Report No. 010927-01

Automatic Dependent Surveillance – Broadcast (ADS-B)

Design Analysis Report: ADS-B Operational Safety Assessment

Operational Services and Environment Definition (OSED)
Operational Hazard Assessment (OHA)
Allocation of Safety Objectives and Requirements (ASOR)

September 27, 2001

Prepared by: Steve Paasch, Certification Services, Inc.

Reviewed by: _____
Gene Rice, Adsystech, Inc.

Concurrence by: _____
Scott VanBuren, ASD-110
Co-chair, System Safety Working Group

Approved by: _____
Mike Harrison, ASD-100
Chairman, System Engineering Council

Revision History:

Revision Identification	Date	Description of Changes
-	September 27, 2001	

Contents:

1. Operational Services and Environment Definition (OSED) 1

2. Operational Hazard Assessment (OHA) 39

3. Allocation of Safety Objectives and Requirements (ASOR) 154

1. Operational Services and Environment Definition (OSED)

OSED Contents:

1. Operational Services and Environment Definition (OSED) 1
1.1. Introduction 3
1.1.1. Purpose and Scope 3
1.1.2. Background 3
1.1.3. Acronyms 4
1.2. Chapter Organization 4
1.3. Referenced Documents and Bibliography 5
1.3.1. Referenced Documents 5
1.3.2 Additional Bibliographical Material 5
1.4. Stakeholder Identification 5
1.5. Operational Environment Description 6
1.6. Operational Objectives, Intentions, and Capabilities 8
1.7. Air Traffic Services Descriptions 9
1.8. ATS Description Development Worksheets 11

OSED Tables:

Table 1.6-1: Operational Objectives, Intentions, and Capabilities List 8
Table 1.7-1: ATS Descriptions Related to Objectives, Intentions, and Capabilities 9
Table 1.8-1: ATS Worksheets 12

1.1. Introduction

1.1.1. Purpose and Scope

An Operational Services and Environment Definition (OSED), per the guidance in **Reference a**, is used as the basis for assessing and establishing operational, safety, performance, and interoperability requirements for a proposed Communication, Navigation, Surveillance / Air Traffic Management (CNS/ATM) system. This OSED captures operational services and environment information shared among appropriate stakeholders for the purpose of assessing and establishing safety requirements for Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information System-Broadcast (TIS-B) in the context of surveillance services and situational awareness.

The scope of this OSED includes identifying stakeholders, operational objectives, intentions, and capabilities, air traffic services (ATS), and the operational environment characteristics pertinent to the development of an operational safety assessment (OSA). as related to ADS-B and TIS-B. Information related to operations, performance, and interoperability is limited to only that data necessary for assessing and establishing safety requirements; however, with appropriate future revisions, this OSED could be expanded to include all information necessary for the assessment and establishment of performance and interoperability requirements discussed in **Reference a**. The term "ATS" is used throughout this document to refer to "ATS supported by ADS-B and TIS-B."

As this OSED is intended to facilitate the formulation of technical and procedural requirements based on operational expectations and needs, it should be updated as necessary throughout the coordinated requirements determination processes of the OSA. As assessments proceed, this OSED should be revised to capture data that has been derived and/or validated as being necessary for the definition of particular operational services.

This OSED was developed using the guidance provided in **References a**, **b**, and **f**.

1.1.2. Background

The Federal Aviation Administration (FAA), in the interests of enhancing safety and air traffic management, and in response to the expressed desires of the aviation community, has concurred with the need to consider dependent surveillance and traffic information capabilities for the National Airspace System (NAS) CNS/ATM system. The **Reference c** Minimum Aviation System Performance Standards (MASPS) has been written to describe ADS-B system functional requirements. The Safe Flight 21 and Free Flight initiatives (see **References d and e**) have developed initial operational concepts incorporating dependent surveillance capability. The Capstone project was initiated to provide ADS-B capability as an aid to visual acquisition, improve traffic flow, and enhance traffic awareness and surveillance capabilities in adverse weather conditions, especially on geographically challenging routes and at minimally equipped airports in Alaska. The Ohio Valley project was initiated to demonstrate and evaluate the capability of ADS-B to aid visual acquisition, enhance traffic awareness and surveillance capabilities, and provide conflict detection aid. This OSED was initiated to provide a basis for determining operational safety requirements related to the establishment of an FAA infrastructure for NAS-wide ADS-B and TIS-B operational use.

1.1.3. Acronyms

A/C	Aircraft
ADS-B	Automatic Dependent Surveillance Broadcast
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CDTI	Cockpit Display of Traffic Information
CNS	Communication, Navigation, and Surveillance
CNS/ATM	Communication, Navigation, and Surveillance/Air Traffic Management
FIR	Flight Information Region
FMS	Flight Management System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MASPS	Minimum Aviation System Performance Standards
NAS	National Airspace System
OSA	Operational Safety Assessment
OSED	Operational Services and Environment Definition
RNAV	Radio Navigation
TIS-B	Traffic Information System Broadcast
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1.2. Chapter Organization

This chapter is organized into eight sections as follows:

- Section 1.1 provides an introduction, including purpose and scope, background, and acronyms used in the chapter.
- Section 1.2 explains the organization of the chapter.
- Section 1.3 provides a list of documents referenced in this chapter and additional bibliographical material used in the development of this chapter.
- Section 1.4 identifies the stakeholders for this effort.
- Section 1.5 describes the characteristics of the operational environment in which ADS-B and TIS-B operate.

- Section 1.6 identifies the operational objectives, intentions, and capabilities related to the use of ADS-B and TIS-B, and shows their relationship to Safe Flight 21 concepts.

- Section 1.7 lists the ATS supported by ADS-B and TIS-B and shows their relationship to each objective, intention, and capability they implement.

- Section 1.8 consists of worksheets used to expand the descriptions for the objectives, intentions, and capabilities, identify ATS, identify equipage, and identify procedural considerations.

1.3. Referenced Documents and Bibliography

1.3.1. Referenced Documents

a. RTCA document DO-264, Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications

b. FAA, System Safety Handbook: Practices and Guidelines for Conducting System Safety Engineering and Management.

c. RTCA document DO-242, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B).

d. FAA Safe Flight 21 Functional Specification, and Surveillance Vision Plan.

e. RTCA Joint Government/Industry Roadmap for Free Flight Enhancements.

f. FAA, NAS Modernization, System Safety Management Program, FAA Acquisition Management System.

1.3.2 Additional Bibliographical Material

a. FAA NAS CONOPS 2005, NAS Architecture, Version 4.

b. FAA ADS-B Mission Need Statement #326.

c. FAA ADS-B Plan.

d. ICAO Manual of ATS Data Link Applications.

e. ICAO Doc 4444, Annex 11, Appendix 5, Aeronautical Data Quality Requirements.

1.4. Stakeholder Identification

This OSED is developed primarily as a basis for ascertaining the provisioning and operational requirements for the FAA infrastructure required to support operations using ADS-B and TIS-B. Consequently, the stakeholders include the FAA, all potential ADS-B/TIS-B equipped aircraft operators and service providers, equipment manufacturers, and equipment installers (including airframe manufacturers). As the stakeholder community is both broad and inclusive, and not limited by the requirements of a specific applicant's project, a more specific enumeration of stakeholders is not provided.

1.5. Operational Environment Description

As ADS-B is intended for use under a variety of conditions throughout the NAS, it is expected that the operating environment will include some of the most complex scenarios current today and into the future in terms of mixed equipage and aircraft performance capabilities, route crossings, altitude crossings, and traffic volumes and densities. Therefore, a complex scenario assumption should be used when developing the OSA unless specific operating environment constraints are otherwise specified or implied by the nature of a service or its related operational objectives, intentions, and capabilities. **Reference a** provides a template for capturing environment data. However, as **Reference a** was written with communications systems in mind, some of the items in the template may not be pertinent to surveillance and related situational awareness. Therefore, the template has been modified as appropriate and the environment description is as follows:

Operational Characteristics:

	Primary	Supplemental
ATC ADS-B/TIS-B means:	Varies with capability and service.	
ATC radar/other:	X When available.	

Flight Phases/Regimes:	Yes	No
Oceanic/Remote:	X	
Offshore:	X	
En route/Domestic:	X	
Terminal:	X	
Takeoff:	X	
Approach:	X	
Landing:	X	
Airport Surface:	X	

Air Traffic Complexity:	Yes	No
Altitude transition:	X	
Crossing traffic:	X	
Speed management:	X	

Route Configuration:	Yes	No
Fixed Tracks:	X	
Flexible Tracks:	X	

Type of Control:	Yes	No
Procedural:	Varies with capability and service.	
Tactical:	Varies with capability and service.	

Other:	Yes	No => If yes, qualify constraints
FIR and ATC sector structure:	Various. Assume constraints in NAS sectors of interest.	

Separation Minima: Varies: current separation standards apply for their related operations in the NAS. (Reduced separation standards under specific conditions involving ADS-B and TIS-B as well as developing navigation and communication systems may be considered in the future, and are noted in the descriptions of pertinent objectives, intentions, and capabilities where applicable).

Traffic Characteristics (Anticipated for traffic growth over capability life cycle):

- CNS equipment of aircraft: Mixed equipage environment.
- Speed: Mixed and extremely diverse aircraft performance. environment.
- Altitude: Mixed and extremely diverse aircraft performance. environment.
- Climb/descent: Mixed and extremely diverse aircraft performance. environment.

Possibilities include all aircraft types operating in the NAS

Technical Characteristics:

See **Reference c**. ATC system performance requirements and automation dependencies are not available at this time.

Availability and Continuity Characteristics:

To be generally determined during OSA development as pertinent to hazards related to loss of function.

Volume Characteristics:

For specific rates and volumes, the RTCA/SC-189 Continental SPR working group is currently assessing the continental airspace environment. Although their effort is directed toward air traffic services aided by data link communications, their working papers may be referred to for general air space environmental factors such as traffic density and volume. For the use of this OSED as a basis for an ADS-B/TIS-B related OSA, a relative qualitative measure of volume and density is sufficient, and it is assumed that ADS-B and TIS-B will potentially be utilized in any NAS sector; therefore, high traffic volume and density should be assumed when assessing operational hazards.

General Environmental Characteristics (e.g., weather, volcanic ash):

Relevant weather characteristics are various and may be implied in the descriptions of objectives, intentions, and capabilities. Other environmental characteristics are assumed to be the full range encountered in NAS operations. Flight Information Service updates are assumed available with appropriate equipage.

Communications Sub-Networks:

Not considered for development of the OSA for which this OSED is a basis.

Special Use Airspace Restrictions:

Consideration assumed to be unnecessary for the OSA for which this OSED is a basis.

1.6. Operational Objectives, Intentions, and Capabilities

Operational objectives, intentions, and capabilities have been identified from **Reference d**, and are descriptions of the operations ADS-B and TIS-B equipage will make possible, augment, or enhance. From **Reference d**, twenty-seven operational objectives, intentions, and capabilities have been identified as of realistic interest to operators and the FAA. **Table 1.6-1** provides a list, by title, of those used in this OSED along with their **Reference d** relationship. Each objective, intention, or capability is described more fully in the worksheets in **Section 1.8** of this chapter per the information in **Reference d**. Operational objectives, intentions, and capabilities form the basis for identifying ATS, which implement the objectives, intentions, and capabilities.

Table 1.6-1: Operational Objectives, Intentions, and Capabilities List

	Operational Objective, Intention, Capability Title	SF-21 ID
1	Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only	3.1.1
2	Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only	3.1.2
3	Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B	3.1.3
4	Approach Spacing for Visual Approaches	3.2.1
5	Approach Spacing for Instrument Approaches	3.2.2
6	Departure Spacing / Clearance (VMC in Radar)	3.4
7	Approaches to Closely Spaced Parallel Runways	3.5
8	Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)	4.1.1
9	Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)	4.1.2
10	Conflict Detection	4.2.1
11	Conflict Resolution	4.2.2
12	Pilot Situational Awareness Beyond Visual Range	5.2.1
13	Delegated air-to-air self separation for one-in-one-out airspace	5.2.2
14	Runway and Final Approach Occupancy Awareness (Using ADS-B only)	6.1.1
15	Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)	6.1.2
16	Airport Surface Situational Awareness	6.2
17	Enhanced IMC airport surface operations	6.3
18	Enhance Existing Surface Surveillance with ADS-B	7.1
19	Surveillance Coverage at Airports without Existing Surface Surveillance	7.2
20	Center situational awareness with ADS-B	8.1
21	Radar-like Services with ADS-B	8.2
22	Tower Situational Awareness Beyond Visual Range	8.3
23	Radar Augmented with ADS-B in Terminal Airspace	9.1.1
24	Radar Augmentation with ADS-B to achieve existing separation standards in terminal airspace	9.1.2
25	Radar Augmented with ADS-B in En Route Airspace	9.2
26	Radar Augmentation with ADS-B to achieve existing separation standards in en route airspace	9.2.2
27	Reduced separation standards with ADS-B	9.3

1.7. Air Traffic Services Descriptions

ATS allow for the practical implementation of the operational objectives, intentions, and capabilities identified in **Section 1.6**. **Table 1.7-1** provides a list of ATS related to the operational objectives, intentions, and capabilities which they implement.

Table 1.7-1: ATS Descriptions Related to Objectives, Intentions, and Capabilities

	Operational Objective, Intention, Capability Title		Implementing Air Traffic Services
1	Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only	1.1	ADS-B for enhanced visual acquisition of aircraft during visual approach.
2	Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only	2.1	ADS-B for enhanced visual acquisition of aircraft during visual approach using call signs.
3	Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B	3.1	TIS-B augmented ADS-B for enhanced visual acquisition of aircraft during visual approach.
4	Approach Spacing for Visual Approaches	4.1	ADS-B for achieving and maintaining desired in-trail spacing during visual approach.
5	Approach Spacing for Instrument Approaches	5.1	ADS-B for achieving and maintaining desired in-trail spacing during instrument approaches with ATC monitoring.
6	Departure Spacing / Clearance (VMC in Radar)	6.1	ADS-B for achieving and maintaining desired in-trail spacing during visual departure with ATC monitoring.
7	Approaches to Closely Spaced Parallel Runways	7.1	ADS-B for proximate traffic awareness on instrument approach to closely spaced parallel runways.
		7.2	ADS-B for conflict detection/alerting/resolution aid.
8	Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)	8.1	ADS-B for aided "see and avoid."
9	Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)	9.1	TIS-B augmented ADS-B for aided "see and avoid."
10	Conflict Detection	10.1	ADS-B for conflict detection.
11	Conflict Resolution	11.1	ADS-B for conflict detection and tactical resolution.
12	Pilot Situational Awareness Beyond Visual Range	12.1	TIS-B augmented ADS-B for traffic awareness beyond visual range.
13	Delegated air-to-air self separation for one-in-one-out airspace	13.1	ADS-B for awareness of A/C traffic in non-radar airspace.
14	Runway and Final Approach Occupancy Awareness (Using ADS-B only)	14.1	ADS-B for awareness of traffic in final approach path and on runway surface.
15	Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)	15.1	TIS-B augmented ADS-B for awareness of traffic in final approach path and on runway surface.
16	Airport Surface Situational Awareness	16.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.

