ASSAP Test Scenario Generation

1 Purpose

Need brief discussion of Mitre model here – (Chris, Robert)

This appendix describes the assumptions and techniques used to generate scenarios to feed into the model described above, so that realistic, achievable performance levels may be determined for ASSAP processing metrics. These levels of performance feed into the development of requirements for ASSAP processing (Section XX).

Use of radar tracks from Atlanta to generate all data (ownship, ADS-B, ADS-R, TIS-B, TCAS) and discussions of scenarios – (Chris, Jeff)

2 Assumptions

This section describes the assumptions that were made In order to generate the data inputs for the model. The ASSAP function has to be able to receive and process data from a number of sources:

- Direct ADS-B message transmissions from other aircraft
- TIS-B messages transmitted from the ground, based on radar and other sensor information
- ADS-R messages transmitted from the ground, based on ADS-B receptions on the other ADS-B data link
- TCAS messages transmitted from other nearby aircraft

Section 2.1 discusses assumptions governing the ADS-B avionics; section 2.2 deals with the TIS-B process assumptions; section 2.3 handles ADS-R; and section 2.4 describes the TCAS model used.

2.1 ADS-B Avionics

The ADS-B avionics are assumed to be certified to perform ADS-B functions by either TSO-C154A (in conformance with DO-282A) or TSO-C166A (in conformance with DO-260A), to correspond with the proposed rule.

Note: *For the first edition of this standard, it is assumed that there will initially be equipment that is not compliant with the proposed rule. This is expected to be 1090 ES equipment that conforms to DO-260, so separate data scenarios have been generated to simulate this type of equipment.* ***Is this correct?***

In the ADS-B link MOPS, the ADS-B avionics are categorized by class, which indicates different transmit/receive capabilities according to the type of aircraft (e.g., General Aviation or Air Transport). In order to avoid multiple repetitive data sets to accommodate all possible combinations of different types of ADS-B equipage, the data scenarios are characterized by Message Success Rate (MSR). This allows the scenarios to be equipage-independent (e.g., no need to use different transmit powers or receiver sensitivities), as well as providing a way to perform sensitivity analysis on the algorithm used in the model.

It is also assumed that the avionics are equipped with GPS systems that provide updates at a 1 Hz rate.

Section 2.1.1 describes the assumptions governing on-board latency for the ADS-B system components, while section 2.1.2 discusses accuracy and integrity of the information transmitted by the system.

2.1.1 Latency

- 500 ms uncompensated check fPR (sep stds assumption)
- Updating of registers
- extrapolating

2.1.2 Accuracy and Integrity

- Minimum requirements for applications aircraft transmit minimum values
- Talk about sources of errors, including altitude error model and encoding to 25 or 100 ft
- NACp = 5, NIC=4, NACv = 1 (maybe scenario section should define accuracy and integrity for each scenario and aircraft)
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2.2 TIS-B

The ADS-B ground service provider receives radar (and other sensor) data as well as the ADS-B transmissions of equipped aircraft, and then must determine which aircraft are not ADS-B equipped, so that TIS-B messages can be uplinked to provide information to equipped aircraft about these unequipped aircraft.

Section 2.2.1 describes the assumptions about the radar providing the information on the unequipped aircraft and the characteristics of the position information provided. Section 2.2.2 discusses the assumptions regarding the TIS-B processing that ingests the radar information and prepares the ADS-B messages for uplink. Section 2.2.3 describes the transmission assumptions.

2.2.1 Radar

The TIS-B component of scenario data generation requires realistic radar data that is used to provide input to the TIS-B processor, which then outputs tracked data for uplink by the TIS-B transmit function. The radar input data was simulated using a model developed by MIT-LL which was based on the characteristics of a MSSR radar [Ref MIT1]. The features of this model and other assumptions about the radar are described in Sections 2.2.1.1 through 2.2.1.4.

[MIT1] Thompson, S.D. and others, "Required Surveillance Performance Accuracy to Support 3-Mile and 5-Mile Separation in the National Airspace System," Project Report ATC-323, Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA. November 1, 2006

2.2.1.1 Processing Latency

The time that it takes for the radar to process and format the target update is modeled as a Gaussian process that has a mean of 400 ms, with a standard deviation of 40 ms. This time represents the period from the Time of Measurement (TOM) to delivery of the information to the Service Delivery Point (SDP) at the entry to the automation system. This distribution was derived from Common ARTS (CARTS) Flight Test Data [Ref CARTS1].

[Ref CARTS1] "Analysis of RTQC and Beacon Message Delays from ASR-9 Radars at PHL & ACY ER9 ADS-B Separation Standards Flights on 10-04-05", CNS Aviation Services, October 21, 2005.

2.2.1.2 Error Model

The scenario generation process introduces modifications to the smooth radar tracks in order to simulate real-life radar measurements. Each of these adjustments will be described in more detail below. First, random radar error models are used to modify the radar track data to provide normal measurement jitter on position values derived from the smooth radar tracks. This process treats the errors in the azimuthal and range directions as separate Gaussian distributions. On top of those random errors, the model superimposes a number of observed biases. The final range and azimuth values are then subjected to the quantization of values imposed by the CD-2 format used to report the radar measurements.

The model adds a jitter on both the range and azimuth values provided by the smooth radar track, based on normal distributions with zero mean and standard deviations of 0.068° for azimuth and 25 feet for range. In addition to these random errors, both range and azimuth are subject to a bias component, up to 1 ACP in the case of azimuth and up to 200 feet transponder bias for the range value. The azimuth bias is due to the rotating radar, and is presumed to be the same for aircraft nearby each other; however, the range bias resulting from inaccurate transponder delays will vary from aircraft to aircraft.

Finally, the calculated range and azimuth values, which include the both the random errors and biases, are quantized to CD-2 restrictions: 1/64 NM for terminal radar range values and 1 ACP for azimuth values.
Randy – Is this section right?

2.2.1.3 Range from Targets

The aircraft are assumed to be 40 NM from the radar location for scenarios 1, 2, and 3. For the Atlanta scenario(s?), the aircraft are placed at locations as measured from the actual sensor location. The distance from the sensor affects the magnitude of the azimuth error in terms of distance around the aircraft.

2.2.1.4 Update Probability per Sweep

It is assumed that the radar updates each target on every sweep, i.e., the update probability per sweep is set to 100%.

2.2.2 TIS-B Processing

The TIS-B processing system receives radar position updates and ADS-B reports received from equipped aircraft. It then incorporates the radar updates into tracks, and correlates the ADS-B reports with the radar tracks. The TIS-B processor then prepares messages to be uplinked through the transmitter for radar tracks that do not have associated ADS-B reports.

2.2.2.1 Latency

The latency requirement on the TIS-B processing, as specified in the FAA Essential Services Specification [Ref XX] is a maximum of 1.5 seconds from the Service Delivery Point where radar updates are received to the Time of Transmission of the uplink messages. The scenario generator assumes a uniform distribution between 1.3 seconds and 1.5 seconds. This latency includes the transmit latency, so that need not be considered separately. In addition, the media access requirements, as outlined in the FAA Essential Services Specification, have been incorporated into the scenario generator.

2.2.2.2 Update Interval

The scenario generator assumes that the TIS-B update interval is six seconds, corresponding to a six-second sweep from a single radar. Therefore, every six seconds the scenario generator produces six 1090 ES uplink messages and/or one UAT uplink message for each aircraft unequipped with ADS-B.

The TIS-B uplink messages are characterized by MSR (see Section 2.1), which is ADS-B link-dependent. For 1090 ES, for example, the MSR may be varied from 20% to 40% to determine the effect on the ASSAP processing algorithm performance, while for UAT the limits would be different.

2.2.2.3 Extrapolation

The TIS-B positions are required to be extrapolated to the Time of Applicability of the positions as required by the ADS-B data link MOPS. The scenario generator accounts for this in the following way: For 1090 ES, the TIS-B position is required to be extrapolated to within 100 ms of the TOT, while for UAT the TIS-B position is required to be extrapolated to the beginning of the UTC second during which the transmission takes place.

2.3 ADS-R

The ground service receives ADS-B transmission from equipped aircraft and translates the received ADS-B information into ADS-B messages for uplink on the other ADS-B data link (e.g., information in ADS-B messages received on 1090 ES are rebroadcast by the ground on UAT). This service provides ADS-B information on both links to all equipped users, regardless of the ADS-B equipage. ADS-R: 45% (5 sec 95%, 1/sec) suggest sensitivity to this (only downward)

2.3.1 UAT Rx Latency and reception probability same for UAT and 1090

2.3.1.1 Latency

Latency is included in ADS-R Processing

2.3.1.2 Reception Probability

- 3 seconds 95% service requirement [Critical Serv. Spec]

2.3.2 ADS-R Processing

2.3.2.1 Latency

- Max 1 second (ITT 164 ms average, 500 ms max) [Critical Serv. Spec] will use narrow distribution near max

2.3.2.2 Update Interval

- 5 messages per received message in terminal domain need to do requirements for multiple received messages on same update
- 10 messages in enroute domain

2.3.3 1090 Tx

2.3.3.1 Latency

Latency is included in ADS-R Processing

2.3.3.2 Media Access

- >=1 ms between start of messages [Critical Serv. Spec]
- Randomized transmit times [Critical Serv. Spec]

2.3.3.3 Extrapolation

- Extrapolate to within 100 ms of TOT [Critical Serv. Spec]

2.4 TCAS

[TBD]

3 Data Generation Process

3.1 Include both 1090 AND UAT ownship versions discuss ownship source/timing

3.2 Include "unmolested" (Don wants that to be the label) versions, where MSR are 100% for use in debugging algorithms

Include discussion of MSR variation

Not planning on leaving this in appendix, but leaving in order to leave reminder for **Randy, who will be writing this section**.

Module	**Function**	**Effort**	☒
Scenario	Read in waypoint files	Half Day	☒
	Interpolate altitude	Easy	☐
MessageGenerator	Assign altitudes	Easy	☐
1090 Airborne Tx	Add all 1090 squitters	Easy	☐
TCAS	Generate TCAS reports based on ownship position	Half Day	☐
1090 Airborne Rx	Add ADS-B receive capability	Easy	☐
Ownship1090	Ownship contains 1090 Rx and TCAS capability	Half Day	☐
TISB 1090	Receive radar reports, convert to 1090 fields, Tx to ownship.	Half Day	☐
UAT Rx	Update UAT Receive Module, dust out cobwebs	Easy	☐
ADSR 1090	Receive UAT reports, convert to 1090 fields, Tx to ownship.	Easy	☐
		UNK	☐
Phase 2 - UAT Ownship Version			
UAT Airborne Rx	Add ADS-B receive capability	Easy	☐
OwnshipUAT	Ownship contains UAT Rx and TCAS capability	Easy	☐
TISB UAT	Receive radar reports, convert to UAT fields, Tx to ownship.	Easy	☐
ADSR UAT	Receive 1090 reports, convert to UAT fields, Tx to ownship.	Easy	☐
		UNK	☐
		UNK	☐
		UNK	☐