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RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #7

Draft 1 of a Proposed Appendix for Ground Processing for TIS-B and FIS-B

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SUMMARY
In response to Action Item 6-6, and to stimulate discussion within WG-3, this Working Paper presents the requirements for the Ground Broadcast Services (GBS) to be implemented at the Memphis International Airport (MEM) for the Cargo Airline Association (CAA)/SafeFlight 21 (SF21) Operational Evaluation 3 (OpEval 3). It is a mix of 1090 MHz and UAT for TIS-B and FIS-B. It includes the draft functional specification for the Broadcast Uplink 1090 MHz Transmitter. Since one of the functions of the GBS is to act as a media translator by reporting target positions for ADS-B equipped aircraft on the opposite link from what the aircraft is equipped (e.g. ADS-B reports from aircraft using a UAT link will be shown on aircraft displays equipped with a 1090 MHz ADS-B link) maybe the mention of UAT should not be separated out in this Appendix? I don't know. Also, since doing TIS-B, doesn't it make sense to also include FIS-B in the appendix?

APPENDIX THAT DESCRIBES GROUND PROCESSING FOR TIS-B AND FIS-B

APPENDIX X

1090 MHZ TIS-B AND FIS-B
GROUND ARCHITECTURE EXAMPLE

X.1 Introduction and Purpose

Appendix D defines an example ground architecture that can support surveillance for ATC using downlink 1090 MHz Extended Squitter ADS-B reports from airborne aircraft and aircraft on the airport surface. This appendix defines an example ground architecture that can support situational awareness for ADS-B equipped airborne aircraft and aircraft on the airport surface using uplink 1090 MHz Extended Squitter TIS-B and FIS-B reports from surveillance (e.g. radar, ADS-B reports, etc.) and other sources available on the ground. The FAA has been investigating ground architectures that would be appropriate for this purpose. The results are summarized in this appendix. As new information arises from programs such as Safe Flight 21 and Alaska Capstone, the FAA and the NAS users will collectively revise the architecture to refine the course of NAS modernization.

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PART I: SYSTEM OVERVIEW

1.0 SCOPE

This document identifies requirements for the Ground Broadcast Services to be Implemented at the Memphis International Airport (MEM) for the Cargo Airline Association (CAA)/SafeFlight 21 (SF21) Operational Evaluation 3 (OpEval 3) of surface surveillance technologies and arrival visual acquisition applications.

2.0 BACKGROUND

Traffic Information System-Broadcast (TIS-B) has been implemented at Dallas/Fort Worth (DFW) airport in a prototype system called the Data Link Manager (DLM) built by Trios Associates. This system was developed for the Federal Aviation Administration (FAA) Runway Incursion Reduction Program (RIRP) and the National Aeronautics and Space Administration (NASA) Runway Incursion Prevention System (RIPS) program. The DLM uplinks targets from the Volpe Fusion Server.

MITRE/CAASD developed the Capstone Communications Control Server (CCCS) implementation for the Capstone program in Alaska. The CCCS includes TIS-B and Flight Information System-Broadcast (FIS-B) uplinks over a Universal Access Transceiver (UAT) link.

The MITRE/CAASD CCCS code and the Trios DLM system will be used in the development of the Ground Broadcast Server (GBS) for MEM.

3.0 MEMPHIS ARCHITECTURE

The overall ground architecture for OpEval 3 at MEM is shown in Figure 1.

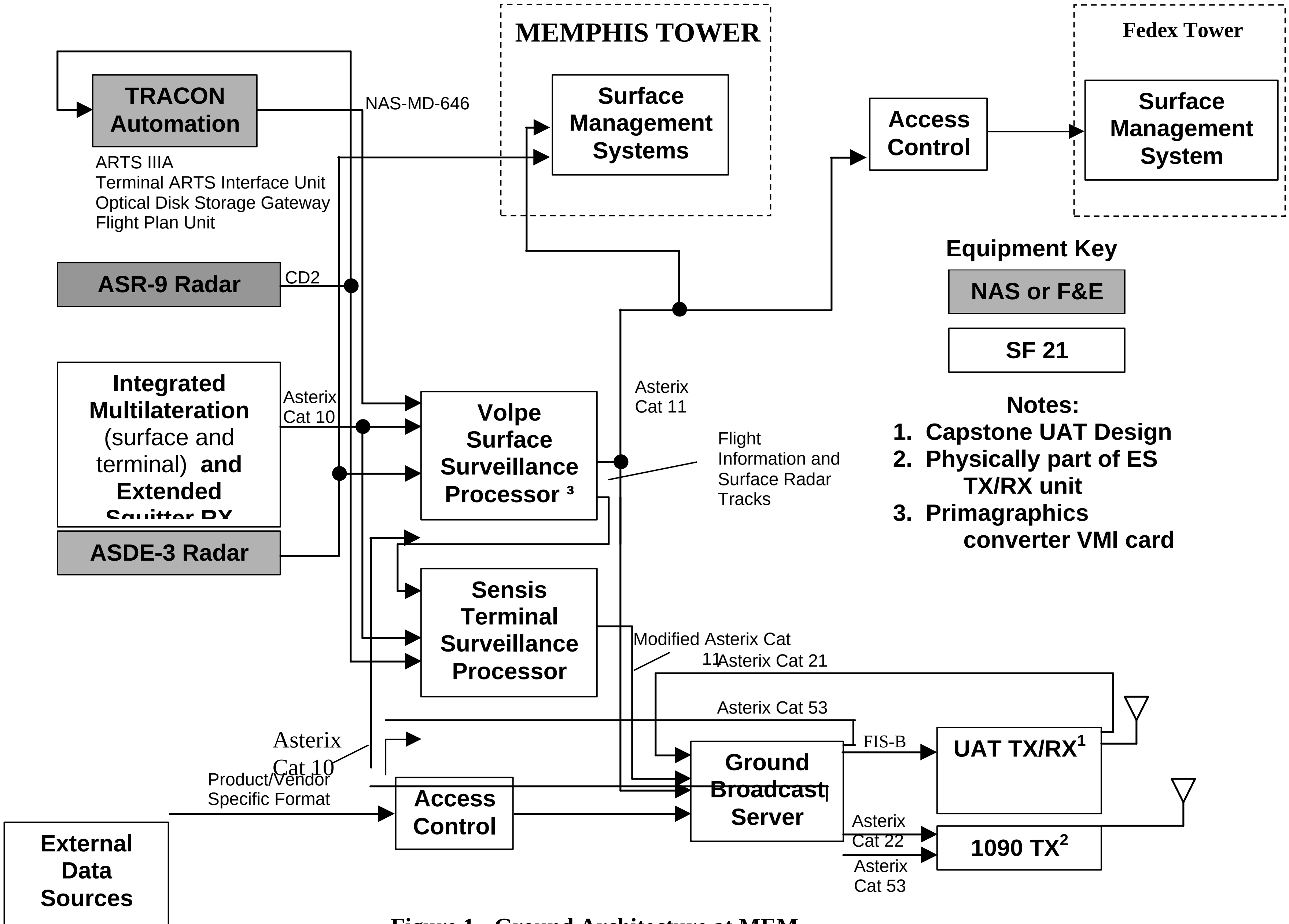

Figure 1 - Ground Architecture at MEM

PART II: GROUND BROADCAST SERVER FUNCTIONAL REQUIREMENTS

1.0 PROPOSE

The main purpose of the GBS is to act as a TIS-B/FIS-B uplink to aircraft equipped with 1090 and UAT avionics that can receive TIS-B and FIS-B messages. The TIS-B messages should look like Automatic Dependent Surveillance (ADS-B) messages to equipped aircraft. The GBS will act as a protocol translator for converting the various ground surveillance formats/protocols such as ASTERIX Category 11, Category 21, etc. The GBS TIS-B function will act as a gap-filler for showing non-ADS-B equipped targets to ADS-B equipped aircraft. The GBS will act as a media translator by reporting target positions for ADS-B equipped aircraft on the opposite link from what the aircraft is equipped, e.g. ADS-B reports from aircraft using a UAT link will be shown on aircraft displays equipped with a 1090 ADS-B link.

2.0 GENERAL REQUIREMENTS

The GBS has Client Server Architecture. Every interface is a client process. Clients can be initiated and terminated without have to reboot the system. The system has a robust design in order to maintain high reliability.

3.0 INTERFACES

The architecture of the interface clients follows the basic Open System Interconnection (OSI) Reference Model. However, Internet protocols are used instead of International Organization for Standardization (ISO) protocols. The structure and choices for each layer are shown in Table 1.

Table 1 - OSI layers and the choices of protocols for each layer

OSI Layer	Protocol(s)
Application	ADS-B, TIS-B, FIS-B
Presentation	ASTERIX Category 10, 11, 21, 22, 53
Session	TCP, UDP
Transport	TCP, UDP
Network	IP
Data link	CSMA-CD
Physical	Ethernet

3.1 Inputs

Inputs are summarized in Table 2.

3.1.1 SSDS

The GBS shall accept target data from the Surface Surveillance Data Server (SSDS) (developed by the Volpe Center). The input format shall be ASTERIX Category 11. The transport and network layers shall be Transport Control Protocol (TCP)/Internet Protocol (IP). The link and physical layers shall be Ethernet.

3.1.2 Terminal Fusion Server

The GBS shall accept a modified ASTERIX Category 11 from the Terminal Fusion Server (developed by the Sensis Corporation). The details of the interface will be determined during discussion between Trios Associates and the Sensis Corporation. The transport and network layers shall be User Datagram Protocol (UDP)/IP. The link and physical layers shall be Ethernet.

3.1.3 FIS-B Source Data

The GBS shall accept FIS-B source data from external sources. A breakout of source of data by type is given in Table 2. The input data format varies by type. The specifies of these interfaces are TBD.

Table 2 – Overview of FIS-B Input Data

Product	Text	Graphic	Map Overlay	Source	Status
Reflectivity NEXRAD		X (regional)		WSI/MITRE	Already Specified
METAR	X			WSI/MITRE	Already Specified
TWIP	X			TBD	New Development
D-ATIS	X		X (subset)	TBD	New Development
Airport NOTAMs	X		X	Test System (Trios)	New Development

3.1.4 ADS-B (UAT)

The GBS shall accept ADS-B target reports from multiple UPSAT Ground Broadcast Transceivers (GBTs) in the ASTERIX Category 21 format. The transport and network layers shall be UDP/IP. The link and physical layers shall be Ethernet.

3.1.5 ADS-B (1090 MHz)

The GBS shall accept 1090ADS-B target reports from multiple Sensis GBTs through Sensis Fusion Server in the ASTERIX Category 11 format. The transport and networks layers shall be UDP/IP. The link and physical layers shall be Ethernet.

3.1.6 NTP

The GBS shall be configurable as either a Network Transfer Protocol (NTP) client or server. If configured as a client, the GBS NTP client shall accept timing information from an NTP server and adjust the GBS system clock accordingly. If configured as an NTP server, the GBS shall have real-time access to either Global Positioning System (GPS) or an atomic clock source. The NTP server shall deliver time to other systems.

3.1.7 Status

The GBS shall accept status information from the GBTs.

3.1.8 Input

A summary of inputs and formatting is presented in Table 3.

Table 3: Summary of Inputs

Device/Function	Presentation Layer	Transport Layer	Data Link/Physical Layer
Volpe Surface Surveillance Server	Asterix Category 11	TCP	Ethernet
Sensis Terminal Surveillance Server	Asterix Category 11	TCP	Ethernet
GBT (UAT)	Asterix Category 21	UDP	Ethernet
NTP Server	N/A		Ethernet
GBT status (for buffering)	TBD	UDP	Ethernet
METAR/Reflectivity (NEXRAD)	TBD	TBD	TBD
TWIP/D-ATIS	TBD	TBD	TBD
Airport NOTAMS	TBD	TBD	RS-232

3.2 Outputs

3.2.1 SSDS

The GBS shall provide ADS-B target reports to the SSDS in the ASTERIX Category 10 format. The transport and network layers shall be UDP/IP. The link and physical layers shall be Ethernet.

3.2.2 Terminal Surveillance Fusion Server

The GBS shall provide ADS-B target reports to the Terminal Fusion Server in the ASTERIX Category 53 format. The transport and network layers shall be UDP/IP. The link and physical layers shall be Ethernet.

3.2.3 TIS-B Over UPSAT GBTs

The GBS shall provide TIS-B reports to multiple UPSAT GBTs. The data shall be in the ASTERIX Category 22 format. The transport and network layerss shall be UDP/IP. The link and physical layers shall be Ethernet. The update rate shall be 1Hz.

3.2.4 FIS-B Over UPSAT GBTs

The GBS shall provide FIS-B data to multiple GBTs in the Application Protocol Data unit (APDU) format. The data shall be packetized to fit within the UAT FIS-B frames. The transport and network layers shall be UDP/IP. The link and physical layers shall be Ethernet. See reference [14] for details.

3.2.5 TIS-B (1090 MHz)

The GBS shall provide TIS-B reports to multiple Sensis GBTs. The data shall be in the ASTERIX Category 53 format. The transport and network layers shall be UDP/IP. The link and physical layers shall be Ethernet. The update rate shall be 1Hz. See Appendix A for details.

3.2.6 FIS-B (1090 MHz)

The GBS shall provide FIS-B data to multiple GBTs in the APDU format. The data shall be packetized to fit within the 1090 FIS-B frames. The transport and network layers shall be UDP/IP. The link and physical layers shall be Ethernet. See Appendix A and reference [15].

3.2.7 Outputs

A summary of outputs and formatting is presented in Table 4.

Table 4 - Summary of Outputs

Device	Presentation Layer	Transport Layer	Data Link/Physical Layer
Volpe Surface Surveillance Server	Asterix Category 10	UDP	Ethernet
Sensis Terminal Surveillance Server	Asterix Category 53	UDP	Ethernet
UAT GBT (FIS-B)	See reference [14]	See reference [14]	Ethernet
UAT GBT (TIS-B)	See reference [15]	See reference [15]	Ethernet
1090 GBT FIS-B	TBD	TBD	TBD
1090 GBT TIS-B	Asterix Category 53	TBD	TBD

4.0 PROCESSING FUNCTIONAL REQUIREMENTS

4.1 Report Processing

4.1.1 ADS-B Reports

The GBS shall accept ADS-B reports from UAT ground stations and provide them to the SSDS. The GBT Ground Side Interface Description shall define the GBT interface. See reference [17] for UAT interface Asterix Cat 21 (Capstone).

The GBS shall receive position and identification information from UAT ground stations over an Ethernet interface. The protocols for this interface will be ADS-B/Asterix Cat 21/UDP/IP/Ethernet.

4.1.1.1.

The GBS shall encode the received UAT ASD-B reports in ASTERIX category 10 format to send to the Volpe Fusion Server and Asterix Cat 53 to send to the Sensis Fusion Server.

4.1.1.2.

The GBS shall provide the SSDS with all ADS-B reports received from the UAT GBTs over an Ethernet interface. The interface shall be defined by the DLM to Runway Incursion Reduction Program (RIRP) Local Area Network (LAN) Interface Control Document (ICD). See reference [?].

4.1.2 Target Reports

The GBS shall accept target reports from the SSDS or Sensis Terminal Fusion Server and provide them to other systems. The GBS shall accept and process up to 255 target reports per second. The GBS shall be able to uplink up to 100 targets per second over UAT and up to 100 targets per second over 1090 MHz.

4.1.2.1.

The GBS shall receive target reports from the SSDS Over a network interface. The interface shall be defined by the DLM to RIRP LAN ICD.

4.1.2.2.

The GBS shall decode target reports from the ASTERIX category 11 format.

4.1.2.3.

The GBS shall encode TIS-B reports in the ASTERIX Category 22 format for the UAT GBTs. The GBT Ground Side Interface Description shall define the interface. The GBS shall encode TIS-B reports in the Asterix Cat 53 format for the 1090 UAT GBTs. See reference [16].

4.1.2.4.

The GBS shall disseminate TIS-B reports to multiple ground stations over an Ethernet interface. The protocol for this interface will depend on ground station type.

4.1.3 ADS-B Rebroadcast

ADS-B reports received in the GBS from the UAT GBTs shall be routed to the 1090 transmitter. The associated TIS-B report shall be filtered and kept from being sent to the 1090 transmitter. 1090 ADS-B reports will be received in the GBS from the Sensis Fusion Server. These reports shall be sent to the UAT GBTs for uplink. The associated TIS-B reports shall be suppressed. See Figures 2.a and 2.b below.

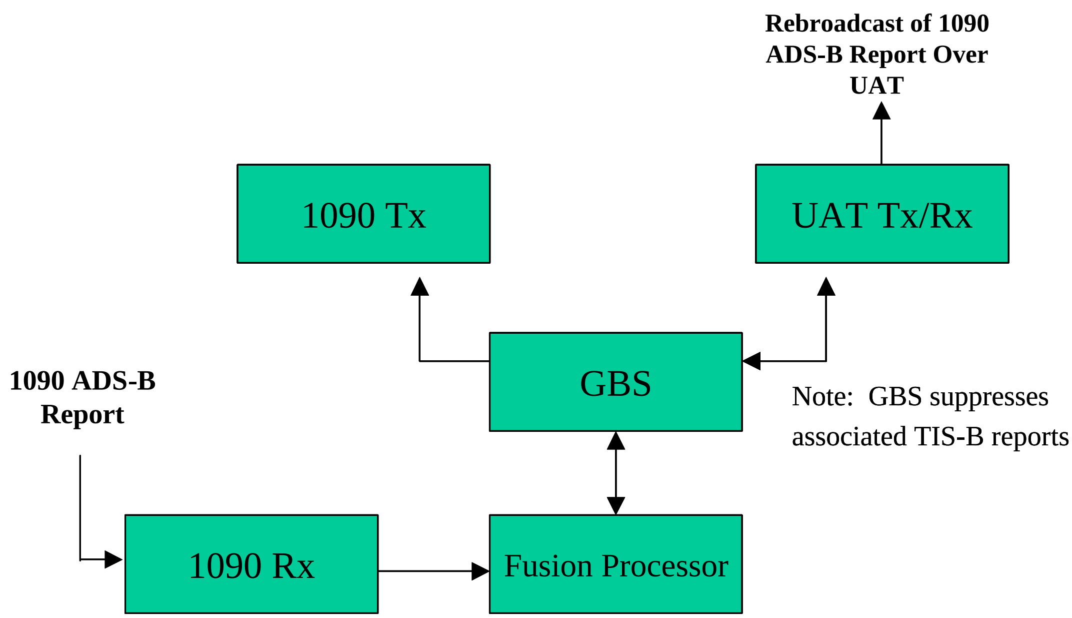

Figure 2.a-ADS-B Report Input 1090/ Rebroadcast UAT

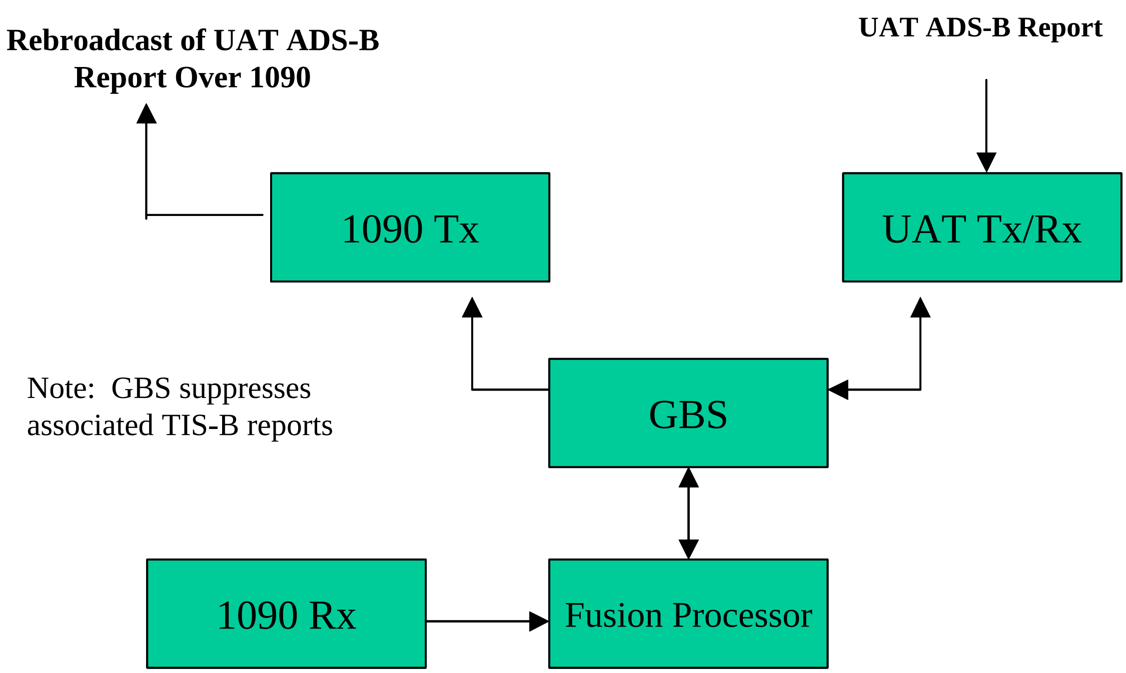

Figure 2.b-ADS-B Report Input UAT/Rebroadcast 1090

4.2 Service Management

4.2.1 Service Volumes

The GBS shall process and distribute TIS-B information for one service volume, which is a cylinder of radius 60 Nautical Mile (NMi) with the center at MEM and altitude from 0 AGL to 18,000 ft MSL. The GBS shall process and distribute FIS-B information for one service volume, which is a circle of radius 100 NMi with the center at MEM.

4.2.2 Ground Sites

Each GBS shall support one UAT and one 1090 ground site with multiple GBTs.

4.2.3 Event Driven Reporting

The GBS shall report data as it becomes available within a given update cycle. If multiple reports on the same target are received during a single update cycle, then the most recent report shall be broadcast and the others shall be discarded.

4.3 Prioritization

The GBS shall prioritize reports sent to the GBTs based on message type. The higher priority messages shall be sent before the lower priority messages. The following order of importance shall be followed from most important to least:

- ADS-B messages
- TIS-B messages
- FIS-B messages

Initial priority is based on report type. Lower priority reports shall increase in priority over time to ensure delivery requirements are met. Messages with similar priorities, but different lengths, may be juggled to optimize data packet size.

4.4 Aircraft ID suppression (anonymous)

The GBS shall be capable of removing the beacon code, for aircraft address, and/or flight ID.

4.5 Report Filtering

The GBS shall be capable of filtering TIS-B reports in the following manner:

- Radius from a circular center
- Altitude floor and/or ceiling
- Polyhedron

4.5.2 Geographic (SV)

The GBS shall not provide for geographic filtering of TIS-B reports based on a defined service volume.

4.5.3 Content

4.5.3.1. Mode A Code

The GBS shall remove specific identifying aircraft data in accordance with FAA Order 1200.22B.

4.6 Multiple GBTs

The GBS shall route reports to multiple GBTs regardless of site location or radio type.

4.7 Conversion

4.7.1 Format

The GBS shall format incoming FIS-B content into the APDU and product format as defined [14,15].

4.7.2 Protocol

4.7.2.1. ASTERIX Cat 11 to 22

The GBS shall provide protocol conversion from ASTERIX Category 11 inputs to ASTERIX Category 22 outputs.

4.7.2.2. ASTERIX Cat 21 to 10

The GBS shall provide protocol conversion from ASTERIX Category 21 inputs to ASTERIX Category 10 outputs.

4.7.3 Weather data to FIS-B

External sources shall provide weather data over a to be determined (TBD) interface which shall be processed and output as FIS-B messages.

4.8 Data Recording/Archiving

The GBS shall provide data recording capabilities to facilitate troubleshooting, playback/replay, and data analysis. The GBS shall archive all data that is passed into and out of the GBS from any external system.

4.8.1

The GBS shall provide a means to record, at the application level, all data items received from the SSDS or Sensis Terminal Fusion Server with Universal Coordinated Time (UTC) time stamps.

4.8.2

The GBS shall provide a means to record, at the application level, all data items from the GBTs with UTC time stamps.

4.8.3

The GBS shall provide a means to record, at the application level, all data items sent to the SSDS or Sensis Terminal Fusion Server with UTC time stamps.

4.8.4

The GBS shall provide a means to record, at the application level, all data items sent to the GBTs with UTC time stamps.

4.9 Synchronize with NTP server via Ethernet connection

The GBS shall synchronize its internal time clock with an NTP server via the interface described above.

5.0 DISPLAY

The main function of the display capability is to use for debugging purposes. The display shall present in real-time all data items sent to the GBTs. The display shall also support playback of recorded data items.

6.0 NTP SERVER SYNCHRONIZATION

The GBS shall be synchronized with other systems to ensure consistent time stamping in all systems.

6.1

The GBS shall periodically synchronize with a NTP server via an Ethernet interface.

7.0 PERFORMANCE MONITORING

The GBS shall monitor interfaces to assess load.

7.1

The GBS shall provide a means to monitor loading on all interfaces in near real-time.

8.0 CONFIGURATION

The GBS shall be configurable to facilitate different modes of testing.

8.1

The GBS shall provide a means to save standard configurations and easily recall them for later use.

9.0 INFORMATION SECURITY

The GBS shall prevent outside agents from gaining access to data concerning Department of Defense (DoD), drug enforcement, or other sensitive flight operations per FAA Order 1200.22B. Tracks containing sensitive and/or controlled national defense or law enforcement data must have identifiers removed or replaced with 1200 equivalent codes before sending to the GBTs.

PART III: END-TO-END PERFORMANCE REQUIREMENTS

The maximum GBS process latency shall be TBD.

PART IV: APPENDIX

APPENDIX A - DRAFT FUNCTIONAL SPECIFICATION FOR BROADCAST UPLINK 1090 MHZ TRANSMITTER, JONATHAN BERNAYS, MIT/LL, VERSION 2.0 FEBRUARY 5, 2001

1.1 Introduction

The proposed Operational/Evaluation 3 at Memphis International Airport is currently defined to include a demonstration of Traffic Information Service Broadcast (TIS-B). TIS-B will use data from the surveillance sources available at Memphis to assemble a list of TIS-B messages. Position reports from aircraft from which ADS-B messages have been received will be suppressed and the remaining uplink list will be provided to the TIS-B transmission stations. Both UAT and Extended Squitter (1090 MHz) are expected to be demonstrated as part of the MEM TIS-B implementation. This memorandum defines the functional specification for the MEM Extended Squitter uplink transmission station.

The 1090 MHz Transmitter is expected to receive baseband data from a surveillance source and supply an r.f. signal to an omnidirectional DME antenna. The output power, modulation characteristics, and spectral shape should mimic a Mode S transponder. No processing or message formatting is expected to take place within the 1090 MHz Transmitter; all of the desired bits within each Extended Squitter are supplied in the input baseband message.

FIS-B is also expected to play a part in the Memphis Op/Eval 3. Although definition of the FIS-B applications are currently lacking, the minimum specification to distinguish FIS-B squitters from TIS-B or ADS-B messaging is included in this document.

1.2 TIS-B Message Content

For the Extended Squitter TIS-B implementation, the position and velocity of all aircraft shall be transmitted using an Extended Squitter message format that is currently unassigned. Field definitions for assigned Extended Squitter ADS-B messages are shown below in Figure 1.

1.2.1 TIS-B Coarse Airborne Position/Velocity Message Format

In support of applications for which normal radar-like surveillance is adequate (e.g., enhanced visual acquisition) a TIS-B Coarse Airborne message format will be used for encoding the position and velocity of airborne targets in the uplink list. The TIS-B Coarse Airborne message shall have a DF=18 with a CF field of 2. The ME field within the DF=18 TIS-B message is defined in Figure 2.

1.2.2 TIS-B Surface Position Message Format

TIS-B targets that are on the ground are included in the uplink list with a DF=18 Mode S message (CF = 2), and the ME field as is used for DF=17 or 18 ADS-B messaging. This ME field definition is illustrated in Figure 3. The TIS-B Surface Position Message ME field shall have a type code of 19 (10011).

1.2.3 TIS-B Fine Airborne Velocity Message Format

Support of this message type shall be optional. If implemented, the formats shall be supported as defined in the FAA TESIS PD.

1.2.4 TIS-B Fine Airborne Position Message Format

Support of this message type shall be optional. If implemented, the formats shall be supported as defined in the FAA TESIS PD.

ADS-B MESSAGE BASELINE FORMAT STRUCTURES					
BIT #	1 --- 5	6 - 8	9 --------------- 32	33 -- 88	89 ----------- 112
DF=17 FIELD NAME	DF [5]	CA [3]	AA [24]	ME [56]	PI [24]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB
DF=18 FIELD NAME	DF [5]	CF [3]	AA [24]	ME [56]	PI [24]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB
DF=19 FIELD NAME	DF [5]	AF[4] [3]	AA [24]	ME [56]	PI [24]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB
DF=19 FIELD NAME	DF [5]	AF[4] [3]	9 --------------- RESERVED FOR MILITARY APPLICATIONS----------------- 112 [104]		
	MSB LSB	MSB LSB	MSB LSB		

Notes:

1. *"[#]" provided in the Field indicates the number of bits in the field.*
2. *"CA" field shown above is used in DF=17 messages, while "CF" is used for DF=18 messages.*
3. *DF=19 mesages are intended for Military Application systems only.*
4. *For DF=19, if the AF field is equal to 000 then bits 9-32 shall be used for the AA field, bits 33-88 shall be used for the ME field, and bits 89-112 shall be used for the PI field. If the AF field is equal to 001 - 111 then bits 9 - 112 shall be used for the "RESERVED FOR MILITARY APPLICATIONS" field (Note: this format is reserved for military use only.*

Figure 1. ADS-B Formats for Extended Squitter Messages

	Mode S = 0, ATCBS = 1
2	No Emergency=0, Emergency=1
3 4 5 6	 **SITE CODE**
7	RESERVED
8	Direction Bit For E-W Velocity (0=East, 1=West)
9 10 11 12 13	 EAST-WEST VELEOCITY (5 bits) LSB
14	Direction Bit For N-S Velocity (0=North 1=South)
15 16 17 18 19	 NORTH-SOUTH VELEOCITY (5 bits) LSB
20 21 22 23 24 25 26 27 28 29 30 31	 ALTITUDE Specified by the Format Type Code (1) the altitude code (AC) as specified in section 2.2.13.1.2 of DO-181B but with the M-bit removed (Ref ARINC 429 Label 203), or (2) GNSS height (HAE) (Ref. ARINC 429 Label 370)
32	CPR FORMAT (F) (See A.4.2.1)
33 34 35 36 37 38 39 40 41 42 43 44	MSB ENCODED LATITUDE (CPR Airborne Format See TBD) LSB (~160m)
45 46 47 48 49 50 51 52 53 54 55 56	MSB ENCODED LONGITUDE (CPR Airborne Format See TBD) LSB (~160m)

Velocity coding
LSB=32 kt

Value	Velocity
0	no .velocity info
1	0 kts
2	32 kt
3	64 kt
.	
.	
30	928 kt
31	>944 kt

Figure 2. TIS-B Coarse Airborne ME message definition

SURFACE POSITION MESSAGE "ME" FIELD								
MSG BIT #	33--37	38 --------- 44	45	46 --------- 52	53	54	55 --------- 71	72 --------- 88
"ME" BIT #	1 --- 5	6 ---------- 12	13	14 --------- 20	21	22	23 --------- 39	40 --------- 56
FIELD NAME	TYPE [5]	MOVEMENT [7]	GROUND TRACK STATUS [1]	GROUND TRACK [7]	TIME (T) [1]	CPR FORMAT (F) [1]	ENCODED LATITUDE [17]	ENCODED LONGITUDE [17]
	MSB LSB	MSB LSB		MSB LSB			MSB LSB	MSB LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 3. "ME" Field Definition for DF=18 Surface Position TIS-B Message

1.3 FIS-B Message Format

FIS-B squitters shall be formatted as DF=18 with a CF=3. Currently the ME field is undefined, as is the application layer encoding for the FIS-B information. The Broadcast 1090 MHz transmitter shall be implemented such that addition of FIS-B information will require only a software upgrade in the formating software that assembles broadcast squitter messages.

1.4 Data Interface to Broadcast 1090 MHz Transmitter

The 1090 MHz Transmitter shall be configured to receive data from an external source. The external source shall provide the data content and time of transmission for each Extended Squitter. Data content for each desired squitter shall be supplied as the full 112 bits (per Figure 1) for the desired Extended Squitter. Time of transmission may be indicated implicitly (transmission of Extended Squitter within 1 millisecond of presentation of data at interface) or explicitly (specification of desired time of transmission by UTC time with 1 millisecond resolution).

Given the maximum specified transmission rate (Section 6), the data interface should support data communication rates of at least 19.2kbits/second (assuming 112 bits of Extended Squitter content, 20 bits of time, and 8 bits of overhead, at a 100 Hz rate, and 70% channel utilization). If necessary this could be reduced to fit within a 9.6kbs data rate using more efficient encoding of the baseband data.

1.5 Transmission Power and Frequency

The 1090 MHz Transmitter shall transmit with between 150 and 250 Watts at the transmitter terminals into a load whose VSWR at L-band is less than 2.0. The transmission power shall droop less than 1 dB from beginning to end of the transmission of any Extended Squitter. The frequency of the carrier frequency shall be 1090 MHz +/- 1 MHz. The spectral characteristics of the transmitted signal shall match those specified for a high altitude, Mode S transponder in RTCA/DO-181a (Mode S Transponder MOPS).

1.6 Antenna Characteristics

The 1090 MHz Transmitter shall be connected to an L-band antenna with a VSWR of less than 2.0 (typically an omnidirectional DME antenna). Cable loss of 3 dB or less is assumed for the connection between the TIS-B transmitter and the antenna.

1.7 Transmission rate

The 1090 MHz Transmitter shall transmit up to 100 Extended Squitters per second, evenly spaced at 10 millisecond intervals. Safeguards shall be provided to assure that a minimum interval of 8 milliseconds is maintained between consecutive transmissions of Extended Squitters (to protect against a "stuck mike").