Table 1.7-1: ATS Descriptions Related to Objectives, Intentions, and Capabilities (continued)

17	Enhanced IMC airport surface operations	17.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.
18	Enhance Existing Surface Surveillance with ADS-B	18.1	ADS-B augmented surface surveillance for surface traffic management.
19	Surveillance Coverage at Airports without Existing Surface Surveillance	19.1	ADS-B for surface traffic management.
20	Center situational awareness with ADS-B	20.1	ADS-B for center traffic situational awareness in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.
21	Radar-like Services with ADS-B	21.1	ADS-B for radar-like services in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.
22	Tower Situational Awareness Beyond Visual Range	22.1	ADS-B for traffic awareness beyond tower visual range.
23	Radar Augmented with ADS-B in Terminal Airspace	23.1	ADS-B augmented radar surveillance for terminal area air traffic management.
		23.2	ADS-B augmented radar surveillance for terminal area reduced separation.
24	Radar Augmentation with ADS-B to achieve existing separation standards in terminal airspace	24.1	ADS-B augmented radar surveillance for terminal area air traffic separation.
25	Radar Augmented with ADS-B in En Route Airspace	25.1	ADS-B augmented radar surveillance for en-route air traffic management.
		25.2	ADS-B augmented radar surveillance for en-route reduced separation.
26	Radar Augmentation with ADS-B to achieve existing separation standards in en route airspace	26.1	ADS-B augmented radar surveillance for en-route separation.
27	Reduced separation standards with ADS-B	27.1	ADS-B augmented radar surveillance for reduced separation.

1.8. ATS Description Development Worksheets

Table 1.8-1 is a set of worksheets used to identify the service descriptions and considerations, and includes detailed descriptions of each operational objective, intention, and capability, a description of the related ATS, top-level lists of equipage necessary to take full advantage of a service, and procedural considerations which may possibly constrain the service, mitigate hazards related to the services, or should be considered in order to fully implement the service. Human factors considerations have been touched on in the descriptions of the objectives, intentions, and capabilities. Flight phases are indicated in the descriptions of operational objectives, intentions, and capabilities. Scenarios, per **Reference a**, are outlined in the descriptions of operational objectives, intentions, and capabilities.

Table 1.8-1: ATS Worksheets

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **1. Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only** The primary objective of this application is to help the pilot (through the use of the CDTI) to visually acquire and identify an aircraft that has been referenced as traffic by ATC, so that the controller may clear the aircraft for a visual approach. The controller will issue the pilot advisories to visually acquire another specific relevant aircraft. The pilot initially looks out the window to visually acquire the referenced traffic. If the traffic is ADS-B equipped, the pilot can then use the CDTI to better focus his/her out-the-window scan to acquire the traffic visually. The CDTI then, should make it easier for the pilot to correlate the target aircraft and trajectory information from the CDTI to the actual aircraft as seen out-the-window. Once established, the pilot should then be better able to maintain visual separation. The controller is then relieved from separation responsibilities for that aircraft in the same manner as in today's environment where the controller relinquishes separation responsibilities to the pilot who is authorized to perform a visual approach and has the aircraft to be followed in sight. The pilot is then responsible for maintaining a safe approach interval and adequate wake turbulence separation. Relevant flight phase(s): descent and approach. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 1.1. ADS-B for enhanced visual acquisition of aircraft during visual approach.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **2. Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only** For this application, the controller must know which aircraft are ADS-B/CDTI equipped. Prior to authorizing the visual approach, the controller will issue an advisory to the pilot to visually acquire the relevant traffic, if any. With this procedure, the controller can use the "call sign" for the traffic aircraft if he/she knows that both aircraft are ADS-B/CDTI equipped. With the "call sign," the pilot: (1) knows the aircraft being sought is ADS-B equipped and, therefore, should show up on the CDTI, and (2) can better isolate the traffic to be acquired by looking for the call sign on the CDTI. Once the traffic is visually acquired and the visual approach is authorized, the pilot will monitor the CDTI for changes in the traffic's speed, altitude or direction of flight, and flies the approach visually while keeping the traffic in sight by out-the-window visual scanning. Relevant flight phase(s): descent and approach. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 2.1. ADS-B for enhanced visual acquisition of aircraft during visual approach using call signs.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems. ATC: ADS-B/CDTI call sign identification system or procedure, and requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New procedures are required involving call signs for ADS-B/CDTI capability information.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **3. Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B** Under this application, use is made of Traffic Information Service-Broadcast (TIS-B) to increase the number of aircraft that ADS-B/CDTI-equipped aircraft can "see." TIS-B effectively permits non-ADS-B (but transponder equipped) aircraft to be displayed in ADS-B/CDTI cockpits. This feature should increase the number of aircraft that the CDTI will display, thus increasing aircraft that can participate in this application. In addition, this feature should improve the ability of the pilot to visually acquire, identify, and maintain visual contact with relevant traffic, as well as give the pilot more complete situational awareness of more aircraft in a mixed-equipage environment. Even though TIS-B data will not be as accurate or extensive as the ADS-B data, it should provide enhanced ability of CDTI equipped pilots to conduct visual approaches behind a wider variety of aircraft. Relevant flight phase(s): descent and approach. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 3.1. TIS-B augmented ADS-B for enhanced visual acquisition of aircraft during visual approach.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems. Some target aircraft may be equipped with only a transponder and requisite communication and navigation systems. TIS-B will allow these to show up on ADS-B/TIS-B traffic display equipped A/C. ATC: Terminal area radar, ADS-B reception and input processing equipment with TIS-B processing and broadcast capability, and/or ADS-B/CDTI-call sign identification system, and requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New procedures are required involving call signs for ADS-B/CDTI capability information.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **4. Approach Spacing for Visual Approaches** The primary goal in this application is to increase the precision and consistency of inter-arrival spacing of aircraft on visual approaches requested by either the pilot or ATC. Through the use of ADS-B/CDTI, the pilot is expected to be able to more precisely manage spacing on the aircraft ahead during this type of approach. This includes not only long, straight-in final approaches, but also other terminal area routings leading to a final approach; e.g., vectors to the final approach, or radio navigation (RNAV)/flight management system (FMS)-based terminal area transitions. With reference to speed and other data on the CDTI, the pilot should be able to make real-time speed adjustments in response to lead aircraft actions and projections. Relevant flight phase(s): descent and approach. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 4.1. ADS-B for achieving and maintaining desired in-trail spacing during visual approach.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New phraseology needed to enable instructions to the crew to allow variability in approach spacing in relationship to the lead aircraft.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **5. Approach Spacing for Instrument Approaches** The primary goal in this application is to improve the precision and consistency of inter-arrival spacing (ATC assigned) through the pilot's use of ADS-B/CDTI in instrument meteorological conditions (IMC) in the context of an instrument approach procedure, where the "out-the-window" visual component is not available. The controller points out the traffic that the pilot is expected to follow, and will specify the target spacing interval to be maintained. The pilot is to identify the traffic on the CDTI and then use the CDTI to achieve and maintain the assigned spacing. The pilot maintains the interval spacing and the controller monitors for compliance to ensure that separation is maintained. Since the pilot is flying an instrument approach procedure, his/her spacing task must be combined with precise lateral path and descent profile management. Relevant flight phase(s): descent and approach.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 5.1. ADS-B for achieving and maintaining desired in-trail spacing during instrument approaches with ATC monitoring.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system augmented with appropriate feature and alerts relevant to the target spacing, non-ADS-B transponder, requisite communication and navigation systems. ATC: Terminal area radar, display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New pilot/controller procedures will need to be developed, along with associated phraseology.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **6. Departure Spacing / Clearance (VMC in Radar)** This application is to explore the potential of ADS-B technology and procedural modifications in increasing safety and improving airport departure capacity and efficiency by reducing unnecessary gaps between successive departures. It is assumed that an ADS-B/CDTI-equipped aircraft (i.e., the trailing aircraft) is in sequence to depart behind another ADS-B equipped aircraft (i.e., the lead aircraft). This application is considered to be suitable only for airport configurations where the runway is used exclusively for departures, and there are no intersecting active runways or flight paths. This application adds a level of redundancy by involving both the pilot and controller. The controller would first issue a standard, conventional takeoff clearance to the lead departing aircraft. The controller then issues a clearance to the trailing aircraft which authorizes the aircraft to proceed onto the active runway and start its takeoff roll when the lead aircraft has progressed to the specified (pre-determined) distance ahead. The pilot of the trailing aircraft may begin the takeoff roll only after he/she identifies the target lead aircraft on the CDTI, acknowledges the ATC clearance, and achieves the assigned minimum separation distance. Just as with current departure clearances, the controller should ensure that the pilot executes the assigned clearance properly; the application is not intended to shift existing responsibilities for aircraft separation. Relevant flight phase(s): takeoff (departure). Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 6.1. ADS-B for achieving and maintaining desired in-trail spacing during visual departure with ATC monitoring.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system, non-ADS-B transponder, requisite communication and navigation systems. ATC: Terminal area radar, display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New takeoff/departure procedure allowing following aircraft to utilize dependent surveillance for takeoff timing.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **7. Approaches to Closely Spaced Parallel Runways** The goal of this application is to provide an alternative to the Precision Runway Monitor (PRM) system for providing the required safety for conducting parallel ILS approaches for the minimum wake turbulence independence of 2500 feet, or potentially even closer spacing. ADS-B/CDTI surveillance in the cockpit will provide pilots with a means to monitor independent traffic streams on both parallel approaches. Airborne conflict resolution logic would give warnings to prevent a collision hazard in the event of error or navigation blunder. A variation of the application will provide dependent approach pairs with longitudinal stagger supported by the CDTI information. Blunder and collision detection are supported by airborne alerting as above. Relevant flight phase(s): approach. Human factors: consideration of compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 7.1. ADS-B for proximate traffic awareness on instrument approach to closely spaced parallel runways. 7.2. ADS-B for conflict detection/alerting/resolution aid.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, traffic display system, conflict detection/resolution system, algorithms for determining suitable spacing, appropriate alerting for blunders and conflicts, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New approach and landing procedures allowing equipped aircraft to use dependent surveillance for independent approaches, and pairwise equipped aircraft to use dependent surveillance for dependent approaches.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **8. Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)** The goal of this application is to improve the pilot's ability to visually acquire other traffic, both in the air and on the ground, so that he/she can more effectively apply the see-and-avoid principle. This application is intended to enhance the initial visual acquisition of other aircraft. The initial acquisition part of see-and-avoid is the most prone to failure. This application will focus on providing traffic information via a cockpit display, although other interfaces may also be used. Using ADS-B only, only ADS-B equipped aircraft will be observed on the CDTI, and thus the pilot must be aware that not all aircraft will be on the CDTI. When an aircraft is receiving ATC services, a controller may issue traffic advisories that will serve to aid the pilot in visual acquisition of other aircraft. The controller may also aid the pilot by providing an indication of whether the referenced traffic is ADS-B equipped. Relevant flight phase(s): all. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 8.1. ADS-B for aided "see and avoid."
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current visual acquisition procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **9. Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)** The goal of this application is to improve the pilot's ability to visually acquire other traffic, both in the air and on the ground, so that he/she can more effectively apply the see-and-avoid principle. This application is intended to enhance the initial visual acquisition of other aircraft. The initial acquisition part of see-and-avoid is the most prone to failure. This application will focus on providing traffic information via a cockpit display, although other interfaces may also be used. By having TIS-B in addition to ADS-B, the proportion of displayable traffic observed on the CDTI does not depend on proximate aircraft being ADS-B equipped. The ground system function, TIS-B, provides position and altitude on aircraft within coverage of the radar site and broadcasts the information. The information is received along with ADS-B information for display on a CDTI. Relevant flight phase(s): all. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 9.1. TIS-B augmented ADS-B for aided "see and avoid."
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment with TIS-B capability, non-ADS-B transponder, traffic display system, requisite communication and navigation systems. ATC: Terminal area radar, ADS-B reception and input processing equipment with TIS-B processing and broadcast capability, display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current visual acquisition procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **10. Conflict Detection** The goal of this application is to enhance the basic awareness of proximate traffic that the pilot has gained through ADS-B/CDTI, by including a feature that alerts the pilot to a traffic situation where safe separation may be compromised. With ADS-B conveying accurate position information a Conflict Detection System incorporated with ADS-B/CDTI can provide early alerts to potential losses of separation, and may allow the pilot to resolve the situation with minor adjustments to the flight plan. This may reduce the need for reliance on conflict resolution functions. Relevant flight phase(s): all.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 10.1. ADS-B for conflict detection.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, traffic display system, conflict detection system, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New pilot/controller procedures will need to be developed, along with associated phraseology.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **11. Conflict Resolution** The goal of this application is to provide TCAS/ACAS-like conflict detection and resolution using ADS-B, by including a feature that alerts the pilot to traffic situation where safe separation is compromised and provides tactical resolution. Relevant flight phase(s): all.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 11.1. ADS-B for conflict detection and tactical resolution.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, traffic display system, conflict detection system, conflict resolution system, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New pilot/controller procedures will need to be developed, along with associated phraseology to allow an early resolution of conflicts. Since this conflict detection is prior to that of TCAS/ACAS (if available) appropriate pilot/controller coordination procedures for conflict resolution may need to be developed.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **12. Pilot Situational Awareness Beyond Visual Range** The primary goal of this application is to provide pilots operating under VFR (or Special VFR) with an awareness of proximate traffic beyond visual range. The intent is to give the VFR pilot a longer lead time in order to start resolving potential conflicts with more modest maneuvers (change in altitudes and/or directions) before the other traffic is visually acquired. The application is predicated on the aircraft being equipped with ADS-B/CDTI and the other aircraft either ADS-B equipped or their positions provided through TIS-B. Proximate aircraft beyond the visual range can then be displayed on the CDTI and the pilot can resolve potential conflicts. This application is intended only for use in VMC and by pilots operating under VFR. Since the operation is not intended for operations under IFR, no impact is expected on ATC. Relevant flight phase(s): climb through descent. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 12.1. TIS-B augmented ADS-B for traffic awareness beyond visual range.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment with TIS-B capability, non-ADS-B transponder, traffic display system, requisite communication and navigation systems. ATC: Area radar, ADS-B reception and input processing equipment with TIS-B processing and broadcast capability, display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **13. Delegated air-to-air self separation for one-in-one-out airspace** The goal of this application is to improve efficiency in non-radar airspace where procedural separation is currently used and allow more aircraft to share the airspace using self-separation techniques. Currently ATC estimates aircraft positions using pilot reports. ADS-B will provide pilots with timely and accurate surveillance information. Many airports that are currently located outside of radar coverage only allow for one-in one-out IFR operations (i.e., ATC can only clear one aircraft at a time for an instrument approach or departure). These types of operations are very inefficient and workload intensive for a controller. With ADS-B reports, ATC could delegate separation from designated targets to pilots for more efficient operations. Relevant flight phase(s): takeoff through approach.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 13.1. ADS-B for awareness of A/C traffic in non-radar airspace.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New procedures would have to be developed to determine when controllers are relieved of current control responsibilities of the ADS-B/CTDI equipped aircraft. New procedures would also have to be developed for the pilot assuming his/her own separation responsibilities. New procedures would have to be developed for failure modes of the transferred separation responsibility.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **14. Runway and Final Approach Occupancy Awareness (Using ADS-B only)** The primary goal of this application is to increase pilot's awareness of traffic (including aircraft and surface vehicles) that are on or near the runway surface, and also aircraft on final approach. The application makes use of ADS-B and CDTI to provide the pilot with a picture of the traffic situation on other aircraft (or surface vehicles) suitably equipped with ADS-B on or near the runway surface. 'Near the runway surface' includes that airspace around the final approach path from the surface up to approximately 1000 feet above the runway. This application does not cover operations on taxiways or ramps away from the runway. It is expected that this application will reduce the number of collisions or near-misses that occur because pilots were unaware of one another's presence. The pilot will need to be reminded that only ADS-B aircraft will be displayed on the CDTI. Relevant flight phase(s): approach and landing. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 14.1. ADS-B for awareness of traffic in final approach path and on runway surface.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, traffic display system, requisite communication and navigation systems. Surface vehicle: Surface vehicle based ADS-B output processing and transpondence system, Surface vehicle position determination system, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **15. Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)** The primary goal of this application is to increase pilot's awareness of traffic (including aircraft and surface vehicles) that are on or near the runway surface, and also aircraft on final approach. The application makes use of ADS-B and CDTI to provide the pilot with a picture of the traffic situation on and near the runway surface. Using TIS-B along with ADS-B allows the pilot to be aware of aircraft/vehicles that are not ADS-B equipped and thus gain a more comprehensive picture of proximate traffic on or near the runway. In the terminal area, it should be noted that Secondary Surveillance Radar (SSR) does not process data for aircraft that are not moving or are less than approximately 300 feet above the airport. It should also be noted that not all surface vehicles and aircraft operating on the ground have an operating transponder, and thus are invisible to SSR sensors. However, multilateration is planned for a large number of airports, and its improved accuracy and update rate may be a key factor in enabling these applications. No impact on ATC is expected. Relevant flight phase(s): approach and landing. Human factors: consideration of head-down time and compelling erroneous information in the cockpit.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 15.1. TIS-B augmented ADS-B for awareness of traffic in final approach path and on runway surface.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment with TIS-B capability, non-ADS-B transponder, traffic display system, requisite communication and navigation systems. Surface vehicle: Surface vehicle based ADS-B output processing and transpondence system, Surface vehicle position determination system, requisite communication systems. ATC: Terminal area and surface radar/ASDE, ADS-B reception and input processing equipment, display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **16. Airport Surface Situational Awareness** This application is focused on providing the pilot with a more reliable means of maintaining awareness of his/her own position on the airport surface, as well displaying other aircraft and surface vehicles on an ADS-B CDTI, thereby reducing the likelihood of runway incursions and ground collisions. One goal is to provide the pilot with cockpit moving map display of the airport surface such that the pilot could conduct all surface movements solely by reference to cockpit displays and systems, thus allowing the potential for safely taxiing in "zero visibility" conditions. The second goal is to provide the pilot with an awareness of proximate surface traffic on ramps, taxiways, and runways. Beyond reducing the threat of collisions on the surface, the pilot will be allowed to better participate in the flow of traffic to or from the runway in accordance with ATC instructions. Relevant flight phase(s): surface (pushback and taxi).
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 16.1. ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, A/C based airport surface map display with ADS-B target display capability, requisite communication and navigation systems. Surface vehicle: Surface vehicle based ADS-B output processing and transpondence system, Surface vehicle position determination system, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **17. Enhanced IMC airport surface operations** The goal of this application is to improve pilot safety on the surface by providing situational awareness of traffic in IMC. This will enhance the safety of maneuvering around an airport with the use of a traffic map. Visual acquisition of proximate traffic, vehicles and obstacles cannot be relied upon. Relevant flight phase(s): pushback and taxi
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 17.1. ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, A/C based ADS-B reception and input processing equipment, A/C based airport surface map display with ADS-B target display capability, requisite communication and navigation systems. Surface vehicle: Surface vehicle based ADS-B output processing and transpondence system, Surface vehicle position determination system, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **18. Enhance Existing Surface Surveillance with ADS-B** This application is intended to enhance existing surface surveillance systems to provide the ground controller with a more comprehensive and reliable picture of surface traffic situation through the use of ADS-B, as well as provide a level of redundancy for critical operations. It is intended that ADS-B will fill in gaps in ASDE coverage, such as shadowing, resolution of closely spaced targets, and the lack of a data block to show target identity. Through ADS-B, the controller will be provided with better information in the form of aircraft data blocks and better position/movement information. In this application, standard ADS-B position reports will be transmitted by equipped aircraft operating on the airport surface, and will be received by one or more nearby ADS-B listening stations. This information is then portrayed on the ground controller's ASDE display along with other ASDE targets. In the likely mixed-equipage environment, some aircraft will not be ADS-B equipped and will show up on the display as common, unaugmented ASDE primary radar returns. Aircraft that are ADS-B equipped, however, will show up as primary radar returns with supplementary data provided by ADS-B. In cases where the aircraft taxis into a shadow of ASDE coverage, the ADS-B data would still be displayed, but the primary radar return would be missing. This application could also involve surface vehicles being displayed on the ASDE console via ADS-B. Depiction of these vehicles would be helpful to the controller, especially for crash/fire/rescue (CFR) vehicle responding to a call. Relevant flight phase(s): surface (pushback and taxi).
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 18.1. ADS-B augmented surface surveillance for surface traffic management.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. Surface vehicle: Surface vehicle based ADS-B output processing and transpondence system, requisite communication systems and position determination equipment. ATC: ASDE, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply. (While basic ADS-B augmentation of ASDE is not expected to alter pilot/controller procedures significantly, future applications involving very low visibility operations or increased use of surface movement automation will require proper treatment of human factors and procedure development).

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **19. Surveillance Coverage at Airports without Existing Surface Surveillance** This application is geared to towered airports that do not have ASDE. This application is to provide the controller with a display of the airport surface depicting runways, taxiways, ramps, aprons, and other areas of operational interest. ADS-B reports from equipped aircraft and surface vehicles would be monitored from listening station(s) on or near the airport, and then portrayed on the controller's display. Subject to the limitations associated with mixed equipage, the controller can use displayed information to monitor aircraft movement and conformance to taxi clearances as well as better coordinate CFR responses. This should prove most beneficial for operations conducted at night and in low-visibility conditions. Because ASDE is not installed, ADS-B information would comprise the full report for all equipped aircraft. Aircraft without ADS-B would not show up on the display. Relevant flight phase(s): surface (pushback and taxi).
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 19.1. ADS-B for surface traffic management.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. Surface vehicle: Surface vehicle based ADS-B output processing and transpondence system, requisite communication systems and position determination equipment. ATC: ADS-B reception and input processing equipment, display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Due to mixed equipage, current surface maneuvering procedures apply, both VFR and IFR.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **20. Center situational awareness with ADS-B** This application provides center controllers with enhanced situational awareness of traffic in non-radar airspace by identifying ADS-B equipped aircraft and their trajectories on a controller display. This will aid the controller in providing procedural separation and other non-radar services and in coordinating with the tower controller on airspace changeovers between IFR en route operations and terminal area SVFR operations. ADS-B could potentially be used to aid in search and rescue and for communicating aircraft emergency conditions to the controller. Relevant flight phase(s): climb, cruise, descent.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 20.1. ADS-B for center traffic situational awareness in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: ADS-B reception and input processing system/stations, traffic display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: New procedure may need to be developed to handle a mixed equipage environment. However, it is assumed that this service is provided as an enhancement only, and that current procedures will be maintained, with ATC monitoring flights from communicated A/C position and flight plans.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **21. Radar-like Services with ADS-B** This application will effectively permit the use of radar-based techniques and services (flight following and traffic advisories, minimum safe altitude warning, navigational assistance, etc). in airspace that does not have radar coverage. ADS-B is used to provide the controller with position and other information on ADS-B aircraft. This application assumes a network of strategically-placed ground-based listening stations that passively monitor the ADS-B frequency for ADS-B messages from equipped aircraft flying in the area. These messages are forwarded to the cognizant ATC facility for processing to be displayed to the controller. Depiction of ADS-B-derived information on the display would be similar to what the controller sees for aircraft under conventional ground-based surveillance. Additionally, the same services and procedures would be used for both ADS-B-derived and conventional radar data. Relevant flight phase(s): climb, cruise, descent.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services (or other services) will be needed to do it): 21.1. ADS-B for radar-like services in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: ADS-B reception and input processing system/stations, traffic display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Radar monitoring procedures apply in addition to current procedures for non-radar monitored flight (mixed equipage).

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **22. Tower Situational Awareness Beyond Visual Range** This application is to provide the tower local controller at VFR towers with a tool to enhance his/her awareness of the traffic situation so that current local pattern procedures can be effectively applied. Currently, at "VFR" towers (local towers not having a dedicated radar approach control facility), the local controller must rely on direct visual observation of the aircraft and/or pilot position reports to develop and maintain the traffic picture around the airport. This application extends the tower cab controller situational awareness of traffic that is beyond visual range by using ADS-B to identify aircraft and their trajectories on a tower display. During VFR, SVFR and night operations, this application will aid tower-pilot and tower-center coordination by showing the over-all multiple-aircraft pattern of operations in the airspace rather than only those aircraft that are nearest the tower and within visual range. This application assumes a supporting infrastructure of ground-based listening stations on or near the airport to receive ADS-B messages, as well as the connectivity and processing to ultimately display aircraft position in the tower cab. Relevant flight phase(s): climb, descent, approach (departure and arrival).
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 22.1. ADS-B for traffic awareness beyond tower visual range.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: ADS-B reception and input processing equipment, traffic display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **23. Radar Augmented with ADS-B in Terminal Airspace** The emphasis on this application is on the integration of ADS-B into an established terminal area ground-based radar environment for the purpose of augmenting and improving overall terminal area radar operations. This application, therefore, assumes a terminal area system with ground-based radar, a network of listening stations to receive and decode ADS-B messages, and the technical means to process and use both sets of information. One focus will be on the inherent accuracy of ADS-B, and on the availability of aircraft-determined velocity vector information, as inputs to ground-based automation and controller tools. Another focus will investigate the availability and reliability of ADS-B for it to serve as a viable back-up to ground-based radar. In each case, the goal is to take advantage of ADS-B's strengths for the consideration of new separation minima, ground automation, and pilot/controller procedures. Consideration will be given to what information the controller needs to see on the display to effectively manage the situation. Prior to display on the controller's plan view display, ADS-B and ground-based radar data for a given aircraft will be cross-correlated when appropriate. It is expected that ADS-B-equipped aircraft will be displayed to the controller, along with appropriate supplementary information available through ADS-B. Relevant flight phase(s): climb, descent, approach.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 23.1. ADS-B augmented radar surveillance for terminal area air traffic management. 23.2. ADS-B augmented radar surveillance for terminal area reduced separation.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: For service 23.1: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Terminal area radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems. For service 23.2: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Terminal area radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: For service 23.1: Current procedures apply. For service 23.2: Procedures and requirements for reduced separation will need to be developed, including procedures for reversion to standard separation minima.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **24. Radar Augmentation with ADS-B to achieve existing separation standards in terminal airspace** The goal of this application is to improve air-ground surveillance by augmenting radar information with ADS-B surveillance data. This augmenting of the radar data would provide a means of verifying radar surveillance, as well as provide more accurate surveillance data, higher update rates, and additional intent information for suitable equipped aircraft. Relevant flight phase(s): terminal airspace (climb, descent, approach (departure and arrival)).
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 24.1. ADS-B augmented radar surveillance for terminal area air traffic separation.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Terminal area radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Current procedures apply.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **25. Radar Augmented with ADS-B in En Route Airspace** This application is meant to apply the features of ADS-B to technically and operationally supplement the existing en route surveillance system. Four objectives of this application are: (1) improve the accuracy of position information used by the controller and ground-based system. (2) Provide a back-up surveillance capability to enable consideration of reduced separation minima. (3) Ensure that the various mixed equipage situations are effectively addressed. (4) The incorporation of longer-term intent information as supplied by some ADS-B-equipped aircraft. The last objective will permit a more extensive air-ground coordination that is unique to the en route environment. With aircraft down linking (via ADS-B) their planned route/altitude for the next 'x' miles or minutes, the controller and ground automation will each have a reasonably accurate forecast of that aircraft's planned movement through the airspace. With the more precise position and intent data via ADS-B, separation minima could possibly be reduced in some situations. Relevant flight phase(s): cruise.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 25.1. ADS-B augmented radar surveillance for en-route air traffic management. 25.2. ADS-B augmented radar surveillance for en-route reduced separation.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: For service 25.1: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems. For service 25.2: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: For service 25.1: Current procedures apply. For service 25.2: Procedures and requirements for reduced separation will need to be developed, including procedures for reversion to standard separation minima.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **26. Radar Augmentation with ADS-B to achieve existing separation standards in en route airspace** The goal of this application is to improve air-ground surveillance by augmenting radar information with ADS-B surveillance data. This augmenting of the radar data would provide a means of verifying radar surveillance, as well as provide more accurate surveillance data, higher update rates, and additional intent information for suitable equipped aircraft. Relevant flight phase(s): en-route airspace.
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 26.1. ADS-B augmented radar surveillance for en-route separation.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: For service 26.1: Procedures and requirements for reduced separation will need to be developed, including procedures for reversion to standard separation minima.

Table 1.8-1: ATS Worksheets (continued)

OPERATIONAL OBJECTIVE/INTENTION/CAPABILITY DESCRIPTION (what will aircraft and/or ATC do): **27. Reduced separation standards with ADS-B** The goal of this application is to improve air-ground surveillance by augmenting radar information with ADS-B surveillance data. This augmenting of the radar data would provide a means of verifying radar surveillance, as well as provide more accurate surveillance data, higher update rates, and additional intent information for suitable equipped aircraft. This improved information is expected to support reduction of separation minima and hence increase airspace capacity and throughput. Relevant flight phase(s): all
AIR TRAFFIC SERVICE(S) DESCRIPTION allowing/fulfilling operational objective/intention/capability (what surveillance services will be needed to do it): 27.1. ADS-B augmented radar surveillance for reduced separation.
EQUIPAGE providing the ATS. If mixed equipage, describe mixes: A/C: A/C based ADS-B output processing and transpondence system, requisite communication and navigation systems. ATC: Radar, ADS-B reception and input processing equipment including fusion processing and display, requisite communication systems.
PROCEDURES constraining/enabling operational objective/intention/capability: Procedures and requirements for reduced separation will need to be developed, including procedures for reversion to standard separation minima.

2. Operational Hazard Assessment (OHA)

OHA Contents:

2. Operational Hazard Assessment (OHA) 39
2.1. Introduction 41
2.1.1. Purpose and Scope 41
2.1.2. Background 41
2.1.3. Acronyms 42
2.2. Chapter Organization 42
2.3. Referenced Documents and Bibliography 43
2.3.1. Referenced Documents 43
2.3.2 Additional Bibliographical Material 43
2.4. Stakeholder Identification 44
2.5. Operational Hazard Assessment Methodology 44
2.6. Operational Objectives, Intentions, and Capabilities and Air Traffic Service Descriptions 48
2.7. Summary of Assessment Results 49
2.8. Tabulation of Operational Hazard Assessment Results 58

OHA Tables:

Table 2.5-1: Hazard Severity Effects 46
Table 2.5-2: Hazard Classification and Safety Objectives Relationship 46
Table 2.5-3: Definition of Probability Terms 47
Table 2.5-4: Hazard Classification and Development Assurance Level Relationship 47
Table 2.6-1: Objectives, Intentions, Capabilities and ATS Relationships 48
Table 2.7-1: Operational Hazards Assessed as "Catastrophic" 51
Table 2.7-2: Operational Hazards Assessed as "Hazardous" 51
Table 2.7-3: Operational Hazards Assessed as "Major" 52
Table 2.7-4: Operational Hazards Assessed as "Minor" 54

OHA Notes, Legends, and Worksheets:

Notes for the OHA worksheets 59
Legend: System Operating Phase codes in OHA worksheets column C 59
Legend: Notes codes in OHA worksheets column G 60
Legend: Recommendations codes in OHA worksheets column G 60
Legend: Candidate requirements and assumptions codes in OHA worksheets column G (assumptions are coded with a beginning "A" and not converted to candidate requirements. 61
OHA Worksheets (multiple pages) 62

2.1. Introduction

2.1.1. Purpose and Scope

An Operational Hazard Assessment (OHA), per the guidance in **References a**, **b**, and **h**, is a qualitative assessment of hazards related to operational services that are documented in an Operational Services and Environment Definition (OSED). An assessment is made in order to identify and classify hazards that could adversely affect the services captured in the OSED, and to identify safety requirements at the service or functional level. The OHA serves as a basis for an allocation of safety objectives and requirements (ASOR) among components (e.g., airborne and ground-based components) of a Communication, Navigation, Surveillance / Air Traffic Management (CNS/ATM) system and organizations responsible for those components.

The purpose and scope of this OHA is to assess hazards related to air traffic services (ATS) supported by Automatic Dependent Surveillance-Broadcast (ADS-B), in some cases augmented by Traffic Information System-Broadcast (TIS-B), as documented in **Reference c**, and to establish candidate safety requirements related to each identified hazard. This OHA identifies stakeholders, identifies hazards related to ADS-B and TIS-B augmented ADS-B functions required to implement the ATS identified in **Reference c**, provides an assessment of each hazard, and provides candidate requirements for assuring safety as related to ADS-B and TIS-B augmented ADS-B. The term "ATS" is used throughout this document to refer to "ATS supported by ADS-B."

This OSED was developed using the guidance provided in **References a**, **b**, and **h**.

2.1.2. Background

The Federal Aviation Administration (FAA), in the interests of enhancing safety and air traffic management, and in response to the expressed desires of the aviation community, have concurred with the need to consider dependent surveillance and traffic information capabilities for the National Airspace System (NAS) CNS/ATM system. The **Reference d** Minimum Aviation System Performance Standards (MASPS) has been written to describe ADS-B system performance standards. The Safe Flight 21 and Free Flight initiatives (see **References e and f**) have developed initial operational concepts incorporating dependent surveillance capability. The Capstone project was initiated to provide ADS-B capability as an aid to visual acquisition, improve traffic flow, and enhance traffic awareness and surveillance capabilities in adverse weather conditions, especially on geographically challenging routes and at minimally equipped airports in Alaska. The Ohio Valley project was initiated to demonstrate and evaluate the capability of ADS-B to aid visual acquisition, enhance traffic awareness and surveillance capabilities, and provide conflict detection aid. This OHA was initiated to provide a basis for determining operational safety requirements related to the establishment of an FAA infrastructure for NAS-wide ADS-B and TIS-B augmented ADS-B use.

2.1.3. Acronyms

A/C	Aircraft
ADS-B	Automatic Dependent Surveillance Broadcast
ASOR	Allocation of Safety Objectives and Requirements
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
CDTI	Cockpit Display of Traffic Information
CNS	Communication, Navigation, and Surveillance
CNS/ATM	Communication, Navigation, and Surveillance/Air Traffic Management
HMI	Hazardously Misleading Information
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MASPS	Minimum Aviation System Performance Standards
NAS	National Airspace System
OHA	Operational Hazard Assessment
OSA	Operational Safety Assessment
OSED	Operational Services and Environment Definition
SIS	Signal in Space
TIS-B	Traffic Information System Broadcast
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

2.2. Chapter Organization

This chapter is organized into eight sections as follows:

- Section 2.1 provides an introduction, including purpose and scope, background, and acronyms used in the chapter.
- Section 2.2 explains the organization of the chapter.
- Section 2.3 provides a list of documents referenced in this chapter and additional bibliographical material used in the development of this chapter.
- Section 2.4 identifies the stakeholders for this effort.

- Section 2.5 describes the methodology used to perform the OHA.
- Section 2.6 shows the relationships of the operational objectives, intentions, and capabilities to the ATS assessed for hazards in the OHA.
- Section 2.7 is a summary of OHA results.
- Section 2.8 consists of worksheets used to capture the information resulting from the assessment effort, and contains lists of notes, recommendations, and candidate requirements identified during the assessment effort.

2.3. Referenced Documents and Bibliography

2.3.1. Referenced Documents

g. RTCA document DO-264, Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications

h. FAA, System Safety Handbook: Practices and Guidelines for Conducting System Safety Engineering and Management

i. FAA, Automatic Dependent Surveillance-Broadcast (ADS-B) Operational Services and Environment Definition (OSED), Review Draft, Revision 1, June 15, 2001

j. RTCA document DO-242, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)

k. FAA Safe Flight 21 Functional Specification, and Surveillance Vision Plan

l. RTCA Joint Government/Industry Roadmap for Free Flight Enhancements

m. FAA AC 25-11, Transport Category Electronic Display Systems

n. FAA, NAS Modernization, System Safety Management Program, FAA Acquisition Management System

2.3.2 Additional Bibliographical Material

f. FAA NAS CONOPS 2005, NAS Architecture, Version 4

g. FAA ADS-B Mission Need Statement #326

h. FAA ADS-B Plan

i. ICAO Manual of ATS Data Link Applications

j. ICAO Doc 4444, Annex 11, Appendix 5, Aeronautical Data Quality Requirements

k. Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems

l. SAE ARP 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

2.4. Stakeholder Identification

As this OHA is developed primarily as a basis for capturing safety requirements for the FAA infrastructure required to support operations using ADS-B and TIS-B, the stakeholders include the FAA, all potential ADS-B/TIS-B equipped aircraft operators and service providers, equipment manufacturers, and equipment installers (including airframe manufacturers). As the stakeholder community is both broad and inclusive, and not limited by the requirements of a specific applicant's project, a more specific enumeration of stakeholders is not provided.

2.5. Operational Hazard Assessment Methodology

The OHA was developed using information from the OSED as input. From the OSED, each operational objective, intention, and capability has associated with it one or more ATS supported by ADS-B and TIS-B. The OHA was developed and the information captured on the worksheets in **Section 2.8** according to the following steps:

a. Each operational objective, intention, and capability was listed in the OHA worksheets along with its associated ATS from the OSED.

b. For each ATS listed, hazards were identified that would impair the effectiveness of the service. Each hazard was described at a functional-level as a failure or malfunction related to ADS-B (and TIS-B where appropriate). Current radar systems or procedural surveillance and monitoring were assumed to be operational where existing and as described in the OSED.

c. For each hazard identified, the operating phases, and if pertinent, aircraft type and meteorological conditions, for which the related ATS is proposed to be provided were identified and listed. Where the effects and severity of a hazard would be expected to differ in different operating phases, different aircraft types (heavy versus light), or different meteorological conditions, that hazard was listed and assessed for each differing condition. For example, if a service was expected to be provided for both cruise and approach, and the severity of a hazard was expected to be different in cruise than in approach, the hazard was assessed separately for each of the two operating phases.

d. Factors expected to mitigate the hazard's severity were identified. This included factors such as service redundancy from standard ATC radar surveillance, and procedures or operational requirements limiting reliance on ADS-B and TIS-B. When considered as a mitigator, currently implemented systems and procedures associated with the service were assumed to be operating or available as described in the OSED.

e. The effect of each hazard was then described in sufficient detail to classify the severity of the hazard. Only effects that would typically be expected to occur in an authorized flight with an airworthy aircraft were considered. Unauthorized operations, flight outside the approved operating envelope of the aircraft, and flight with non-compliant equipage were considered to be outside the scope of an OHA. The description of the hazard effects take into account the mitigators identified for the hazard; however, to avoid redundancy the mitigation description was typically not repeated in the hazard effect description.

f. From the hazard description, a note as to the most likely cause of the hazard was added to the worksheet. These notes are not detailed nor comprehensive causes, but simply guides for developing fault trees for allocating requirements in the ASOR.

g. The effect of each hazard was compared against the guidance in **Table 2.5-1**, and a severity classification was identified from the table and listed in the worksheet. As noted in **Step e** above, the hazard effect takes into account the mitigators identified for the hazard. Therefore, the mitigation is "built in" to the severity classification, so to speak.

h. Based on the severity classification, a candidate qualitative probability requirement for the hazard was identified in accordance with **Table 2.5-2**. "Catastrophic" hazards must be extremely improbable. "Hazardous" hazards must be extremely remote. "Major" hazards must be remote. "Minor" hazards may be probable. "No safety effect" hazards have no probability requirement. Definitions of probability terms are provided in **Table 2.5-3**.

i. Based on severity classification, a candidate functional-level or hazard-level development assurance requirement was identified in accordance with **Table 2.5-4**. It should be noted that this identification is not necessarily at a system, software, or hardware level. The process of allocation that takes place during ASOR development will determine, based on the system architecture relevant to the service being assessed, the allocation of development assurance level candidate requirements to specific component systems, software, and hardware that provide the functionality for implementing the ATS.

j. Based on mitigation expectations, candidate procedural and other requirements were identified. It should be noted that, as the hazard effects and severity classifications take into account the mitigations for the hazard, any related candidate requirements that are not accepted for specification may invalidate both the hazard effect description and the hazard severity classification.

k. As the final step, recommendations, usually identifying other analysis types that should be undertaken for the hazard but that are not within the scope of an OHA, were identified. Typically, these recommendations relate to human action and human error analysis.

Table 2.5-1: Hazard Severity Effects

Hazard Severity:	**Hazard effects:**
Catastrophic	Result in multiple fatalities usually with loss of the vehicle.
Hazardous	Reduce the capability of the system or the operator ability to cope with adverse conditions to the extent that there would be – (1) Large reduction in safety margin or functional capability. (2) Crew physical distress or excessive workload such that operators cannot be relied upon to perform required tasks accurately or completely. (3) Serious or fatal injury to small number of occupants of aircraft (except operators).
Major	Reduce the capability of the system or the operators to cope with adverse operating conditions to the extent that there would be – (1) Significant reduction in safety margin or functional capability. (2) Significant increase in operator workload. (3) Conditions impairing operator efficiency or creating significant discomfort. (4) Physical distress to occupants of aircraft (except operators) including injuries.
Minor	Do not significantly reduce system safety. Actions required by operators are well within their capabilities. Effects include – (1) Slight reduction in safety margin or functional capabilities. (2) Slight increase in workload such as routine flight plan changes. (3) Some physical discomfort to occupants of aircraft (except operators).
No Safety Effect	Have no effect on safety.

Table 2.5-2: Hazard Classification and Safety Objectives Relationship

Severity / Probability	No Safety Effect 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Probable					
Remote					
Extremely Remote					
Extremely Improbable					

High Risk
Medium Risk
Low Risk

Note for **Table 2.5-2**: Candidate requirements are identified to assure that risk is within the medium or low risk zones of the table, and not within the high risk zone.

Table 2.5-3: Definition of Probability Terms

Probable	Qualitative: Anticipated to occur one or more times during the entire system/operational life of an item. Quantitative: None.
Remote	Qualitative: Unlikely to occur to each item during its total life. May occur several time in the life of an entire system or fleet. Quantitative: Probability of occurrence per operational hour is less than or equal to 1×10^{-5}.
Extremely Remote	Qualitative: Not anticipated to occur to each item during its total life. May occur a few times in the life of an entire system or fleet. Quantitative: Probability of occurrence per operational hour is less than or equal to 1×10^{-7}.
Extremely Improbable	Qualitative: So unlikely that it is not anticipated to occur during the entire operational life of an entire system or fleet. Quantitative: Probability of occurrence per operational hour is less than or equal to 1×10^{-9}.

Table 2.5-4: Hazard Classification and Development Assurance Level Relationship

Hazard Classification	Development Assurance Level
Catastrophic	A
Hazardous	B
Major	C
Minor	D
No Safety Effect	E

2.6. Operational Objectives, Intentions, and Capabilities and Air Traffic Service Descriptions

Table 2.6-1 identifies each objective, intention, and capability and shows the related ATS which were assessed.

Table 2.6-1: Objectives, Intentions, Capabilities and ATS Relationships

	Operational Objective, Intention, Capability Title		Implementing Air Traffic Services
1	Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only	1.1	ADS-B for enhanced visual acquisition of aircraft during visual approach.
2	Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only	2.1	ADS-B for enhanced visual acquisition of aircraft during visual approach using call signs.
3	Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B	3.1	TIS-B augmented ADS-B for enhanced visual acquisition of aircraft during visual approach.
4	Approach Spacing for Visual Approaches	4.1	ADS-B for achieving and maintaining desired in-trail spacing during visual approach.
5	Approach Spacing for Instrument Approaches	5.1	ADS-B for achieving and maintaining desired in-trail spacing during instrument approaches with ATC monitoring.
6	Departure Spacing / Clearance (VMC in Radar)	6.1	ADS-B for achieving and maintaining desired in-trail spacing during visual departure with ATC monitoring.
7	Approaches to Closely Spaced Parallel Runways	7.1	ADS-B for proximate traffic awareness on instrument approach to closely spaced parallel runways.
		7.2	ADS-B for conflict detection/alerting/resolution aid.
8	Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)	8.1	ADS-B for aided "see and avoid."
9	Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)	9.1	TIS-B augmented ADS-B for aided "see and avoid."
10	Conflict Detection	10.1	ADS-B for conflict detection.
11	Conflict Resolution	11.1	ADS-B for conflict detection and tactical resolution.
12	Pilot Situational Awareness Beyond Visual Range	12.1	TIS-B augmented ADS-B for traffic awareness beyond visual range.
13	Delegated air-to-air self separation for one-in-one-out airspace	13.1	ADS-B for awareness of A/C traffic in non-radar airspace.
14	Runway and Final Approach Occupancy Awareness (Using ADS-B only)	14.1	ADS-B for awareness of traffic in final approach path and on runway surface.
15	Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)	15.1	TIS-B augmented ADS-B for awareness of traffic in final approach path and on runway surface.
16	Airport Surface Situational Awareness	16.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.

Table 2.6-1: Objectives, Intentions, Capabilities and ATS Relationships (continued)

17	Enhanced IMC airport surface operations	17.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.
18	Enhance Existing Surface Surveillance with ADS-B	18.1	ADS-B augmented surface surveillance for surface traffic management.
19	Surveillance Coverage at Airports without Existing Surface Surveillance	19.1	ADS-B for surface traffic management.
20	Center situational awareness with ADS-B	20.1	ADS-B for center traffic situational awareness in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.
21	Radar-like Services with ADS-B	21.1	ADS-B for radar-like services in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.
22	Tower Situational Awareness Beyond Visual Range	22.1	ADS-B for traffic awareness beyond tower visual range.
23	Radar Augmented with ADS-B in Terminal Airspace	23.1	ADS-B augmented radar surveillance for terminal area air traffic management.
		23.2	ADS-B augmented radar surveillance for terminal area reduced separation.
24	Radar Augmentation with ADS-B to achieve existing separation standards in terminal airspace	24.1	ADS-B augmented radar surveillance for terminal area air traffic separation.
25	Radar Augmented with ADS-B in En Route Airspace	25.1	ADS-B augmented radar surveillance for en-route air traffic management.
		25.2	ADS-B augmented radar surveillance for en-route reduced separation.
26	Radar Augmentation with ADS-B to achieve existing separation standards in en route airspace	26.1	ADS-B augmented radar surveillance for en-route separation.
27	Reduced separation standards with ADS-B	27.1	ADS-B augmented radar surveillance for reduced separation.

2.7. Summary of Assessment Results

This section provides a summary of the results tabulated in **Section 2.8**. The summary includes a list of operational hazards ordered by severity classification and a list of candidate operational safety requirements and assumptions for consideration when developing requirements for ADS-B, including a Safety and Performance Requirements (SPR) document. The candidate operational safety requirements are simple summary statements for reference, whereas more formal wording and wording modifications related to differences in airborne, surface vehicle, and ATC ground equipage will be developed in the ASOR.

A very small number of basic hazards were identified which deal with functional loss or hazardously misleading information, but the process of assessing each of these under different ATS and operating phase conditions results in the larger total number of individual assessments in **Section 2.8**, as summarized in this section. For example, a hazard identified as "*Hazardously misleading ADS-B information for a single aircraft*" could potentially be assessed some twenty or more times based on the number of ATS and operating phase differences. Also, because HMI for a single aircraft would most likely be the result of failures on a transmitting end while HMI for multiple aircraft would most likely be

due to failures on a receiving end (but with common cause failures of multiple transmissions also considered), both cases may have had to have been considered where the effect scenario is essentially the same, in order to account for differences in equipment failure causes on the transmitting and receiving ends. Some of this multiplicity will be consolidated when the ASOR determines combined requirements for a single service's equipage. **Table 2.7-1** lists operational hazards assessed as "catastrophic" hazards under conditions pertaining to the related ATS. **Table 2.7-2** lists operational hazards assessed as "hazardous" hazards under conditions pertaining to related ATS. **Table 2.7-3** lists operational hazards assessed as "major" hazards under conditions pertaining to related ATS. **Table 2.7-4** lists operational hazards assessed as "minor" hazards under conditions pertaining to related ATS. Hazards assessed as having "no safety effect" are not listed, but can be found in the full assessment results tabulation (OHA worksheets) in **Section 2.8**.

Each of the above mentioned tables contains six columns:

- The first column (far left) contains the operational hazards with their identifiers from the tabulation in **Section 2.8**.
- The second column contains the ATS identifiers under which the operational hazard severity classification pertains.
- The third column contains the identifier of the objective, intention, and capability under which the operational hazard severity classification pertains.
- The fourth column contains the codes for the operating phases for which the hazard was considered (see **Section 2.8** for codes).
- The fifth column contains the recommendation codes for other analyses which are recommended for the related hazard but are not within the scope of the OHA. Blank cells indicate that no recommendation was identified for that particular hazard (see **Section 2.8** for codes).
- The sixth column (far right) contains candidate safety requirements identifier codes related to the respective hazard and ATS (see **Section 2.8** for codes).

All identifier codes for operating phases, recommendations, and candidate requirements, along with the full text of each, can be found in the legends for the OHA worksheets in **Section 2.8**.

It should be noted that candidate requirements have been identified at the hazard level. A top-down allocation of these candidate requirements, as well as the identification of lower level candidate requirements, will be determined during the process of developing the ASOR portion of the OSA. A complete set of operational safety requirements will be tabulated in the ASOR.

Table 2.7-1: Operational Hazards Assessed as "Catastrophic"

Catastrophic Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
16.1.4 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	16.1	16	S1-zero visibility at an uncontrolled airport or a controlled airport without surface radar	RH2	CP1, CL1
16.1.6 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	16.1	16	S1-zero visibility at an uncontrolled airport or a controlled airport without surface radar	RH2	CP1, CL1
16.1.9 Hazardously misleading map display.	16.1	16	S1-zero visibility at an uncontrolled airport or a controlled airport without surface radar	RH2	CP1, CL1

Table 2.7-2: Operational Hazards Assessed as "Hazardous"

Hazardous Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
7.1.3 Hazardously misleading ADS-B information for a single aircraft.	7.1	7	F4	RH2	CA10, CP2, CL2
7.1.4 Hazardously misleading ADS-B information for multiple aircraft.	7.1	7	F4	RH2	CA10, CP2, CL2
10.1.5 Hazardously misleading ADS-B information for a single aircraft.	10.1	10	F1-F4	RH2	CP2, CL2, (CA10 for closely spaced instrument approaches)
10.1.6 Hazardously misleading ADS-B information for multiple aircraft.	10.1	10	F1-F4	RH2	CP2, CL2, (CA10 for closely spaced instrument approaches)
11.1.3 Hazardously misleading ADS-B information for a single aircraft.	11.1	11	F1-F4	RH2	CP2, CL2, (CA10 for closely spaced instrument approaches)
11.1.4 Hazardously misleading ADS-B information for multiple aircraft.	11.1	11	F1-F4	RH2	CP2, CL2, (CA10 for closely spaced instrument approaches)
21.1.4 Hazardously misleading ADS-B information for multiple aircraft.	21.1	21	F1-F3	RH3	CP2, CL2

Table 2.7-3: Operational Hazards Assessed as "Major"

Major Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
5.1.2 Hazardously misleading ADS-B information for a single aircraft.	5.1	5	F3-F4	RH2	CP3, CL3, CA8
5.1.3 Hazardously misleading ADS-B information for multiple aircraft..	5.1	5	F3-F4	RH2	CP3, CL3, CA8
5.1.4 Loss of aircraft ADS-B information with loss of radar surveillance capability	5.1	5	F3-F4		CP3, CL3, CA8
5.1.5 Loss of aircraft ADS-B information with loss of communications capability.	5.1	5	F3-F4		CP3, CL3, CA8
5.1.6 Aircraft ADS-B hazardously misleading information with loss of communications capability.	5.1	5	F3-F4		CP3, CL3, CA8
7.1.1 Loss of ADS-B information for a single aircraft.	7.1	7	F4		CA10, CP3, CL3
7.1.2 Loss of ADS-B information from multiple aircraft.	7.1	7	F4		CA10, CP3, CL3
10.1.2 Loss of ADS-B information for a single aircraft.	10.1	10	F4 (Closely spaced parallel instrument approach or for operations requiring a conflict detection system).		CP3, CL3, (CA10 for closely spaced instrument approaches)
10.1.4 Loss of ADS-B information from multiple aircraft.	10.1	10	F4 (Closely spaced parallel instrument approach or for operations requiring a conflict detection system).		CP3, CL3, (CA10 for closely spaced instrument approaches)
11.1.1 Loss of ADS-B information for a single aircraft.	11.1	11	F1-F4		CA1, A2, A3, A4, (CA10 for closely spaced instrument approaches), CP3, CL3
11.1.2 Loss of ADS-B information from multiple aircraft.	11.1	11	F1-F4		CA1, A2, A3, A4, (CA10 for closely spaced instrument approaches), CP3, CL3
13.1.3 Hazardously misleading ADS-B information for a single aircraft.	13.1	13	F1-F4	RH2, RS2	CA5, CA11, CO1, CP3, CL3
13.1.6 Hazardously misleading ADS-B information for multiple aircraft.	13.1	13	F1-F4	RH2, RS2	CA5, CA11, CO1, CP3, CL3

Table 2.7-3: Operational Hazards Assessed as "Major" (continued)

Major Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
21.1.3 Hazardously misleading ADS-B information for a single aircraft.	21.1	21	F1-F3	RH3	CP3, CL3
23.2.3 Hazardously misleading ADS-B information for a single aircraft.	23.2	23	F1, F3, F4	RH3	CA12, CP3, CL3
23.2.4 Hazardously misleading ADS-B information for multiple aircraft.	23.2	23	F1, F3, F4	RH3	CA12, CP3, CL3
25.2.3 Hazardously misleading ADS-B information for a single aircraft.	25.2	25	F2	RH3	CA12, CP3, CL3
25.2.4 Hazardously misleading ADS-B information for multiple aircraft.	25.2	25	F2	RH3	CA12, CP3, CL3

Table 2.7-4: Operational Hazards Assessed as "Minor"

Minor Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
1.1.3 Hazardously misleading ADS-B information for a single aircraft.	1.1	1	F3-F4	RH1, RH2	CA1, A2, A3, CL4
1.1.4 Hazardously misleading ADS-B information for multiple aircraft.	1.1	1	F3-F4	RH1, RH2	CA1, A2, A3, CL4
2.1.3 Hazardously misleading ADS-B information for a single aircraft.	2.1	2	F3-F4	RH1, RH2	CA1, A2, A3, CA6, CL4
2.1.4 Hazardously misleading ADS-B information for multiple aircraft.	2.1	2	F3-F4	RH1, RH2	CA1, A2, A3, CA6, CL4
3.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft.	3.1	3	F3-F4	RH1, RH2	CA1, A2, A3, CA6, CL4
3.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft.	3.1	3	F3-F4	RH1, RH2	CA1, A2, A3, CA6, CL4
4.1.2 Hazardously misleading ADS-B information for a single aircraft.	4.1	4	F3-F4	RH1, RH2	CA1, A2, A3, CA7, CL4
5.1.1 Loss of ADS-B information for a single aircraft.	5.1	5	F3-F4		CL4, CA8
6.1.2 Hazardously misleading ADS-B information for a single aircraft.	6.1	6	T1-heavy aircraft	RH2	CA1, CA9, CL4
6.1.3 Hazardously misleading ADS-B information for a single aircraft.	6.1	6	T1-light aircraft	RH2	CA1, CA9, CL4
6.1.4 Hazardously misleading ADS-B information for multiple aircraft.	6.1	6	T1-heavy aircraft	RH2	CA1, CA9, CL4
6.1.5 Hazardously misleading ADS-B information for multiple aircraft.	6.1	6	T1-light aircraft	RH2	CA1, CA9, CL4
8.1.3 Hazardously misleading ADS-B information for a single aircraft.	8.1	8	S1, T1, F1-F4, L1	RH1, RH2	CA1, A2, A3, CL4
8.1.4 Hazardously misleading ADS-B information for multiple aircraft.	8.1	8	S1, T1, F1-F4, L1	RH1, RH2	CA1, A2, A3, CL4
9.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft.	9.1	9	S1, T1, F1-F4, L1	RH1, RH2	CA1, A2, A3, CL4
9.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft.	9.1	9	S1, T1, F1-F4, L1	RH1, RH2	CA1, A2, A3, CL4

Table 2.7-4: Operational Hazards Assessed as "Minor" (continued)

Minor Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
12.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft.	12.1	12	F1-F3	RH1, RH2	CA1, A2, A3, CL4
12.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft.	12.1	12	F1-F3	RH1, RH2	CA1, A2, A3, CL4
13.1.4 Hazardously misleading ADS-B information for a single aircraft.	13.1	13	T1-Heavy aircraft	RH2, RS2	CA5, CA11, CO1, CL4
13.1.5 Hazardously misleading ADS-B information for a single aircraft.	13.1	13	T1-light aircraft	RH2, RS2	CA5, CA11, CO1, CL4
13.1.7 Hazardously misleading ADS-B information for multiple aircraft.	13.1	13	T1-Heavy Aircraft	RH2, RS2	CA5, CA11, CO1, CL4
13.1.8 Hazardously misleading ADS-B information for multiple aircraft.	13.1	13	T1-light aircraft	RH2, RS2	CA5, CA11, CO1, CL4
14.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	14.1	14	F4, L1	RH1, RH2	CA1, A2, A3, A4, CL4
14.1.4 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	14.1	14	F4, L1	RH1, RH2	CA1, A2, A3, A4, CL4
15.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft or surface vehicle.	15.1	15	F4, L1	RH1, RH2	CA1, A2, A3, A4, CL4
15.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft and surface vehicles.	15.1	15	F4, L1	RH1, RH2	CA1, A2, A3, A4, CL4
16.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	16.1	16	S1- VMC or IMC, not with zero visibility	RH2	CA1, A2, A3, A4, CL4
16.1.5 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	16.1	16	S1- VMC or IMC, not with zero visibility	RH2	CA1, A2, A3, A4, CL4
16.1.8 Hazardously misleading map display.	16.1	16	S1 - VMC or IMC, not with zero visibility	RH2	CA1, A2, A3, A4, CL4

Table 2.7-4: Operational Hazards Assessed as "Minor" (continued)

Minor Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
17.1.all hazardously misleading information hazards	17.1	17	S1- VMC or IMC, not with zero visibility	RH2	CA1, A2, A3, A4, CL4
18.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	18.1	18	S1	RH3	CA1, A2, A3, A4, CL4
18.1.4 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	18.1	18	S1	RH3	CA1, A2, A3, A4, CL4
19.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	19.1	19	S1	RH3	CA1, A2, A3, A4, CL4
19.1.4 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	19.1	19	S1	RH3	CA1, A2, A3, A4, CL4
20.1.3 Hazardously misleading ADS-B information for a single aircraft.	20.1	20	F1-F3	RH3	CA1, A2, A3, A4, CL4
20.1.4 Hazardously misleading ADS-B information for multiple aircraft.	20.1	20	F1-F3	RH3	CA1, A2, A3, A4, CL4
21.1.1 Loss of ADS-B information for a single aircraft.	21.1	21	F1-F3	RH3	CL4, Reversion to standard non-radar procedures: CA1, A2, A3, A4
21.1.2 Loss of ADS-B information from multiple aircraft.	21.1	21	F1-F3	RH3	CL4, Reversion to standard non-radar procedures: CA1, A2, A3, A4
22.1.3 Hazardously misleading ADS-B information for a single aircraft.	22.1	22	F1-F3	RH3	CA1, A2, A3, A4, CL4
22.1.4 Hazardously misleading ADS-B information for multiple aircraft.	22.1	22	F1-F3	RH3	CA1, A2, A3, A4, CL4
23.1.3 Hazardously misleading ADS-B information for a single aircraft.	23.1	23	F1, F3, F4	RH3	CA1, A2, A3, A4, CL4
23.1.4 Hazardously misleading ADS-B information for multiple aircraft.	23.1	23	F1, F3, F4	RH3	CA1, A2, A3, A4, CL4
23.2.1 Loss of ADS-B information for a single aircraft.	23.1	23	F1, F3, F4		CA12, CL4
23.2.2 Loss of ADS-B information from multiple aircraft.	23.1	23	F1, F3, F4		CA12, CL4
25.1.3 Hazardously misleading ADS-B information for a single aircraft.	25.1	25	F2	RH3	CA1, A2, A3, A4, CL4

Table 2.7-4: Operational Hazards Assessed as "Minor" (continued)

Minor Hazards					
Operational Hazard	**ATS**	**Objective /Intention /Capability**	**Operating Phase**	**Recom-mendations**	**Candidate Safety Requirements**
25.1.4 Hazardously misleading ADS-B information for multiple aircraft.	25.1	25	F2	RH3	CA1, A2, A3, A4, CL4
25.2.1 Loss of ADS-B information for a single aircraft.	25.2	25	F2		CA12, CL4
25.2.2 Loss of ADS-B information from multiple aircraft.	25.2	25	F2		CA12, CL4

2.8. Tabulation of Operational Hazard Assessment Results

This section contains the tabulated worksheets used to assess each operational objective, intention, and capability, with its attendant ATS. Also included in this section are lists of operating phases, notes, recommendations, and candidate requirements discovered and identified during the assessment process, along with their respective identification codes used in the worksheets and elsewhere in this chapter. The OHA worksheets follow the worksheet related notes and legends which start on the next page of this section.

Notes for the OHA worksheets

1. Hazardously misleading information (HMI) is, by definition, misleading information not associated with suitable warning.

2. An OHA has a specific focus that will not provide answers to some questions. "Recommendations," in column G, can be used for capturing concerns that arose during the course of OHA efforts, but require a different type of analysis to provide answers.

3. The variation in operational hazard descriptions in column B is small and repeated for most services as all hazards for this assessment are related to either loss of, or hazardously misleading information from, the dependent surveillance function. However, the severity of a repeated hazard may vary depending on the service requiring the dependent surveillance function, flight rules and visual conditions under which the service is provided (VFR, IFR, VMC, MVMC, IMC), and the operating phase. The assessment purpose is to determine the hazard severity and candidate requirements for the same hazards under differing services and conditions.

4. Italicized operational hazard severity classifications in column E indicate that these are initial proposals by the assessment author, but that finalization requires consensus input by pilots, air traffic control specialists, and flight standards specialists. Italics will be removed when the project team leader agrees that the classifications have been finalized for this assessment effort.

5. The effects (column D) and their severities (column E) are what would typically be expected if the hazard were to occur when the aircraft is operating within its approved design and airworthiness envelopes, with the air crew and/or air traffic controller performing their tasks in accordance with accepted airmanship and procedures.

6. Worksheet legends are as follows:

Legend: System Operating Phase codes in OHA worksheets column C

Operating Phases				
SURFACE	TAKEOFF	IN-FLIGHT		LANDING
S1 Surface	T1 Takeoff	F1 Climb F2 Cruise F3 Descent	F4 Approach F5 Other (Describe)	L1 Landing

Legend: Notes codes in OHA worksheets column G

Code	Note
NA1	This hazard would likely be caused by loss of surveillance information broadcast by a single aircraft to other aircraft (equipment failure or loss of signal in space).
NA2	This hazard would likely be caused by loss related failure of the ADS-B equipment on a single receiving aircraft, but could be caused by area-wide interference with the signal in space.
NA3	This hazard would likely be caused by misleading surveillance information broadcast by a single aircraft to other aircraft (navigation system HMI, ADS-B faults, corruption of signal in space).
NA4	This hazard would likely be caused by HMI related malfunction of the ADS-B equipment on a single receiving aircraft or corruption of multiple signals in space.
NT1	This hazard would likely be caused by loss of surveillance information broadcast by a single aircraft to other aircraft and/or loss of transponder signal from a single aircraft to ATC radar (equipment failure or loss of signal in space).
NT2	This hazard would likely be caused by loss related failure of the ADS-B/TIS-B equipment on a single receiving aircraft, loss of ATC transponder input or processing capability, loss of ATC TIS-B processing and output capability, or by area-wide interference with signals in space.
NT3	This hazard would likely be caused by misleading surveillance information broadcast by a single aircraft to other aircraft or ground radar (navigation system HMI, ADS-B faults, transponder faults, corruption of signal in space).
NT4	This hazard would likely be caused by HMI related failure of the ADS-B equipment on a single receiving aircraft, by HMI related ATC processing faults, or by area-wide corruption of signals in space.
NG1	This hazard would likely be caused by ATC ground system failures or malfunctions.
NP1	The goal of this application is to provide an alternative to the Precision Runway Monitor (PRM) system for providing the required safety for conducting parallel ILS approaches for the minimum wake turbulence independence of 2500 feet, or potentially even closer spacing. Dependent surveillance therefore replaces a system without which the procedure would not be approved.

Legend: Recommendations codes in OHA worksheets column G

Code	Recommendation
RH1	Human factors specialists, flight standards specialists, and pilots should assess the potential for excessive head-down time, and recommend mitigation if required.
RH2	Human factors specialists, flight standards specialists, and pilots should assess the effect of compelling erroneous information in the cockpit, and recommend mitigation if required.
RH3	Human factors specialists and air traffic control specialists should assess ATC ground system failure and malfunction cues considering controller ability to recognize erroneous display data, and recommend mitigation if required.
RS1	Human factors and flight standards specialists should assess the capability of flight crew to maintain positive ID of displayed targets and, working with aircraft certification specialists, recommend standards for acceptable display. Standards, if not already existing, should be incorporated into design requirements (e.g., MOPS/TSO) for ADS-B systems providing this capability.
RS2	Flight standards specialists should assess recovery procedures for adequacy, and recommend mitigation if required.

Legend: Candidate requirements and assumptions codes in OHA worksheets column G (assumptions are coded with a beginning "A" and not converted to candidate requirements.

Code	Candidate Requirement
CA1	Current requirements for visual acquisition shall be maintained.
A2	Current procedures for the assessed flight phases in VMC under VFR shall be maintained.
A3	Current procedures for the assessed flight phases in MVMC under VFR shall be maintained.
A4	Current procedures for the assessed flight phases in IMC under IFR shall be maintained.
CA5	Procedures shall be developed to assure that the aircrew maintains target awareness and reverts to procedural separation with reporting if a target is lost or questionable.
CA6	ATC traffic advisory procedures shall be modified for using call signs for ADS-B equipped aircraft.
CA7	Procedures shall be modified to enable instructions to the crew to allow variability in approach spacing in relationship to the lead aircraft in VMC and MVMC.
CA8	Current instrument procedures shall be maintained but modified to enable instructions to the crew to allow variability in approach spacing in relationship to the lead aircraft in IMC and to revert to mitigating procedures without sole reliance on ADS-B for separation in the case of total communications failure.
CA9	Takeoff and departure procedures shall be developed for following aircraft to utilize dependent surveillance for takeoff timing.
CA10	New approach procedures shall be developed for equipped aircraft to use dependent surveillance for independent approaches, and pairwise equipped aircraft to use dependent surveillance for dependent approaches.
CA11	Procedures shall be developed: a. to determine when controllers are relieved of current control responsibilities for an ADS-B/CTDI equipped aircraft; b. for the flight crew assuming its own separation responsibilities; and c. for action to be taken in the case of failures of the service-enabling systems and equipment.
CA12	Procedures and requirements for reduced separation shall be developed, including procedures for reversion to standard separation minima.
CA13	Procedures shall be developed for the use of conflict detection information from ADS-B systems equipped with a conflict detection function.
CA14	Procedures shall be developed for the use of conflict resolution information from ADS-B systems equipped with a conflict resolution function.
CP1	The occurrence of the failure condition must be shown to be, at most, extremely improbable.
CP2	The occurrence of the failure condition must be shown to be, at most, extremely remote.
CP3	The occurrence of the failure condition must be shown to be, at most, improbable.
CL1	Development assurance at failure condition level shall be level A.
CL2	Development assurance at failure condition level shall be level B or better.
CL3	Development assurance at failure condition level shall be level C or better.
CL4	Development assurance at failure condition level shall be level D or better.
CO1	Operations using this service and capability shall only be approved if the aircraft is equipped to broadcast its own call sign designator and display other aircraft call sign designators on a CDTI.

OHA Worksheets (multiple pages)

Operational Objective /Intention /Capability:	**1 Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirement**
1.1 ADS-B for enhanced visual acquisition of aircraft during visual approach.	1.1.1 Loss of ADS-B information for a single aircraft.	F3-F4	An aircraft experiencing broadcast failures will not show up on other aircraft CDTI. Lead aircraft target will not show up on CDTI for the in-trail pilot. Visual acquisition time by other pilots will be unenhanced. Would result in no more than inconvenience to operator.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3
	1.1.2 Loss of ADS-B information from multiple aircraft.	F3-F4	An aircraft experiencing reception or processing failures will not provide the pilot with aided visual acquisition of ADS-B equipped aircraft, including lead target aircraft. Would result in no more than inconvenience to operator.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA2 Recommendations: RH1 Candidate Reqs: CA1, A2, A3

Operational Objective /Intention /Capability:	**1 Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirement**
	1.1.3 Hazardously misleading ADS-B information for a single aircraft.	F3-F4	An aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots, including in-trail pilot, may experience minor confusion or assume that the aircraft broadcasting HMI is not the ATC relayed target. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**1 Enhanced Visual Approaches: Visual Acquisition with Existing Procedures, ADS-B Only**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirement**
	1.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F3-F4	An aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may experience minor confusion, assume that a CDTI target is not the ATC relayed target, or assume more traffic than actual. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA4 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**2 Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
2.1 ADS-B for enhanced visual acquisition of aircraft during visual approach using call signs.	2.1.1 Loss of ADS-B information for a single aircraft.	F3-F4	The aircraft experiencing broadcast failures will not show up on other aircraft CDTI. Lead aircraft target will not show up on CDTI for the in-trail pilot. Visual acquisition time by other pilots will be unenhanced with most immediate effect likely being on the in-trail pilot. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3, CA6
	2.1.2 Loss of ADS-B information from multiple aircraft.	F3-F4	An aircraft experiencing broadcast failures will not show up on other aircraft CDTI. Lead aircraft target will not show up on CDTI for the in-trail pilot. Visual acquisition time by other pilots will be unenhanced with most immediate effect likely being on the in-trail pilot. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA2 Recommendations: RH1 Candidate Reqs: CA1, A2, A3, CA6

Operational Objective /Intention /Capability:	**2 Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	2.1.3 Hazardously misleading ADS-B information for a single aircraft.	F3-F4	The aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots, including in-trail pilot, may experience minor confusion or assume that the aircraft broadcasting HMI is not the ATC relayed target. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CA6, CL4

Operational Objective /Intention /Capability:	**2 Enhanced Visual Approaches: Visual Acquisition with New Procedures Using ADS-B Only**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	2.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F3-F4	The aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may experience minor confusion, assume that a CDTI target is not the ATC relayed target, or assume more traffic than actual. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NA4 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CA6, CL4

Operational Objective /Intention /Capability:	**3 Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
3.1 TIS-B augmented ADS-B for enhanced visual acquisition of aircraft during visual approach.	3.1.1 Loss of TIS-B augmented ADS-B information for a single aircraft.	F3-F4	The aircraft experiencing broadcast failures (or transponder failure for non-ADS-B equipped aircraft) will not show up on other aircraft CDTI. (Aircraft experiencing transponder failure may not show up on the ATC display and will not show up on TCAS/ACAS; however, this assessment is not assessing hazards from transponder failure except as related to the effect on TIS-B augmented ADS-B). Lead aircraft target will not show up on CDTI for the in-trail pilot. Visual acquisition time by other pilots will be unenhanced with most immediate effect likely being on the in-trail pilot. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NT1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3, CA6

Operational Objective /Intention /Capability:	**3 Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	3.1.2 Loss of TIS-B augmented ADS-B information from multiple aircraft.	F3-F4	The aircraft experiencing reception or processing failures will not provide the pilot with aided visual acquisition of ADS-B and transponder equipped aircraft, including lead target aircraft. Failures of ATC transponder input or TIS-B processing or output capability will result in multiple aircraft not receiving display data for multiple transponder-only equipped aircraft. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NT2 Recommendations: RH1 Candidate Reqs: CA1, A2, A3, CA6

Operational Objective /Intention /Capability:	**3 Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	3.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft.	F3-F4	The aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data and may show as a dual target. Other pilots, including an in-trail pilot, may experience minor confusion or assume that the aircraft broadcasting HMI is not the ATC relayed target. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NT3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CA6, CL4

Operational Objective /Intention /Capability:	**3 Enhanced Visual Approaches: Visual Acquisition with New Procedures using ADS-B and TIS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	3.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft.	F3-F4	The aircraft experiencing HMI due to on-board equipment failure will have multiple erroneously positioned and multiple dual targets on its CDTI, or other erroneous data. Aircraft receiving HMI from ATC may also have multiple dual targets. Pilots may experience confusion, assume that a CDTI target is not the ATC relayed target, or assume more traffic than actual. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition of ATC relayed targets remains in effect.	Notes: NT4 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CA6, CL4

Operational Objective /Intention /Capability:	**4 Approach Spacing for Visual Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
4.1. ADS-B for achieving and maintaining desired in-trail spacing during visual approach.	4.1.1 Loss of ADS-B information for a single aircraft.	F3-F4	Lead aircraft target will not show up on CDTI for the in-trail pilot. Arrival and approach spacing accuracy will be unenhanced with most immediate effect on the in-trail pilot. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual spacing, and the requirement for visual spacing behind lead aircraft remains in effect.	Notes: NA1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3, CA7
	4.1.2 Hazardously misleading ADS-B information for a single aircraft.	F3-F4	Lead aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. In-trail pilot, may experience minor confusion. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided process of visual spacing, and the requirement for visual spacing behind lead aircraft remains in effect.	Notes: NA3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CA7, CL4

Operational Objective /Intention /Capability:	**5 Approach Spacing for Instrument Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
5.1. ADS-B for achieving and maintaining desired in-trail spacing during instrument approaches with ATC monitoring.	5.1.1 Loss of ADS-B information for a single aircraft.	F3-F4	Lead aircraft target will not show up on CDTI for the in-trail pilot. ATC monitoring remains. Reversion to ATC instructions required, possibly with speed reductions for following aircraft. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	ATC monitoring and communications.	Notes: NA1 Candidate Reqs: CL4, CA8

Operational Objective /Intention /Capability:	**5 Approach Spacing for Instrument Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	5.1.2 Hazardously misleading ADS-B information for a single aircraft.	F3-F4	Lead aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. In-trail pilot would be expected to experience some confusion or rely on erroneous information until receiving instructions from ATC based on ATC monitoring. Trailing pilot may reduce separation based on erroneous data with a lag time in ATC corrective action instructions. Results may include a significant reduction in safety margins or significant increase in operator workload.	*Major*	ATC monitoring and communications.	Notes: NA3 Recommendations: RH2 Candidate Reqs: CP3, CL3, CA8

Operational Objective /Intention /Capability:	**5 Approach Spacing for Instrument Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	5.1.3 Hazardously misleading ADS-B information for multiple aircraft.	F3-F4	Trailing aircraft with HMI will see other aircraft on CDTI in the wrong position or with other incorrect data. In-trail pilot would be expected to experience some confusion or rely on erroneous information until receiving instructions from ATC based on ATC monitoring. Trailing pilot may reduce separation based on erroneous data with a lag time in ATC corrective action instructions. Results may include a significant reduction in safety margins or significant increase in operator workload.	*Major*	ATC monitoring and communications.	Notes: NA4 Recommendations: RH2 Candidate Reqs: CP3, CL3, CA8

Operational Objective /Intention /Capability:	**5 Approach Spacing for Instrument Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	5.1.4 Loss of aircraft ADS-B information with loss of radar surveillance capability	F3-F4	In-trail aircraft has no information on lead aircraft position, or only communicated information based on position reporting. ATC is monitoring by communications only and not by radar. The effect would be essentially the same as an ATC radar failure or aircraft transponder failure without ADS-B considerations. Results may include a significant reduction in safety margins or significant increase in operator workload.	*Major*	Communications and procedures for maintaining approach spacing or rerouting to alternate airport.	Notes: Hazard caused by a combination of dependent surveillance, and ground system surveillance failures or aircraft transponder failure, or EMI on SIS. Candidate Reqs: CP3, CL3, CA8

Operational Objective /Intention /Capability:	**5 Approach Spacing for Instrument Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	5.1.5 Loss of aircraft ADS-B information with loss of communications capability.	F3-F4	Affected aircraft has no information on other aircraft position, and no means of obtaining instructions. Results may include a significant reduction in safety margins or significant increase in operator workload. The effect would be essentially the same as a loss of all communications capability for a monitored non-ADS-B equipped single aircraft, which is currently assessed as a major failure condition per AC 25-11 (Reference g).	*Major*		Notes: Hazard caused by a combination of dependent surveillance failures or EMI on SIS, and total communications failure in a single aircraft. Candidate Reqs: CP3, CL3, CA8

Operational Objective /Intention /Capability:	**5 Approach Spacing for Instrument Approaches**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	5.1.6 Aircraft ADS-B hazardously misleading information with loss of communications capability.	F3-F4	In trail aircraft has erroneous information on lead aircraft position and no means of obtaining ATC instructions. Without ADS-B monitoring, a pilot would normally be expected to take action to assure separation maintenance; however, if no cues as to ADS-B malfunction are available, the pilot may fail to take mitigating action unless procedures are in place to reduce speed or take other mitigating action in case of total communications failure (candidate requirement CA8). Results may include a significant reduction in safety margins or significant increase in operator workload.	*Major*	Candidate requirement CA8.	Notes: Hazard caused by a combination of dependent surveillance system malfunctions or EMI on SIS, and communications failures. Candidate Reqs: CP3, CL3, CA8

Operational Objective /Intention /Capability:	**6 Departure Spacing / Clearance (VMC in Radar)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
6.1. ADS-B for achieving and maintaining desired in-trail spacing during visual departure with ATC monitoring.	6.1.1 Loss of ADS-B information for a single aircraft.	T1	Lead aircraft target will not show up on CDTI for the in-trail pilot. Arrival and approach spacing accuracy will be unenhanced with most immediate effect on the in-trail pilot. Reversion to ATC takeoff clearance based on ATC monitoring. Would result in no more than inconvenience.	*No Safety Effect*	The failure would be obvious. Reversion to ATC takeoff clearance based on ATC monitoring.	Notes: NA1 Recommendations: RH1 Candidate Reqs: CA1, CA9

Operational Objective /Intention /Capability:	**6 Departure Spacing / Clearance (VMC in Radar)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	6.1.2 Hazardously misleading ADS-B information for a single aircraft.	T1	Lead aircraft will appear on other aircraft CDTI in the wrong position or with other incorrect data. In-trail pilot, may experience slight confusion or rely on erroneous information and takeoff prematurely. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected under VMC by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies.	*Minor*		Notes: NA3 Recommendations: RH2 Candidate Reqs: CA1, CA9, CL4

Operational Objective /Intention /Capability:	**6 Departure Spacing / Clearance (VMC in Radar)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	6.1.3 Hazardously misleading ADS-B information for a single aircraft.	T1-light aircraft	Lead aircraft will appear on other aircraft CDTI in the wrong position or with other incorrect data. In-trail pilot, may experience confusion or rely on erroneous information and takeoff prematurely. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected under VMC by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies	*Minor*		Notes: NA3 Recommendations: RH2 Candidate Reqs: CA1, CA9, CL4

Operational Objective /Intention /Capability:	**6 Departure Spacing / Clearance (VMC in Radar)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	6.1.4 Hazardously misleading ADS-B information for multiple aircraft.	T1-heavy aircraft	Lead aircraft will appear on other aircraft CDTI in the wrong position or with other incorrect data. In-trail pilot, may experience confusion or rely on erroneous information and takeoff prematurely. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected under VMC by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies.	*Minor*		Notes: NA4 Recommendations: RH2 Candidate Reqs: CA1, CA9, CL4

Operational Objective /Intention /Capability:	**6 Departure Spacing / Clearance (VMC in Radar)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	6.1.5 Hazardously misleading ADS-B information for multiple aircraft.	T1-light aircraft	Lead aircraft will appear on other aircraft CDTI in the wrong position or with other incorrect data. In-trail pilot, may experience confusion or rely on erroneous information and takeoff prematurely. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected under VMC by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies	*Minor*		Notes: NA4 Recommendations: RH2 Candidate Reqs: CA1, CA9, CL4

Operational Objective /Intention /Capability:	**7 Approaches to Closely Spaced Parallel Runways**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
7.1. ADS-B for proximate traffic awareness on instrument approach to closely spaced parallel runways.	7.1.1 Loss of ADS-B information for a single aircraft.	F4	An aircraft experiencing broadcast failures will not show up on other aircraft CDTI. As this proposed service requires ADS-B supplied proximate traffic awareness, the loss of the required function would result in a significant reduction in safety margins.	*Major*		Notes: NA1, NP1 Candidate Reqs: CA10, CP3, CL3
	7.1.2 Loss of ADS-B information from multiple aircraft.	F4	An aircraft experiencing reception or processing failures will not provide the pilot with proximity information regarding other ADS-B equipped aircraft. As this proposed service requires ADS-B supplied proximate traffic awareness, the loss of the required function would result in a significant reduction in safety margins.	*Major*		Notes: NA2, NP1 Candidate Reqs: CA10, CP3, CL3

Operational Objective /Intention /Capability:	**7 Approaches to Closely Spaced Parallel Runways**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	7.1.3 Hazardously misleading ADS-B information for a single aircraft.	F4	An aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots may experience confusion or assume that the aircraft broadcasting HMI is not the desired target. Use of erroneous data for an A/C on parallel or staggered approach may result in unnecessary evasive action possibly resulting in jostling injuries, perhaps some fatal, to occupants, or an aircraft may "bust" separation minima resulting in a large reduction in safety margins for this service.	*Hazardous*		Notes: NA3, NP1 Recommendations: RH2 Candidate Reqs: CA10, CP2, CL2

Operational Objective /Intention /Capability:	**7 Approaches to Closely Spaced Parallel Runways**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	7.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F4	An aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may experience confusion, assume an erroneous target distance. Use of erroneous data for an A/C on parallel or staggered approach may result in unnecessary evasive action possibly resulting in jostling injuries, perhaps some fatal, to occupants, or an aircraft may "bust" separation minima resulting in a large reduction in safety margins for this service.	*Hazardous*		Notes: NA4, NP1 Recommendations: RH2 Candidate Reqs: CA10, CP2, CL2
7.2 ADS-B for conflict detection/alerting/ resolution aid.	See assessment for service 10, hazards 10.1.2/4/5/6 and service 11-all hazards (Conflict Detection and Conflict Resolution).					

Operational Objective /Intention /Capability:	**8 Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
8.1 ADS-B for aided "see and avoid."	8.1.1 Loss of ADS-B information for a single aircraft.	S1, T1, F1-F4, L1	An aircraft experiencing broadcast failures will not show up on other aircraft CDTI. Visual acquisition time by other pilots will be unenhanced. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and requirements for visual acquisition remain in effect.	Notes: NA1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3
	8.1.2 Loss of ADS-B information from multiple aircraft.	S1, T1, F1-F4, L1	An aircraft experiencing reception or processing failures will not provide the pilot with aided visual acquisition of ADS-B equipped aircraft. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and requirements for visual acquisition remain in effect.	Notes: NA2 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3

Operational Objective /Intention /Capability:	**8 Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	8.1.3 Hazardously misleading ADS-B information for a single aircraft.	S1, T1, F1-F4, L1	An aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots may experience minor confusion or assume that the aircraft broadcasting HMI is not an ATC relayed target. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and requirements for visual acquisition remain in effect.	Notes: NA3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**8 Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B only)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	8.1.4 Hazardously misleading ADS-B information for multiple aircraft.	S1, T1, F1-F4, L1	An aircraft receiving or experiencing HMI due to on-board equipment malfunction will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may experience minor confusion, assume that a CDTI target is not an ATC relayed target, or assume more traffic than actual. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and requirements for visual acquisition remain in effect.	Notes: NA4 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**9 Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
9.1 TIS-B augmented ADS-B for aided "see and avoid."	9.1.1 Loss of TIS-B augmented ADS-B information for a single aircraft.	S1, T1, F1-F4, L1	The aircraft experiencing broadcast failures (or transponder failure for non-ADS-B equipped aircraft) will not show up on other aircraft CDTI. Visual acquisition time by other pilots will be unenhanced. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3
	9.1.2 Loss of TIS-B augmented ADS-B information from multiple aircraft.	S1, T1, F1-F4, L1	An aircraft experiencing reception or processing failures will not provide the pilot with aided visual acquisition of ADS-B or transponder equipped aircraft. Failures of ATC transponder input and processing or TIS-B processing or output capability will result in multiple aircraft not receiving display data for multiple transponder-only equipped aircraft. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT2 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3

Operational Objective /Intention /Capability:	**9 Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	9.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft.	S1, T1, F1-F4, L1	An aircraft broadcasting HMI will appear on other aircraft CDTI or ground radar in the wrong position or with other incorrect data and may show as a dual target to other aircraft. Other pilots may experience minor confusion or assume that the aircraft broadcasting HMI is not an ATC relayed target. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**9 Enhanced Visual Acquisition of Other Traffic for See-and-Avoid (using ADS-B and TIS-B)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	9.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft.	S1, T1, F1-F4, L1	The aircraft experiencing HMI due to on-board equipment failure will have multiple erroneously positioned and/or multiple dual targets on its CDTI, or other erroneous data. Aircraft receiving HMI from ATC may also have multiple dual targets. Pilots may experience minor confusion, assume that a CDTI target is not an ATC relayed target, or assume more traffic than actual. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance with TIS-B augmentation in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT4 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**10 Conflict Detection**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
10.1 ADS-B for conflict detection.	10.1.1 Loss of ADS-B information for a single aircraft.	F1-F4	An aircraft experiencing broadcast failures will not show up on other aircraft ADS-B system for conflict detection processing. Would result in no more than inconvenience to operator.	*No Safety Effect*	Conflict detection will be as it is under current environment without TCAS.	Notes: NA1 Candidate Reqs: CA1, A2, A3, A4, CA13
	10.1.2 Loss of ADS-B information for a single aircraft.	F4 (Closely spaced parallel instrument approach or for operations requiring a conflict detection system).	An aircraft experiencing broadcast failures will not show up on other aircraft ADS-B system for conflict detection processing, resulting in a significant reduction in safety margins for operations requiring conflict detection systems.	*Major*		Notes: NA1 Candidate Reqs: CP3, CL3, CA13, (CA10 for closely spaced instrument approaches)
	10.1.3 Loss of ADS-B information from multiple aircraft.	F1-F4	An aircraft experiencing reception or processing failures will not provide the pilot with conflict detection information regarding other ADS-B equipped aircraft. Would result in no more than inconvenience to operator.	*No Safety Effect*	Conflict detection will be as it is under current environment without TCAS.	Notes: NA2 Candidate Reqs: CA1, A2, A3, A4, CA13

Operational Objective /Intention /Capability:	**10 Conflict Detection**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	10.1.4 Loss of ADS-B information from multiple aircraft.	F4 (Closely spaced parallel instrument approach or for operations requiring a conflict detection system).	An aircraft experiencing reception or processing failures will not provide the pilot with conflict detection information regarding other ADS-B equipped aircraft, resulting in a significant reduction in safety margins for operations requiring conflict detection systems.	*Major*		Notes: NA2 Candidate Reqs: CP3, CL3, CA13, (CA10 for closely spaced instrument approaches)
	10.1.5 Hazardously misleading ADS-B information for a single aircraft.	F1-F4	An aircraft broadcasting HMI will be processed as being in the wrong position or with other incorrect data. Other pilots will be provided either with no conflict detection when needed, or with false detection which, if acted on, would result in unnecessary evasive action possibly resulting in jostling injuries, perhaps some fatal, to occupants.	*Hazardous*		Notes: NA3 Recommendations: RH2 Candidate Reqs: CP2, CL2, CA13, (CA10 for closely spaced instrument approaches)

Operational Objective /Intention /Capability:	**10 Conflict Detection**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	10.1.6 Hazardously misleading ADS-B information for multiple aircraft.	F1-F4	An aircraft receiving or experiencing HMI due to on-board equipment failure will be provide erroneous detection information and alerts. Pilot will be provided either with no conflict detection when needed, or with false detection which, if acted on, would result in unnecessary evasive action possibly resulting in jostling injuries, perhaps some fatal, to occupants.	*Hazardous*		Notes: NA4 Recommendations: RH2 Candidate Reqs: CP2, CL2, CA13, (CA10 for closely spaced instrument approaches)

Operational Objective /Intention /Capability:	**11 Conflict Resolution**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
11.1 ADS-B for conflict detection and tactical resolution.	11.1.1 Loss of ADS-B information for a single aircraft.	F1-F4	An aircraft experiencing broadcast failures will not show up on other aircraft ADS-B system for conflict detection and resolution processing. Results may include a significant reduction in safety margins or significant increase in operator workload.	*Major*		Notes: NA1 Candidate Reqs: CA1, A2, A3, A4, CA13, CA14, (CA10 for closely spaced instrument approaches), CP3, CL3
	11.1.2 Loss of ADS-B information from multiple aircraft.	F1-F4	An aircraft experiencing reception or processing failures will not provide the pilot with conflict detection and resolution information regarding other ADS-B equipped aircraft. Results may include a significant reduction in safety margins or significant increase in operator workload.	*Major*		Notes: NA2 Candidate Reqs: CA1, A2, A3, A4, CA13, CA14, (CA10 for closely spaced instrument approaches), CP3, CL3

Operational Objective /Intention /Capability:	**11 Conflict Resolution**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	11.1.3 Hazardously misleading ADS-B information for a single aircraft.	F1-F4	An aircraft broadcasting HMI will be processed as being in the wrong position or with other incorrect data. Other pilots will be provided either with no resolution or an erroneous resolution which would result in unnecessary evasive action possibly resulting in jostling injuries, perhaps some fatal, to occupants.	*Hazardous*		Notes: NA3 Recommendations: RH2 Candidate Reqs: CP2, CL2, CA13, CA14, (CA10 for closely spaced instrument approaches)
	11.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F1-F4	An aircraft receiving or experiencing HMI due to on-board equipment failure will be provided erroneous detection and resolution information and alerts. Pilot will be provided either with no resolution, or an erroneous resolution which would result in unnecessary evasive action possibly resulting in jostling injuries, perhaps some fatal, to occupants.	*Hazardous*		Notes: NA3 Recommendations: RH2 Candidate Reqs: CP2, CL2, CA13, CA14, (CA10 for closely spaced instrument approaches)

Operational Objective /Intention /Capability:	**12 Pilot Situational Awareness Beyond Visual Range**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
12.1 TIS-B augmented ADS-B for traffic awareness beyond visual range.	12.1.1 Loss of TIS-B augmented ADS-B information for a single aircraft.	F1-F3	The aircraft experiencing broadcast failures (or transponder failure for non-ADS-B equipped aircraft) will not show up on other aircraft CDTI. Visual acquisition time by other pilots will be unenhanced. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT1 Recommendations: RH1 Candidate Reqs: CA1, A2, A3
	12.1.2 Loss of TIS-B augmented ADS-B information from multiple aircraft.	F1-F3	An aircraft experiencing reception or processing failures will not provide the pilot with aided visual acquisition of ADS-B or transponder equipped aircraft. Failures of ATC transponder input and processing or TIS-B processing or output capability will result in multiple aircraft not receiving display data for multiple transponder-only equipped aircraft. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT2 Recommendations: RH1 Candidate Reqs: CA1, A2, A3

Operational Objective /Intention /Capability:	**12 Pilot Situational Awareness Beyond Visual Range**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	12.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft.	F1-F3	An aircraft broadcasting HMI will appear on other aircraft CDTI or ground radar in the wrong position or with other incorrect data and may show as a dual target to other aircraft. Other pilots may experience minor confusion or assume that the aircraft broadcasting HMI is not an ATC relayed target. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT3 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**12 Pilot Situational Awareness Beyond Visual Range**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	12.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft.	F1-F3	The aircraft experiencing HMI due to on-board equipment failure will have multiple erroneously positioned and/or multiple dual targets on its CDTI, or other erroneous data. Aircraft receiving HMI from ATC may also have multiple dual targets. Pilots may experience minor confusion, assume that a CDTI target is not an ATC relayed target, or assume more traffic than actual. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance the otherwise unaided or ATC aided process of visual acquisition, and the requirement for visual acquisition remains in effect.	Notes: NT4 Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, CL4

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
13.1. ADS-B for awareness of A/C traffic in non-radar airspace.	13.1.1 Loss of ADS-B information for a single aircraft.	T1, F1-F4	An aircraft experiencing broadcast failures will not show up on other aircraft CDTI. Other flight crews will likely recognize that designated target is no longer showing and report to ATC. ATC will have to retake separation control and have all aircraft dependent on failed aircraft's data, including failed aircraft, revert to procedural separation, position reports, and one-in-one-out procedures. Would result in no more than inconvenience to operator.	*No Safety Effect*	Information loss probably noticeable if ADS-B targets are designated by ATC with requirement on aircrews to regularly maintain positive target ID on display. Reversion to ATC managed procedural separation, one-in-one-out where applicable.	Notes: NA1 Recommendations: RH1, RS1 Candidate Reqs: CA11, CO1

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.2 Loss of ADS-B information from multiple aircraft.	T1, F1-F4	An aircraft experiencing reception or processing failures will not provide the pilot with designated target data. Flight crew will likely recognize that designated targets are no longer showing and report to ATC. ATC will have to retake separation control for failed aircraft, which will have to revert to procedural separation and position reports. Would result in no more than inconvenience to operator.	*No Safety Effect*	Information loss probably noticeable if ADS-B targets are designated by ATC with requirement on aircrews to regularly maintain positive target ID on display. Reversion to ATC managed procedural separation, one-in-one-out where applicable.	Notes: NA2 Recommendations: RH1, RS1 Candidate Reqs: CA11, CO1

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.3 Hazardously misleading ADS-B information for a single aircraft.	F1-F4	An aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots may experience some confusion or assume that the aircraft broadcasting HMI is not an ATC relayed target. An aircraft, using erroneous data during self-separation may "bust" separation minima, significantly reducing safety margins.	*Major*		Notes: NA3 Recommendations: RH2, RS2 Candidate Reqs: CA5, CA11, CO1, CP3, CL3

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.4 Hazardously misleading ADS-B information for a single aircraft.	T1-Heavy aircraft	An lead aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies.	*Minor*		Notes: NA3 Recommendations: RH2, RS2 Candidate Reqs: CA5, CA11, CO1, CL4

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.5 Hazardously misleading ADS-B information for a single aircraft.	T1-Light aircraft	A lead aircraft broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies.	*Minor*		Notes: NA3 Recommendations: RH2, RS2 Candidate Reqs: CA5, CA11, CO1, CL4

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.6 Hazardously misleading ADS-B information for multiple aircraft.	F1-F4	An aircraft receiving or experiencing HMI due to on-board equipment malfunction will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may experience confusion, assume that a CDTI target is not an ATC relayed target, or assume more traffic than actual. An aircraft, using erroneous data during self-separation may "bust" separation minima, significantly reducing safety margins.	*Major*		Notes: NA4 Recommendations: RH2, RS2 Candidate Reqs: CA5, CA11, CO1, CP3, CL3

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.7 Hazardously misleading ADS-B information for multiple aircraft.	T1-Heavy Aircraft	An trailing aircraft receiving or experiencing HMI due to on-board equipment malfunction will have multiple erroneously positioned targets on its CDTI or other erroneous data. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies.	*Minor*		Notes: NA4 Recommendations: RH2, RS2 Candidate Reqs: CA5, CA11, CO1, CL4

Operational Objective /Intention /Capability:	**13 Delegated air-to-air self separation for one-in-one-out airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	13.1.8 Hazardously misleading ADS-B information for multiple aircraft.	T1-Light aircraft	An trailing aircraft receiving or experiencing HMI due to on-board equipment malfunction will have multiple erroneously positioned targets on its CDTI or other erroneous data. The concern of interest would be for the trailing aircraft to fail to rotate behind lead aircraft rotation point, but this is not effected by the lead aircraft's erroneous distance down range on climb. Trailing pilot responsibility to determine rotation point is unaffected. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload if in-trail separation revisions are required due to ADS-B inaccuracies.	*Minor*		Notes: NA4 Recommendations: RH2, RS2 Candidate Reqs: CA5, CA11, CO1, CL4

Operational Objective /Intention /Capability:	**14 Runway and Final Approach Occupancy Awareness (Using ADS-B only)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
14.1. ADS-B for awareness of traffic in final approach path and on runway surface.	14.1.1 Loss of ADS-B information for a single aircraft or surface vehicle.	F4, L1	An aircraft or surface vehicle experiencing broadcast failures will not show up on other aircraft CDTI. Traffic awareness for other pilots will be unenhanced for a single aircraft or surface vehicle. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of approach path or surface traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect.	Notes: NA1 (with addition of surface vehicle system failures). Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4
	14.1.2 Loss of ADS-B information from multiple aircraft and surface vehicles.	F4, L1	An aircraft experiencing reception or processing failures will not provide the pilot with awareness of ADS-B equipped aircraft or surface vehicles. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect.	Notes: NA2 (with addition of surface vehicle system failures). Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**14 Runway and Final Approach Occupancy Awareness (Using ADS-B only)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	14.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	F4, L1	An aircraft or surface vehicle broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots will not be aided in awareness of aircraft/vehicle with failed system, or may erroneously see aircraft as occupying the approach path or runway and may call for unnecessary missed approach. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect. If a malfunction indicates a false occupancy, communication with ATC would likely eliminate erroneous missed approach action.	Notes: NA3 (with addition of surface vehicle system failures). Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**14 Runway and Final Approach Occupancy Awareness (Using ADS-B only)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	14.1.4 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	F4, L1	An aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may erroneously assume that a CDTI target is occupying the approach path or runway and call for an unnecessary missed approach. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect. If a malfunction indicates a false occupancy, communication with ATC would likely eliminate erroneous missed approach action.	Notes: NA4 (with addition of surface vehicle system failures). Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**15 Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
15.1 TIS-B augmented ADS-B for awareness of traffic in final approach path and on runway surface.	15.1.1 Loss of TIS-B augmented ADS-B information for a single aircraft or surface vehicle.	F4, L1	An aircraft or surface vehicle experiencing broadcast failures will not show up on other aircraft CDTI. Traffic awareness for other pilots will be unenhanced for a single aircraft or surface vehicle. Would result in no more than inconvenience.	*No Safety Effect*	TIS-B augmented ADS-B in this case is an aid only, used to enhance pilot awareness of approach path or surface traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect.	Notes: NT1 (with addition of surface vehicle system failures). