D.1 Introduction and Purpose

This appendix defines examples of ground architectures that can support (1) surveillance for ATC using extended squitter ADS-B reports and (2) Traffic Information Service Broadcast (TIS-B) on 1090 MHz.

ATC Surveillance

Although the first operational uses of extended squitter are expected to be in air-to-air applications, the FAA is also interested in extended squitter as a means of surveillance of aircraft via ground stations. Surveillance of both airborne aircraft and aircraft on the airport surface are of interest. The FAA has been investigating ground architectures that would be appropriate for this purpose. The results are summarized in this appendix. An example 1090 ground architecture for high density airspace in a current radar environment is 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.

Note that the Traffic Information Service (TIS) capability is not included in the extended squitter ground station, since this service will be provided by conventional secondary radars with Mode S capability.

Traffic Information Service Broadcast

Traffic Information Service Broadcast (TIS-B) is a ground-to-aircraft broadcast service that provides "ADS-B like" surveillance transmissions for aircraft that are not equipped for ADS-B. TIS-B makes non-equipped aircraft visible to an aircraft with an ADS-B receiver. The surveillance source for this ground-to-aircraft broadcast can be a rotating beam terminal or enroute radar. Another possible surveillance source is an approach or surface multilateration system. Such multilateration systems provide a higher update rate and better surveillance accuracy than terminal or enroute radars.

TIS-B is considered to be an integral part of an ADS-B system since it is an important element in transition. If extended squitter surveillance is in use in a region of airspace, TIS-B can make all aircraft visible to a user with a 1090 MHz receiver even though not all aircraft are equipped for extended squitter.

D.2 ATC Surveillance

D.2.1 Avionics Equipage

In order to achieve a surveillance system that is based on extended squitter, it is necessary to define a transition strategy for integrating extended squitter into the existing system that will accommodate the mixed environment that will exist for many years during the transition from SSR to a possible full use of extended squitter. For this reason, the following avionics equipment must be accommodated:

1. Mode A/C transponder

2. Mode S transponder without extended squitter

D.3 Traffic Information Service Broadcast (TIS-B)

D.3.1 Overview

The formats and protocols required for avionics implementing TIS-B on 1090 MHZ are specified the body of this MOPS and in Appendix A. Ground processing for TIS-B on 1090 MHz must implement these same formats and compatible algorithms to interoperate with airborne equipment.

Specific requirements for the ground processing component of TIS-B are contained in the TIS-B MASPS. The TIS-B MASPS contain requirements for TIS-B in a link independent manner. The purpose of this section of Appendix D is to provide additional guidance on implementing ground processing for TIS-B service on 1090 MHz.

D.3.2 Ground Determination of Extended Squitter Equipage

The normal mode of TIS-B operation on 1090 MHz. is to provide this service only for aircraft that are not equipped with extended squitter. It is therefore necessary for TIS-B ground processing to determine which aircraft are extended squitter equipped.

Mode S transponders are equipped to provide a data link capability report in response to an interrogation from a Mode S ground radar. This data link report contains a bit flag to indicate if the transponder is equipped for extended squitter. However, this bit flag is not a reliable indicator of actual extended squitter operation. The bit flag is a static indication of the capability of the transponder support for extended squitter formats and protocols. It would not reflect the loss of extended quitter operation due to a malfunction of the transponder or to the navigation input.

The recommended technique for determining active extended squitter operation is to monitor 1090 MHz for extended squitter reception using in an omni directional fashion. The most convenient way to implement this monitoring is to equip the 1090 MHz TIS-B ground stations to receive as well as transmit. This approach will also provide extended squitter determination for aircraft equipped with non-transponder devices.

D.3.3 TIS-B Antenna Siting to Enhance Equipage Determination

The most reliable configuration for the determination of active extended squitter operation is achieved if a ground radar (providing the basis for TIS-B service) and the TIS-B receiver-transmitter station cover the same volume of airspace. This avoids the situation where an extended squitter equipped aircraft is visible to the ground radar but not to the TIS-B station. In this case, the aircraft would not be declared to be extended squitter equipped and this would result in unnecessary TIS-B transmissions.

The way to achieve the same coverage for the ground radar and the TIS-B station is to locate the TIS-B antenna near and at about the same elevation as the ground radar antenna.

D.3.4 Ground Radar Data Considerations

Wherever possible, the ground radar data used as the basis for TIS-B service should be based upon Mode S surveillance. The availability of ground surveillance data identified with the aircraft 24-bit address for Mode S equipped aircraft significantly enhances the correlation of ground surveillance data with received extended squitters. If an ATCRBS radar is used as the basis for TIS-B service, correlation between the ground radar data and the received extended squitters must be based only on position and altitude since Mode A code is not provided by any of the ADS-B systems

D.3.5 TIS-B Format Selection

Two types of formats are defined for TIS-B on 1090 MHz:

1. Fine Formats

The fine TIS-B formats are similar to those used for Extended Squitter ADS-B operation. These formats are intended for use with surveillance data that is the same quality as that used for ADS-B. Examples of such data quality are surveillance inputs obtained by monitoring other ADS-B links, or a ground-based multilateration system.

The following fine TIS-B format types are defined:

Airborne Position
Airborne Velocity
Surface Position
Identification and Category

2. Coarse Format

The coarse format combines both position and velocity data into a single message. It is intended for use with surveillance data sources that are not accurate enough to warrant the use of the fine formats. The principal example is surveillance data derived from a scanning beam ground radar.

D.3.6 Ground Architecture

D.3.6.1 Overview

The TIS-B service area could be composed of a number of hexagonal cells. Each cell defines the area of service for the TIS-B transmitter located in the center of that cell. Overlap (or buffer zone) at cell boundaries only needs to be large enough to ensure continuity of service across the cell boundary. A minimum service overlap between adjacent cells is desirable in order to eliminate unnecessary duplicate TIS-B transmissions. Since TIS-B aircraft position reports are expected to be reasonably accurate in order to provide useful service, a buffer zone of 2 NM is assumed at cell boundaries.

A description of a typical TIS-B cell is presented in Figure 1.

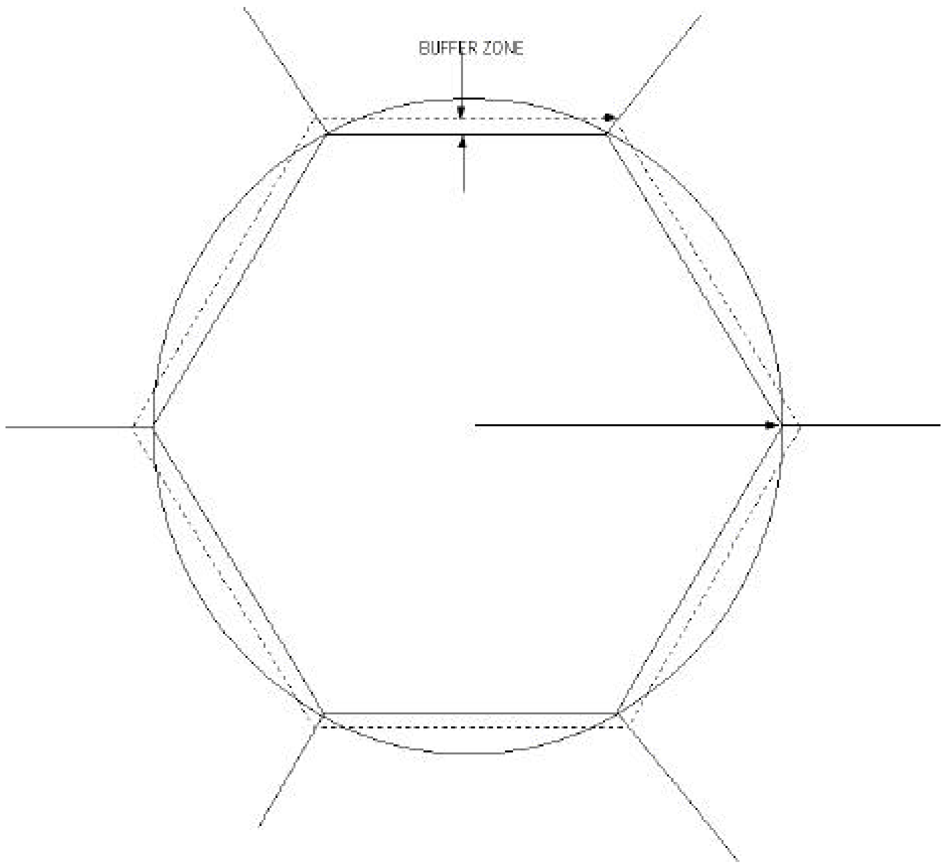

Figure 1. TIS-B Cell Characteristics

D.3.6.2 Cell Size Considerations

The cell size has an important role in determining TIS-B operating characteristics. A Smaller cell size is desirable for the following reasons:

a. A reduced maximum transmission range increases the probability of squitter reception.

b. A smaller cell contains fewer aircraft. This lowers the cell transmission rate and thus reduces the hot spot effect.

c. Due to earth curvature effects, a shorter operating range results in better low altitude coverage.

D.3.7 TIS-B Summary

TBD