET is issued is the time encoded in the APDU timestamp. The time option bits in the APDU Header Time are set to a value of two (2) meaning the Month, Day, Hour and Minute are encoded. See Table A-5.

A.3.3.3.4.2 Modification of Text AIRMET Header by FIS-B Ground System

To maintain consistency with the free text products, the FIS-B application formats the AIRMET text record report in the following syntax.

<Product Type> space <Location ID> space <Timestamp> space <Text Report>

Table A-28 gives the meanings for each component of the text record shown above.

Table A-28: Text AIRMET Header Record Elements

Syntax Element	Description
<>	Denotes a required text string.
Product Type	AIRMET
space	Denotes a single space character (bit encoding of 100000).
RS	Denotes the record separator character (bit encoding of 011101).
Location ID	XXXX (site id for the AIRMET report from the FIS-B data source)
Timestamp	UTC time in the format DDhhmm, where: DD = day of the month hh = hour of the day mm = minutes of the hour
Text report	One or more characters that cannot contain <RS>. This is the actual text of the World Meteorological Organization report that may be displayed exactly as received without additional formatting or interpretation.

A.3.3.3.4.3 "Outlook" Portion of AIRMET

Some AIRMETs are created with an "Outlook" section as the final portion of the report. This Outlook portion is omitted in the uplinked version.

A.3.3.3.4.4 Updates to AIRMET

Sometimes AIRMETs are updated at the source prior to the expiration of the previous AIRMET reporting on the same hazard. There is no reliable "tag" in the AIRMET that allows association of the update with the previous report. This can result in multiple contours showing the progression of the hazard, which could cause clutter on the cockpit display.

A.3.3.4 SIGMET (Product #12)

A.3.3.4.1 APDU Header

An example of the APDU Header for one possible SIGMET is shown in

Table **A-29**. It follows the APDU Header Format as outlined in Section A.2. In this example, the Product Descriptor options are not used. The segmentation capability is also not used in this example; therefore, the Segmentation Flag is set to zero (0). If this were a long enough SIGMET, the Segmentation Flag would have been set to one (1) and the APDU Header format would have been much more detailed according to Section A.2.

Table A-29: SIGMET APDU Header Example

Field	Decimal Value	Binary APDU Encoding
Application Methods Flag Bit	0	0
Geographic Locator Bit Flag	0	0
Provider Specific Bit Flag	0	0
Product ID	12	00000001100
Segmentation flag	0	0
T option	2	10
Month	10	1010
Day of Month	15	01111
Hours	10	01010
Minutes	54	110110
Pad	0	000

SIGMETs are uplinked using a single text record and a corresponding graphical record. The textual information for a SIGMET is uplinked in a separate record from the graphical information of the same SIGMET. It is up to the FIS-B avionics to match the textual SIGMET to its corresponding graphical content. Section B.3.2 provides some guidance on using tags within a text and graphical record to identify matching reports.

A.3.3.4.2 Text Record Payload Example

An example of the formatting of the Text Record Payload can be found in the test vectors supplied with this MOPS.

A.3.3.4.3 Graphical Record Payload Example

An example of the formatting of the Graphical Record Payload can be found in the test vectors supplied with this MOPS.

A.3.3.4.4 Product Specific Notes

A.3.3.4.4.1 APDU Time Stamp

The time the SIGMET is issued is the time encoded in the APDU timestamp. The time option bits in the APDU Header Time are set to a value of two (2) meaning the Month, Day, Hour and Minute are encoded.

A.3.3.4.4.2 Modification of Text SIGMET Header by FIS-B Ground System

To maintain consistency with the free text products, the FIS-B application formats the SIGMET text record report in the following syntax.

<Product Type> space <Location ID> space <Timestamp> space <Text Report>

Table A-30 gives the meanings for each component of the text record shown above.

Table A-30: SIGMET Header Text Record Elements

Syntax Element	Description
<>	Denotes a required text string.
Product Type	“SIGMET” or “WST” (Convective SIGMET)
space	Denotes a single space character (bit encoding of 100000).
RS	Denotes the record separator character (bit encoding of 011101).
Location ID	XXXX (site id for the SIGMET report from the FIS-B data source
Timestamp	UTC time in the format DDhhmm, where: DD = day of the month hh = hour of the day mm = minutes of the hour
Text report	One or more characters that cannot contain <RS>. This is the actual text of the World Meteorological Organization report that may be displayed exactly as received without additional formatting or interpretation.

A.3.3.4.4.3 “Outlook” Portion of SIGMET

Some SIGMETs are created with an “Outlook” section as the final portion of the report. This Outlook portion is omitted in the uplinked version.

A.3.3.4.4.4 Updates to SIGMET

Sometimes SIGMETs are updated at the source prior to the expiration of the previous SIGMET reporting on the same hazard. There is no reliable “tag” in the SIGMET that allows association of the update with the previous report. This can result in multiple contours showing the progression of the hazard which could cause clutter on the cockpit display.

A.4 Current Report List

The CRL is conveyed within Frame Type 14. The CRL frame is encoded within the UAT Ground Uplink Message as shown in Figure A-31.

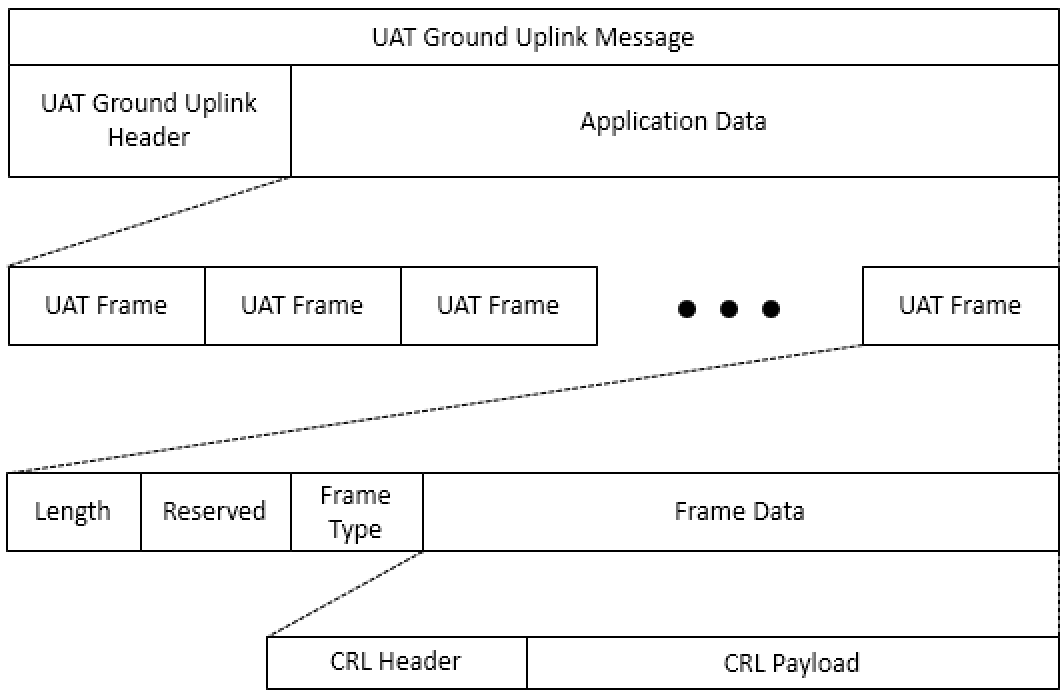
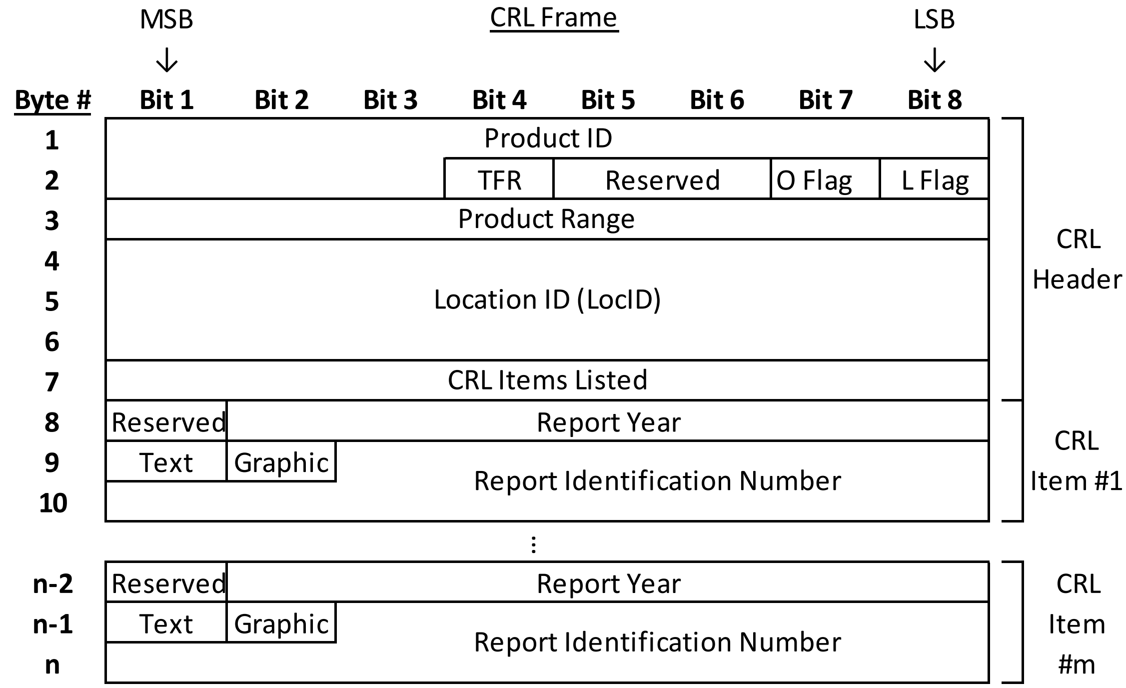


Figure A-31: Decomposition Showing the CRL

The CRL Frame is formatted as shown in Figure A-32.



Notes:

1. *L = 6 + (N * 3) when LocID is included*
2. *L = 3 + (N * 3) when LocID is not included*
3. *A maximum of 138 CRL list items can fit in one CRL frame*

Figure A-32: CRL Encoding

A CRL Frame contains a CRL Header and either zero, one or multiple CRL Items. Each list item will refer to the Report Year and Report 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 consists of the seven (7) byte CRL Header and zero (0) accompanying CRL Items in the CRL Payload. The CRL Header contains all the pertinent header fields and encodes a value of zero (0) in the CRL Items Listed field. 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 (O) Flag will be set to one (1) to indicate that not all items are being uplinked in the CRL.

A.4.1 CRL Header Encoding

A.4.1.1 Product ID

The Product ID field is an 11-bit field that corresponds to the Product ID of the Report Numbers found in the CRL Items. The Product ID field is set to eight (8) for TFR NOTAMs, 11 for AIRMETs and 12 for SIGMETs.

A.4.1.2 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 NOTAMs-D. This bit has no meaning for other Product ID values.

A.4.1.3 Reserved

This 2-bit field is reserved for future use and is set to ALL zeros.

A.4.1.4 O 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 uplinked by the radios are not included in the CRL for this Product ID.

A.4.1.5 L Flag

The L 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 NOTAM-TFR CRLs.

A.4.1.6 Product Range

This field defines the look ahead range 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 an 8-bit value with an LSB of 5 nmi. Therefore, the Product Range has values from 0 to 1,275 nmi on 5 nmi increments.

A.4.1.7 LocID

The LocID field indicates the local identifier associated with the reports found in the CRL List Items. It is optional and for future use by the FIS-B service for NOTAMs-D.

A.4.1.8 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.

A.4.2 CRL Payload Encoding

The CRL Payload is made up of 1 to 138 CRL List Items. Each individual CRL List Item contains the following fields.

A.4.2.1 Reserved Bit

This field is reserved and set to zero (0) to maintain byte boundary consistency.

A.4.2.2 Report Year

The Report Year field indicates the year of the report within each CRL List Item. The Report Year is an exact match to the Report Year encoded in the corresponding report and described in Section A.3.3.1.2.2.

A.4.2.3 Text

The Text bit is set to indicate this report is associated with a Textual record.

A.4.2.4 Graphic

The Graphic bit is set to indicate this report is associated with a Graphical record.

A.4.2.5 Report Number

The Report Number provides the unique report identifier for the Product ID report associated with this CRL List Item. The Report Number is an exact match to the Report Number encoded in the corresponding report and described in Section A.3.3.1.2.1.

Notes:

1. *A text-only report will be uplinked as a single CRL List Item with the Text bit set to one (1) and the Graphic bit set to zero (0).*
2. *A TWGO report will be uplinked as a single CRL List Item with both the Text and Graphic bit set to one (1).*

APPENDIX B FIS-B REPORT PRINCIPLES

B.1 FIS-B Report Hierarchy

B.1.1 FIS-B Report

A FIS-B report is the elemental unit of displayable and pilot consumable FIS-B data. Since the uplink approach of the system is incremental and continuous, the concept of the FIS-B report is important because the onboard FIS-B data must be maintained by the FIS-B avionics at the FIS-B report level as new FIS-B reports are received.

B.1.2 Record

Records apply only to the TWGO class of products (product #8, #11 and #12). For this class of product each FIS-B report is currently composed of a text record and zero or more graphical records.

B.1.3 Field

A field is an element of a Record or Report in which one piece of information is stored. A field is the smallest, most basic data element transmitted. Fields contain data items found in reports or records such as overlay record length, report number or report year.

B.2 Relationship of FIS-B Reports to APDU and to Records by Product

Table B-1 shows the relationship of the FIS-B report to the APDU and the relationship of the FIS-B report to the record.

Table B-1: Relationships of FIS-B Reports to APDU and to Records

Product Class	Product Title	FIS-B Report to APDU	FIS-B Report to Record
Generic Text (#413)	METAR	One METAR per APDU	Not applicable
	TAF	One TAF per APDU	
	WINDS	One WINDS forecast per APDU	
	PIREP	One PIREP per APDU	
Global Block (#63and #64)	CONUS (#64) and REGIONAL NEXRAD (#63)	One or more whole global blocks packed into each APDU	Not applicable
Text with Graphical Overlay	NOTAM (#8)	One NOTAM to one or more APDU	Complete Report may have both Text and Graphic Records that must be linked
	AIRMET (#11)	One AIRMET to one or more APDU	
	SIGMET (#12)	One SIGMET to one or more APDU	
	WST (#12)	One WST to one or more APDU	

Product Class	Product Title	FIS-B Report to APDU	FIS-B Report to Record
	FIS-B PRODUCT UPDATES UNAVAILABLE	One FIS-B Product Updates Unavailable report per APDU	Not applicable

B.3 Guidance for Maintaining a Complete and Unique Set of FIS-B Reports

The FIS-B Ground System is divided into independent FIS-B CS areas (Guam, West, Central and East) with each radio station driven by one of these CSs. This is significant because the CS assigns certain identifying information at both the APDU level and the Report level. Since each CS is independent, it is assigned a fixed block of these identifiers such that aircraft near a border area could in some cases receive the same FIS-B reports but with different identification. This section details the cases where this redundant information could be received.

B.3.1 Processing Segmented APDUs

FIS-B reports large enough to require a Segmented APDU are not guaranteed to always be fully consistent across radio stations. Specifically, the Product File ID could vary for the same FIS-B Report uplinked from different radio stations.

Each CS is assigned its own block of Product File ID codes used for reassembly of segmented APDUs uplinked within that CS area as shown in Table B-2. The Product File ID is contained in the Segmentation Block of the APDU Header. Avionics manufacturers should be aware that an aircraft that is receiving reports from radio stations on both sides of a CS boundary could receive segmented APDUs for the same FIS-B report with a different Product File ID. This forces the FIS-B avionics to decode the same segmented APDU twice with different Product File IDs. These would then need to be processed at the FIS-B report level as described in the sections below to eliminate the FIS-B report redundancy.

Table B-2: Product File ID Block Assignments

	CS (Guam)	CS West	CS Central	CS East
Product File ID Range	0-340	682-1023	341-681	0-340

B.3.2 Processing FIS-B Reports for AIRMET and SIGMET

B.3.2.1 Associating Text and Graphic Records

Each AIRMET and SIGMET will have a unique combination of Report Year and Report Number that can be used for associating Text and Graphic records. However, AIRMETs and SIGMETs must be processed separately for this purpose since the report number space is identical for each.

B.3.2.2 Purging Redundant AIRMETs and SIGMETs

AIRMET and SIGMET reports can be uniquely identified by a combination of Report Year and Report Number contained in the TWGO record. The Report Number is generated by the FIS-B Ground System. It is assigned within a block of numbers assigned to each CS area in a manner similar to that of the Product File ID described above.

Therefore avionics manufacturers should not rely on the Report Year/Report Number alone for detecting and purging redundant FIS-B reports for SIGMET and AIRMET. Other aspects within the FIS-B report would have to be considered to completely identify duplicate reports for purging.

B.3.3 Processing FIS-B Reports for NOTAMs

NOTAM-FDC and NOTAM-TFR reports can be uniquely identified by a combination of Report Year and Report Number contained in the TWGO record. Unlike AIRMET and SIGMET, the Report Year and Report Number are generated uniquely at the source and are consistent across FIS-B CSs. The combination of these fields can be used to uniquely identify a report and associate a Text Record with a Graphical Record.

NOTAM-D report numbers are assigned in a sequence unique to each issuing location or facility to which the report applies. NOTAM-D reports can be uniquely identified by a combination of the Report Number field, the Report Month field and the LocID field. The Report Number is found in the TWGO record. The Report Month field is found in the APDU Header Time. The LocID field comes from the TWGO Header and references the location or facility that the report applies to. The combination of these fields can be used to uniquely identify a report and associate a Text Record with a Graphical Record. See Section A.3.3.2.4.2.2 for uniqueness determination of FIS-B Product Updates Unavailable Report.

This identifying information in NOTAMs is consistent across CS boundaries. Table B-3 summarizes the assignment ranges for the Report Number for the FIS-B Product ID #8 products.

Table B-3: Report Number ranges for FIS-B Product ID #8 Products

FIS-B Product ID #8	Report Number Range
NOTAM FDC/TFR	0 – 9999
Product Update Unavailable	10,000 – 11,999
NOTAM D	12,000 + Report ID from the NOTAM D report (12,000 – 12,999)

B.3.4 Processing FIS-B Reports for Generic Text Products

FIS-B reports for Generic Text products can be uniquely identified using a combination of location and time found in the textual payload. Table B-4 provides an example identifying tag for each Generic Text Product. The identifiers for generating a unique set of Generic Text products are consistent across FIS-B CSs.

Table B-4: Recommended Tag for Unique Identification of Generic Text Products

Product	Recommended "Tag"	Description
METAR	Location ID/Time Example: KHNZ/071655Z	Location ID refers to the four character Location Identifier associated with that report. Time refers to the time of observation of that report given in DDhhmm format. Both of these items can be found in the text of the report.
TAF/ TAF.AMD/ TAF.COR	Location ID/Time Example: KEKN/071646Z	Location ID refers to the four character Location Identifier associated with that report. Time refers to the time of observation of that report given in DDhhmm format. Both of these items can be found in the text of the report.
PIREP	Location/Time Example: /OV TTA270007/071445Z	Location is given in the text after the field labeled "/OV." Note: In the example the location is read as "270 degrees at 7 NM from TTA." Time refers to the time of observation of that report in DDhhmm format. Both of these items can be found in the text of the report.
WINDS	Location ID/Valid Time/Product Available Time Example: KABI/201800Z/1400	Location ID refers to the four character Location Identifier associated with that report and can be found within the text of the report. Valid Time refers to the starting time at which the forecast is valid and can be found within the text of the report in the format DDhhmm. Product Available Time refers to the time at which that report became available and can be found in the APDU Header of the report and is shown in the example in the format hhmm. See Table A-9 for more information on these times.

B.3.5 Processing FIS-B Reports for Global Block Representation Products

For the Global Block Representation products, each global block is considered a report. A combination of the Block Number and the APDU Header Time provides unique identification of these products. The identifiers for generating a unique set of Global Block Products are consistent across FIS-B CSs.

APPENDIX C FIS-B PRODUCT UPDATE AND TRANSMISSION INTERVALS

C.1 FIS-B Transmission Interval

Transmission Interval is defined as the time between the broadcast of a specified FIS-B product from a radio station. This interval depends upon the product type as shown in Table C-1.

Table C-1: FIS-B Product Transmission Intervals

Product	Transmission Interval
AIRMET, SIGMET/Convective SIGMET and METAR	5 minutes
CONUS NEXRAD	15 minutes
Regional NEXRAD	2.5 minutes
NOTAM, PIREP, TAF and WINDS	10 minutes

Note: *See Section 2.2.4.3.5.4 Note 2 for a caveat to the NOTAM transmission interval.*

C.2 FIS-B Update Interval

The update interval is defined as the time between updates of FIS-B products from the data source. This interval depends upon the product type as shown in Table C-2.

Table C-2: FIS-B Product Update Intervals

Product	Update Interval
AIRMET	Every 6 hours at 0255, 0855, 1455, 2055 (in between as needed)
SIGMET	As Available, then every 4 hours
Convective SIGMET	Every 1 hour at ~55 minutes past the hour
METAR	15 minutes to 1 hour (METAR station dependent)
CONUS NEXRAD	15 minutes[3]
Regional NEXRAD	5 minutes
NOTAM, PIREP	As Available
TAF	6 Hours; Amended TAF is uplinked as soon as available
WINDS	6 Hours

[3] Reference Section A.3.2.4.2 and Section I.2 for discussion of CONUS processing by FIS-B CSs and the uplink of CONUS NEXRAD product by Radio Stations in the domain of FIS-B CSs.

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APPENDIX D FIS-B RADIO STATION TIERING

D.1 Introduction

This appendix is informational and provides the general concepts for the tiering of FIS-B ground Radio Stations. The tiering strategy was developed to deliver FIS-B products to aircraft at different altitudes with different look-ahead ranges, while subject to the limitations of channel capacity and co-channel interference. Details and concepts are subject to change as the strategies for management of the ground system Radio Stations and their allocated channel capacities may be modified to meet future changes in the scope of FIS-B products delivered or their requirements.

The UAT schema provides 32 logical channels to the ground for the uplink of data to aircraft as described in APPENDIX G. Of these, logical channels 1 through 31 are allocated to the uplink of FIS-B data. Channel 32 is allocated for other purposes. FIS-B data products are delivered from ground Radio Stations, each using 1, 2, 3 or 4 data channels. If a receiver is within radio coverage of two Radio Stations transmitting on the same logical channel it encounters co-channel interference. If the signal from one Radio Station is not sufficiently stronger than that of the interfering Radio Station the signal will be garbled and neither signal will be successfully received. Therefore, careful selection of Radio Station channel assignments is necessary in order to ensure that whenever Radio Stations are in view of an aircraft receiver, at least one station must be free of co-channel interference in order to ensure delivery of FIS-B data. This appendix describes the means used for Radio Station data channel assignment.

D.2 Cellular and Tiering Concept

D.2.1 Cellular Channel Reuse

A standard method of channel reuse is accomplished by using a cellular reuse pattern. Each Radio Station covers a cell and is assigned a set of channels to use. Neighboring cells, a portion of which are also visible, are assigned different channel sets, so locations where multiple Radio Stations are seen have at least one Radio Station without co-channel interference.

An example of regular cell arrangement with a three cell reuse factor is depicted in Figure D-1. Special considerations are necessary in an airborne environment since the distance at which Radio Stations are visible varies considerably depending upon the aircraft altitude. As an aircraft's altitude increases, the number of visible Radio Stations increase, therefore, Radio Stations that do not exhibit co-channel interference at a low altitude could receive interference at a high altitude. A three-dimensional cellular approach is necessary to ensure full coverage.

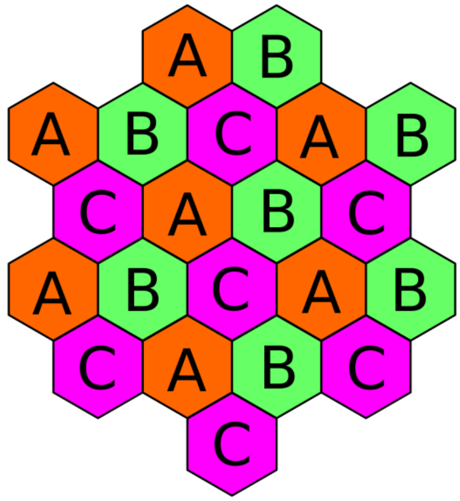


Figure D-1: Example of Three-Cell Reuse Pattern

D.2.2 Tiered Cellular Assignment

D.2.2.1 Tier Altitude Range

Given a nominal cell spacing, there exists an altitude range in which at least one radio station is expected to be visible. A notional two-dimensional example is shown in Figure D-2. The floor and ceiling are determined at the cell boundary. The floor is the lowest altitude at the cell boundary at which both a radio station and its nearest neighbor radio station are visible. The ceiling is the altitude at the cell boundary at which the nearest radio station with the same channel assignment is visible. Note that these are not hard boundaries at either the floor or the ceiling. There is still a great deal of coverage slightly above the ceiling or below the floor. Deviations from the nominal spacing will have the effect of lowering the ceiling and raising the floor.

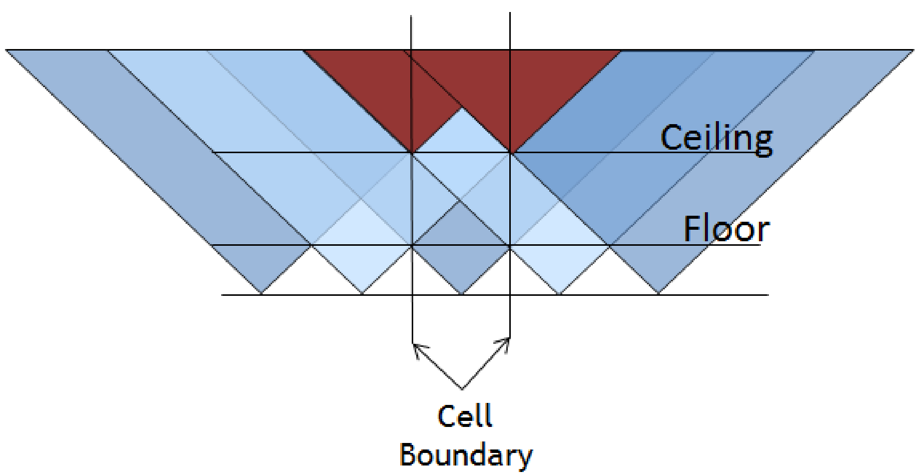


Figure D-2: Tier Altitude Range

D.2.2.2 Tier Implementation

D.2.2.2.1 High Tier

Three separate tiers are designed to ensure coverage from the specified FIS-B service ceiling of 24,000 ft MSL. Starting at the high tier, cell spacing is chosen to reach a nominal ceiling of 36,500 ft MSL, and nominal floor of 9100 ft AGL, allowing for deviations due to radio station location and terrain blockage. The high tier has a cellular reuse factor of three, and the high tier channel assignments are designated as H1, H2 and H3, as seen in Figure D-3.

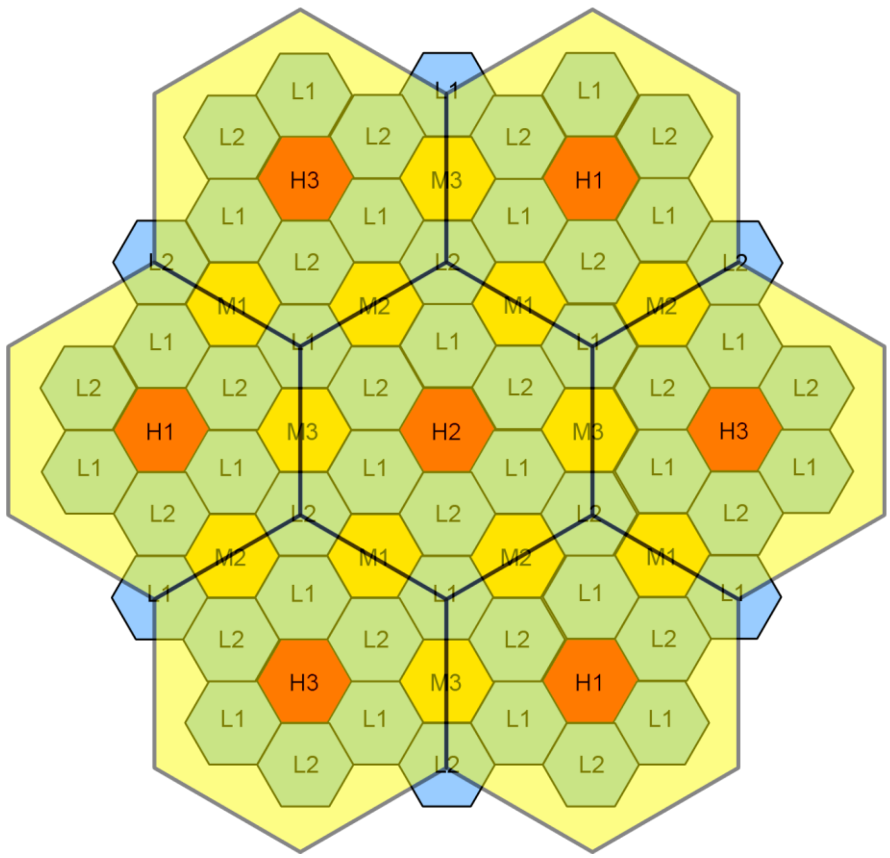


Figure D-3: FIS-B High Tier

D.2.2.2.2 Medium Tier

The medium tier is designed with a cellular reuse factor of 4, and is illustrated in Figure D-4. Three of the channel assignments are designated as M1, M2 and M3. The remaining channel assignment set is taken by a high-tier radio station, (H1, H2, H3) rather than M4. This requires that the high-tier radio stations transmit a superset of the mid-tier radio station data. The medium tier has a nominal ceiling of 13,800 ft AGL, for a considerable overlap with the high tier. This tier has a nominal floor of 2250 ft AGL.

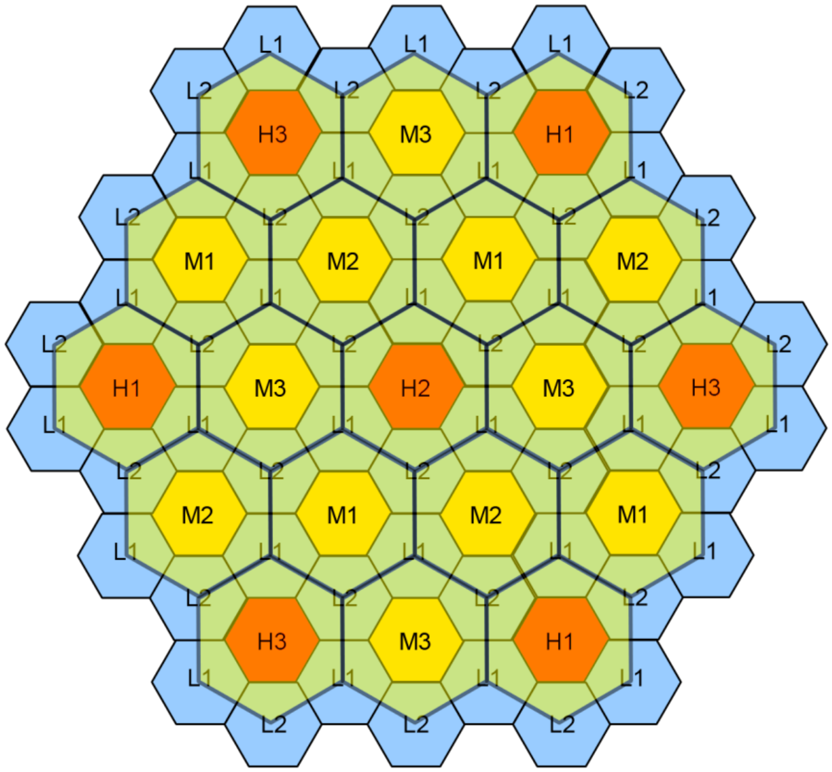
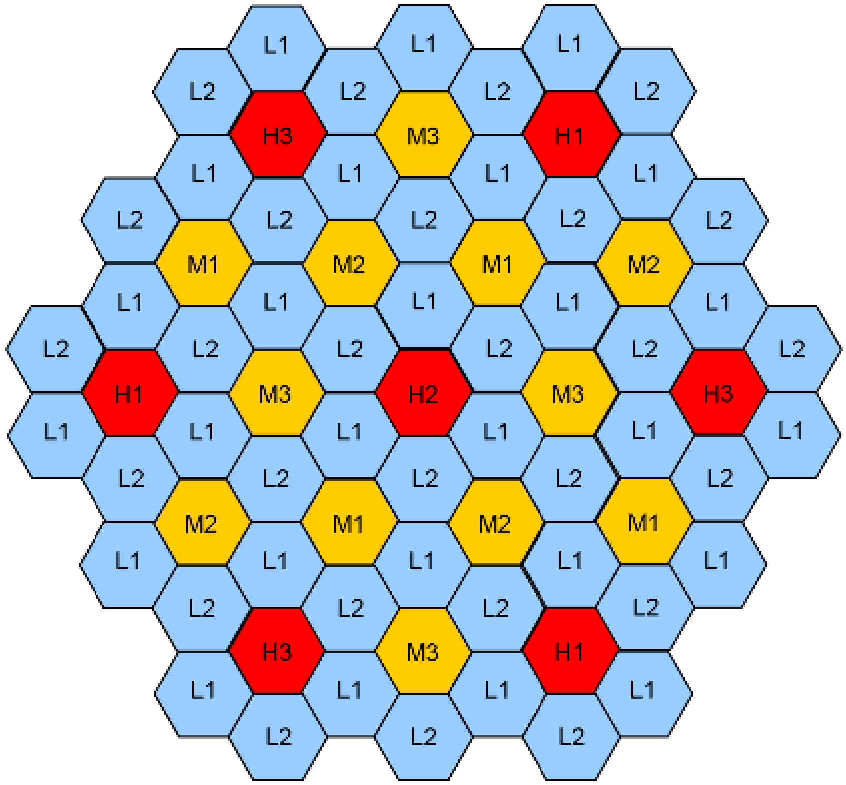


Figure D-4: FIS-B Medium Tier

D.2.2.2.3 Low Tier

The low tier is designed with a cellular reuse factor of 3, and is illustrated in Figure D-5. Two of the channel assignments are designated as L1 and L2. The third channel assignment is taken by a medium- or high-tier station. Finally, a channel assignment L3 is used to assign to radio stations that do not fit within the tiered structure. The floor of the low tier is the system coverage floor. The low tier has a nominal ceiling of 3050 ft AGL, overlapping the medium tier.



<u>Figure D-5:</u> FIS-B Low Tier

D.2.2.2.4 Surface Assignments

In addition to the tiers described in this section, radio stations are located at airports providing service to aircraft and vehicles on the airport surface. These surface radio stations are not included in the tiering structure described. Surface radio stations have channel designations S1, S2, S3 and S4.

Additionally, channel designations L4 and L5 may service the airport surface where the FIS-B data load requires additional capacity.

D.3 Data Channel Assignments

There are a total of 31 channels available for delivery of FIS-B data, and the amount of data any single radio station can deliver is limited by the number of channels assigned to that radio station. Channels have been allocated such that high-tier stations are assigned four channels each, medium-tier stations are assigned three channels each, low tier stations two channels each and surface stations are assigned a single channel. In general, an aircraft's altitude is correlated with its speed and expected flying distance; high-flying aircraft typically fly faster and farther than low-flying aircraft. This is reflected in the increased look-ahead range and data products used in the high tiers over the low tiers.

In addition, each channel set assignment is assigned a Site ID, which may be used by the FIS-B avionics to identify the tier and data channels used by the radio station. See

Sections A.3.3.3.4.2 and A.3.3.4.4.2 for AIRMET and SIGMET Site ID information, respectively.

Notes:

1. *Since the tiering and channel assignments are adjusted to meet the changing dynamics of the FIS-B product load and requirements, the relationship of Site ID designation with channel assignments will be maintained apart from this MOPS.*

2. *The tiering and channel assignments can be known by the avionics with the algorithm in Section 2.2.10.*

APPENDIX E BACKGROUND ON THE NEXRAD UPLINK PRODUCTS

E.1 NEXRAD Network

The network of NEXRAD sensors contributing to the uplink of the Regional NEXRAD (Product #63) and the CONUS NEXRAD (Product #64) is shown in Figure E-1 and Figure E-2 (Source: http://www.roc.noaa.gov/WSR88D/Maps.aspx).

Figure E-1: CONUS NEXRAD Network

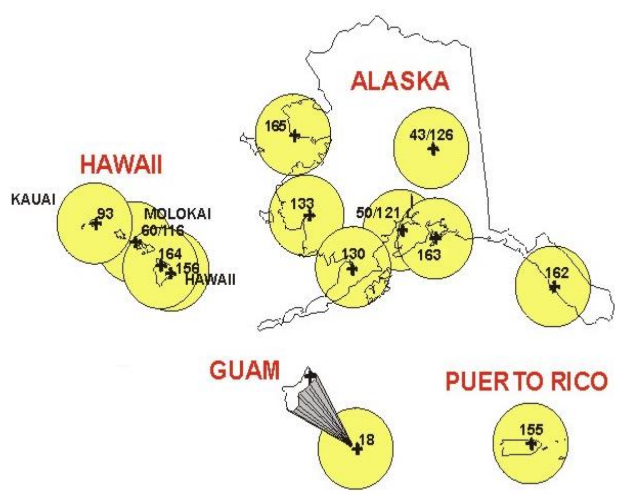


Figure E-2: Outside CONUS NEXRAD Network

E.2 NEXRAD Processing for Uplink

The FIS-B Ground System aggregates the Composite Reflectivity product provided from each NEXRAD sensor to create the resultant NEXRAD product that is uplinked. Each NEXRAD sensor uses a volume scan composed of antenna rotations at multiple elevation angles to create the Composite Reflectivity product. The Composite Reflectivity Product is composed of the greatest echo intensity (reflectivity) value above each NEXRAD mosaic bin (bin size is dependent upon resolution) available from any elevation angle sensed by the NEXRAD sensors.

A mosaic process is performed by the FIS-B Ground System on all NEXRAD sensor data within CONUS, within AK and within HI. Although some areas may only have one NEXRAD that does not require a mosaic, the mosaic process includes quality control and formatting. A mosaic is created for each of these areas based on all the NEXRAD sensors in that area. The Composite Reflectivity product used for the CONUS NEXRAD sensors has a 124 nmi range from each operating NEXRAD sensor. This is the NEXRAD sensor product known as "37/CR" and has a data resolution of 0.54 nmi by 0.54 nmi.

The AK and HI mosaic as well as the single NEXRAD areas of Guam and Puerto Rico use a combination of two NEXRAD Composite Reflectivity products: a short range high-resolution product (37/CR) and a long range lower-resolution Composite Reflectivity product known as "38/CR," which has a data resolution of 2.2 nmi by 2.2 nmi. Within 124 nmi range of each sensor the higher-resolution product (37/CR) is used. Between 124 and 248 nmi of each sensor, the lower-resolution (38/CR) is used.[4] Areas without any NEXRAD sensor coverage are to be rendered in the cockpit as areas of No Data.

The data lattice of bins produced in the initial CONUS mosaic processing and the global block format for data uplinked by FIS-B have similar cylindrical mapping projections, but with different bin sizes from that of the global block format. An additional processing step within the FIS-B Ground System performs the necessary remapping into the Regional (high resolution) and CONUS (medium resolution) global block formats. In addition, the data conversions from the initial mosaic bin intensity values to the FIS-B Intensity Encoded Values for each product are performed.

For the Regional NEXRAD product, each radio station receives a "cutout" of its respective mosaic (or single site NEXRAD in the case of Guam and Puerto Rico) that is tailored to that radio station area. Use of a mosaic in areas with overlapping NEXRAD sensor data gives a seamless view of the NEXRAD data as the aircraft transitions between radio stations along its flight path.

The CONUS NEXRAD product is a downsampled version of the CONUS mosaic. Details of this downsampling are given in the Product Specific Notes section of the CONUS NEXRAD product description in Section A.3.2.4.

E.3 NEXRAD Product Timing and Latency

When there is detectable precipitation within range of a NEXRAD sensor and the measured reflectivity exceeds a specific threshold value, the sensor is automatically

[4] The shorter range is used within CONUS since there is generally better overlapping coverage there. A fixed range is used rather than a terrain mask since the composite reflectivity product includes high-elevation scans of the NEXRAD sensor that will generally not be terrain blocked.

switched into "Precipitation" mode. In the winter, the radar is often left in “Clear Air” Mode because of its higher sensitivity although there may be liquid or frozen precipitation. In Precipitation Mode, the NEXRAD sensor can take up to 6 minutes to complete its volume scan and release the Composite Reflectivity product for use by the FIS-B Ground System.[5] NEXRAD sensors are not synchronized with each other; each sensor’s scan may complete at random times. When the NEXRAD single site contributions are processed into a mosaic by the FIS-B Ground System, the mosaics are generated at a fixed 5-minute interval. These 5-minute epochs of the mosaic processor represent what is termed the “cutoff” time, since the mosaic processor does not wait any longer for newer data and must use the latest Composite Reflectivity product available from each sensor. It is this cutoff time that is encoded in the APDU Header Time.

In any given area where significant Wx is present, the worst case time from original sensing of the Wx to the time a complete update is first available in the cockpit can be estimated for the Regional NEXRAD product as around 14 minutes. This presumes reference to radars in Precipitation Mode that have a higher refresh rate. “Clear Air” Mode radar contributions can have higher latencies, but it is assumed that the time sensitivity of these features is significantly less concerning. Avionics manufacturers should ensure users are aware of this potential latency. The latencies are accumulated during the product creation and transmission steps:

- NEXRAD Scan: The NEXRAD sensor scan time in precipitation mode takes approximately 6 minutes. The latency budget of the data is measured from the start of the scan.
- FIS-B Ground System: The mosaic ground processing, APDU creation, and ground uplink message transmission takes approximately 2 minutes. If the NEXRAD individual site product is received at the first possible time during the five minute window data is collected for the mosaic, this would add 4 minutes and 59 seconds to the data latency as the worst case. In total, this segment could accumulate approximately 7 minutes in latency.
- FIS-B On-board Processing: Delay time in the FIS-B avionics can be <30 seconds – this is rounded up to 1 minute for this latency estimation.

FAA AC 00-45G provides more information on the interpretation and limitations of NEXRAD information.

[5] The normal mode of the radar is “Clear Air” Mode where the volume scan takes longer to complete. The latency budget for Precipitation Mode is the focus as this mode is active during the significant frontal and convective hazards to aviation.

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APPENDIX F UPLINK OF CURRENT REPORT LIST FOR NOTAM/AIRMET/SIGMET

F.1 Background

METAR, TAF, WINDS and NEXRAD products all have known reporting locations and transmit intervals such that the FIS-B avionics may infer if any reports for these products are missing. However, NOTAMs do not have a regular reporting time or location. Additionally, the number of AIRMETs and SIGMETs transmitted from a particular location is variable. Due to the incremental way the Surveillance and Broadcast Services (SBS) FIS-B system uplinks all products, there is no way for the FIS-B avionics to know if it contains a complete set of NOTAM-TFR, AIRMET and SIGMET reports. An incomplete set could occur due to RF fading while an update is in progress.

To overcome this limitation, the SBS FIS-B Ground System uplinks a CRL for NOTAM-TFR, AIRMET and SIGMET reports. The CRL lists the set of report identifiers for those reports that have been broadcast from that radio station and should have been received. If the full report is present in the FIS-B avionics for each of the Report IDs in the CRL, the FIS-B avionics can annunciate the report set is complete for that product or, if some are missing, can annunciate in the negative to caution that the report set is not complete.

Principles of implementation of the CRL are described below.

1. The presence of the CRL has no effect on the uplink of the actual reports. It is backward compatible.
2. The CRL is radio station oriented. This is because the set of reports of NOTAMs-TFR, AIRMETs and SIGMETs will likely be different for each radio station due to their differing areas of product coverage.
3. The FIS-B Ground System will establish different CRLs by product for logical partitioning and to keep the maximum length containable within a single ground uplink message. Table F-1 lists the products available in the CRL. Figure F-1 shows the breakdown of the individual CRLs.

Table F-1: **CRL Availability by Product Name**

Product Class	Product ID #	Product Name	CRL Status
Generic Text	413	METAR	Not Provided
		TAF	
		PIREP	
		WINDS	
Global Block Representation	63	Regional NEXRAD	Not Provided
	64	CONUS NEXRAD	
Text with Graphical Overlay	8	NOTAM-D	Not Provided
		NOTAM-FDC	Not Provided
		NOTAM-TFR	Available
		FIS-B Product Updates Unavailable	Not Provided
	11	AIRMET	Available
	12	SIGMET	Available
		WST	Available

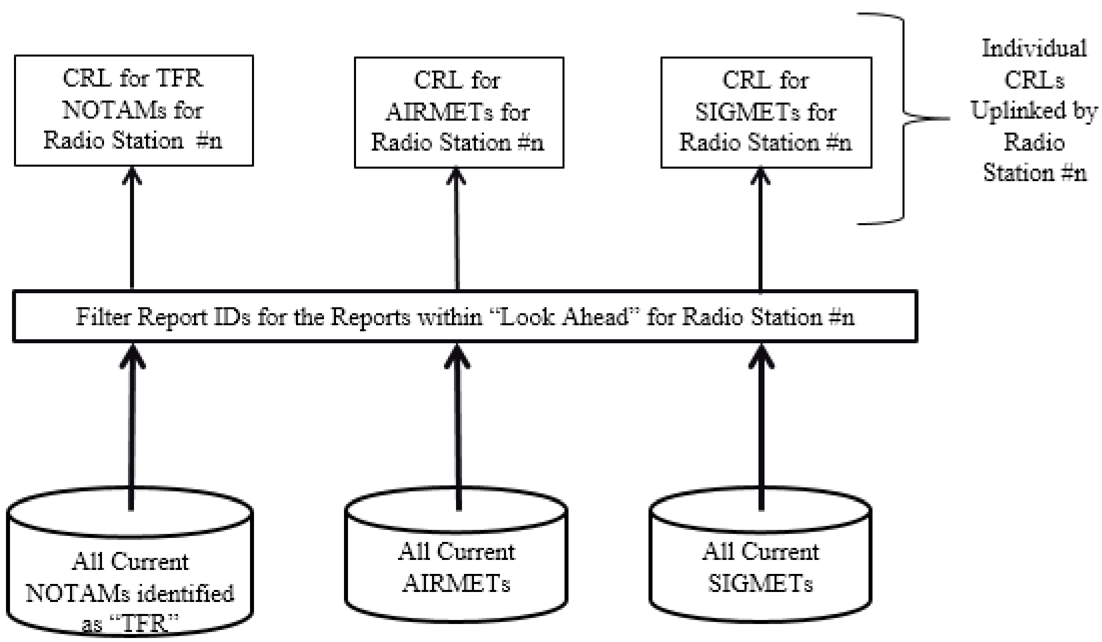

Figure F-1: **The Individual CRL Types**

4. For simplicity of FIS-B avionics, each CRL is containable in a single ground uplink message (~400 bytes max).
5. For efficiency, many small CRLs are packed into a single ground uplink message as long as each packed CRL is fully contained in the message.
6. Each CRL is uplinked at twice the transmission rate of the product itself (See Table C-1).
7. Each CRL is implemented as a new Frame Type containing a CRL Header and CRL Payload (Frame Type #14) (see Table A-2).
8. Each CRL is always sent even if there are no currently uplinked reports (i.e., a NULL CRL).
9. The CRL Frame is formatted as shown in the Figure A-32.

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APPENDIX G GROUND RADIO STATION MEDIA ACCESS FOR FIS-B UPLINK

This appendix describes the media access approach used by the SBSS Radio Stations for uplink of FIS-B data.

SBSS radio stations transmit FIS-B information using 31 of the 32 logical data channels established for Ground Uplink Messages. Transmission Time Slot resources assignable to the radio stations are made on a continually shifting basis. This assignable resource is referred to as a "Data Channel" to distinguish it from a Transmission Time Slot. Each radio station will be assigned 1, 2, 3 or 4 fixed Data Channels for uplink of FIS-B depending on the class (tier) of the radio station.

Table G-1 shows each of the 32 time slots in terms of Message Start Opportunities (MSOs). Both the UAT Ground Uplink Message and the MSOs are described in RTCA DO-282B.

Table G-1: Transmission Time Slot Definition for the UAT Ground Segment

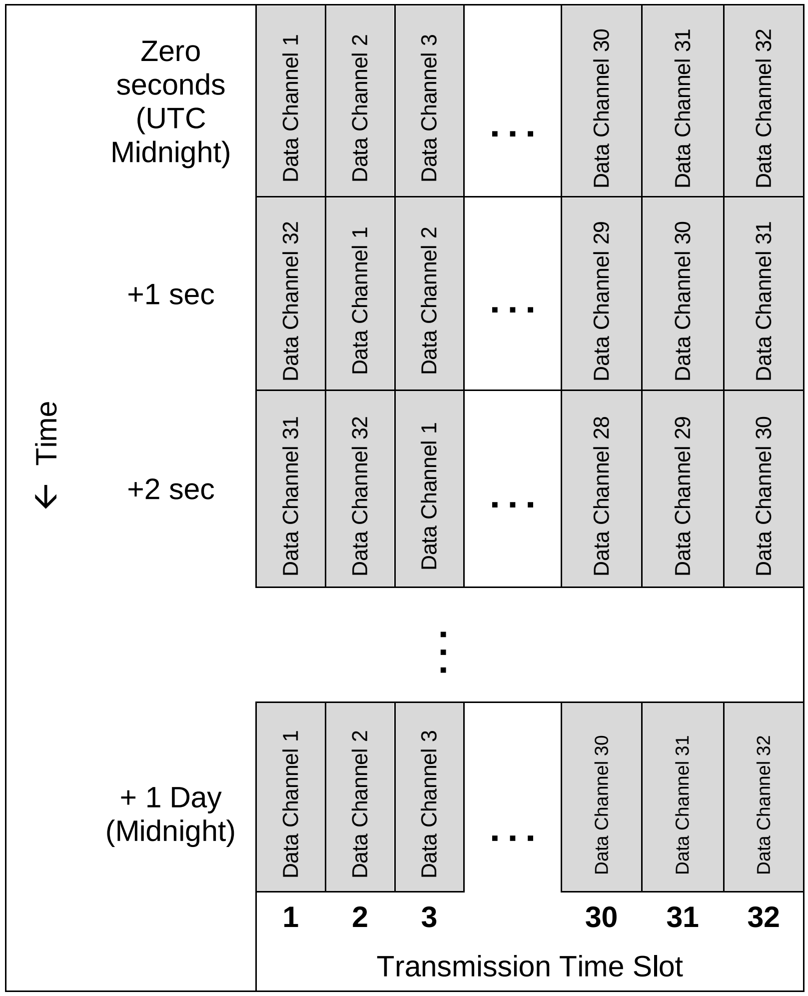
Transmission Time Slot	Starting MSO	Transmission Time Slot	Starting MSO
1	0	**17**	352
2	22	**18**	374
3	44	**19**	396
4	66	**20**	418
5	88	**21**	440
6	110	**22**	462
7	132	**23**	484
8	154	**24**	506
9	176	**25**	528
10	198	**26**	550
11	220	**27**	572
12	242	**28**	594
13	264	**29**	616
14	286	**30**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

Note: *MSOs represent discrete points in time.*

The Transmission Time Slot used for a given data channel increments by 1 Time Slot per second according to the following rule:

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

The Data Channel number and Transmission Time Slot number are equal at midnight UTC time and every 32 seconds thereafter (Figure G-1).



<u>Figure G-1:</u> Relationship of "Data Channel Numbers" to Transmission Time Slot Numbers

<u>Note:</u> *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.*

The 32-slot rotation fits seamlessly into the 86,400-second UTC day. When UTC time is adjusted by the addition or subtraction of a leap second, the UAT channel rotation also must adjust. Table G-2 illustrates a normal day and how adding or subtracting a leap second is accommodated. On a normal day the slot rotation through midnight has no repetitions or skips. On a leap second addition, the channel assignment is not rotated and the data channels transmit in the same time slot as the previous second. In the unlikely event of a negative leap second, the rotation skips by 2 slots. In all cases, Data Channel 1 occupies Transmission Time Slot number 1 at 0:00:00 UTC time.

Table G-2: UAT Channel Rotation Adjustment for Leap Second

UTC Time	Slot Assignment for Data Channel 1		
	Normal	Add Leap Second	Delete Leap Second
23:59:58	31	31	31
23:59:59	32	32	Does Not Exist
23:59:60	Does Not Exist	32	Does Not Exist
00:00:00	1	1	1

Ground Uplink Message transmissions begin at the start of the Transmission Time Slot determined by the next available assigned Data Channel.

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 radio stations with common line of sight to the same aircraft.*

The radio station will transmit a Ground Uplink Message every second for each specified Data Channel. An empty Ground Uplink Message will be sent as a heartbeat, once per second, if no FIS-B product messages are scheduled to be sent from a ground radio station. This heartbeat takes the form of a valid UAT Ground Uplink Header, but with no product data. This heartbeat is sent to inform aircraft of the availability of the FIS-B service. A heartbeat message can be distinguished from other Ground Uplink Messages if the UAT Frame length is encoded as zero (0) for the first UAT Frame. When this is the case, the remaining bytes in the Ground Uplink Message Application Data field need not be processed (they will all be zero).

Note: *Regardless of the availability of application data, the Ground Uplink Message contains location and timing data.*

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APPENDIX H UPLINK OF SPECIAL USE AIRSPACE (PRODUCT #13)

As this MOPS was being developed, the FIS-B ground system included the uplink of an SUA Product (Product ID #13). SUA "reports" (Product ID # 13) are not an official source of SUA status and inconsistencies have been noted with both the published SUA active hours and NOTAMs regarding SUA outside of active hours. To avoid providing potentially misleading or conflicting information this MOPS only addresses specifications for the FAA NOTAM received over the FIS-B UAT data link which may modify published SUA status. Pilots should obtain current SUA status by radio from the published controlling agency.

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APPENDIX I ACCEPTABLE METHOD FOR ALL-AT-ONCE UPDATE OF NEXRAD IMAGE

The CONUS and Regional NEXRAD products uplinked by the FIS-B Ground System require a sequence of ground uplink messages for each "update". However, there is no explicit information in the uplink that conveys that the uplink sequence is complete.

The cockpit display can be updated in a continuous and incremental fashion (as the individual Global Blocks are received) or the display can be updated once when the full update is received. If the latter approach is desired by the avionics manufacturer, this appendix provides guidance for an acceptable way for maintaining the display.

The FIS-B Ground System has established a consistent NEXRAD update cycle. Regional NEXRAD updates are generated on a 5 minute interval on the hour and at: 05, 10…:55 after the hour. CONUS NEXRAD updates are generated on a 15 minute interval. The display update timing guidance provided below is relative to these *NEXRAD Update Epoch* times (i.e., mosaic cutoff time). The FIS-B Ground System will broadcast an original transmission and a retransmission of Regional NEXRAD APDUs within each 5 minute NEXRAD Update Epoch. The original transmission will be completed within two minutes after the NEXRAD Update Epoch. The retransmission will begin around 2.5 minutes after the NEXRAD Update Epoch and will be completed within 4.5 minutes after the NEXRAD Update Epoch. For the CONUS NEXRAD product, the FIS-B Ground System will only broadcast one transmission per NEXRAD Update Epoch. This transmission will be completed within four minutes after the NEXRAD Update Epoch.

I.1 Regional NEXRAD Display Update Guidance

At two minutes after the NEXRAD Update Epoch the display is cleared and updated with the union of all global blocks received from any radio station received in the last two minutes (this is the original transmission sequence).

Note: *This display method will satisfy the requirement of Section 2.2.4.2.1.6 since the FIS-B Ground System will not begin the uplink sequence prior to 20 seconds after the NEXRAD Update Epoch and is required to complete the uplink sequence by 120 seconds after the NEXRAD Update Epoch.*

At 2.5 minutes later the display is filled in with any new global blocks received in the retransmit sequence from any radio station that were missed in the original transmission (this is the retransmission of the same update). This retransmits sequence data could also be posted to the display as it is received.

Notes:

1. *The data age indication would range from 2 to 7 minutes (relative to the APDU timestamp) and always reset to two minutes to give some assurance updates are happening. It would prevent having the time stamp "contaminated" by old data that may be from a radio station now over the horizon behind the aircraft.*
2. *The main disadvantage of this approach is that it could show significant areas of "No Data" for 2 to 3 minutes if fading or coverage problems are encountered during the original transmission since it will not allow combining with prior NEXRAD Update Epoch data to fill in.*
3. *The prior NEXRAD Update Epoch image should be retained if zero new Regional global blocks have been received.*

I.2 CONUS NEXRAD Display Update Guidance

Per this MOPS, the CONUS NEXRAD global block imagery is required to be displayed within 100 seconds of receipt of the APDU containing that global block content. When doing an All-at-Once Update of global blocks the following method is acceptable for updating the CONUS NEXRAD display:

- At 100 seconds after the first CONUS NEXRAD APDU received in a new NEXRAD Update Epoch, the display is cleared and updated with the union of all global blocks received from any radio station in the last 100 seconds. Since the CONUS NEXRAD transmission sequence is not guaranteed to be completed until 240 seconds after the NEXRAD Update Epoch, if any additional CONUS NEXRAD APDUs are received between 100 and 240 seconds after the NEXRAD Update Epoch, these should be added to the display in an incremental fashion.

Notes:

1. *The Regional NEXRAD data are available for display would range from approximately 2 to 19 minutes (relative to the APDU timestamp).*
2. *The prior NEXRAD Update Epoch image should be retained if zero new CONUS global blocks have been received subject to the 75 minute maximum age of Section 2.2.4.2.2.5.*
3. *It is possible that the CONUS NEXRAD product could be received from radio stations with different synchronization of their 15 minute update interval to the 5 minute NEXRAD Update Epoch. In this case, the process would be repeated with the new data (clear the display and update with the union of global blocks received from any radio station in the last 100 seconds.*

APPENDIX J FIELD UPDATEABILITY OF FIS-B AVIONICS

The FIS-B Ground System may need to change over time both to improve spectrum efficiency, as well as to introduce product improvements or new products. It may be impractical for the FAA to support backward compatibility for all products defined in this MOPS as changes are made. For this reason, it is highly recommended that manufacturers provide some mechanism for upgradeability of the FIS-B avionics software in response to any FIS-B Ground System changes that would impact the FIS-B avionics. The FAA will provide advance notice of any FIS-B Ground System changes that affect this MOPS (or any TSO incorporating this MOPS) so updates could be made and the industry notified. Potential future changes to the FIS-B Ground System fall into two broad categories. Those involving adaptations to certain uplink parameters in the FIS-B Ground System and those involving actual enhancements and/or new functionality. Examples of each are given below.

Adaptations:

- Radio Station Look-ahead Ranges: Each radio station provides FIS-B products up to a configurable distance from the radio station. For example, an AIRMET within 375 nmi of a medium tier station will be uplinked from that station. Future changes could be made to these ranges to "tune" the system for optimum spectrum efficiency as experience is gained or new products need to be accommodated. For most products a change in ranges should have no direct impact on the FIS-B software. However, future changes in the NOTAM-TFR, AIRMET and SIGMET ranges in particular could affect the CRL area of completeness description.
- Product Transmission Interval: The transmission interval is defined in Section 1.8. Product latency requirements in particular are derived from the product's transmission interval. A future change to a product's transmission interval may result in an update to a latency requirement in a future version of the MOPS.

Enhancements:

- CRL Update to Include NOTAM-D/FDC: The CRL will be broadcast for AIRMET, SIGMET and NOTAM-TFR products. Future revisions of the MOPS may expand use of the CRL mechanism to include NOTAM-FDC and NOTAM-D.
- UAT Frame to Include Version Number: The UAT Frame currently does not have a mechanism to indicate the version of FIS-B uplink product that corresponds to the encoding of this version of the MOPS. Future revisions of the MOPS may utilize Reserved Bits to indicate a FIS-B product version.
- Potential Product Changes: The FIS-B products defined in this MOPS may change in the way they are issued at the source. In extreme cases, this could affect the way they are defined and uplinked in APPENDIX A. An example would be graphical airport NOTAMs which would require some expansion of the definition of the graphical record format of Section A.3.3.1.3.
- Potential Addition of New Products: The SBS System specifications, as written when the system was originally designed, contained a set of both "Basic" and "Optional" products that were to be implemented over time. As of the writing of this MOP only the Basic set of products have been implemented. The Optional products do not, at this time, have a fixed implementation date nor set of specific products.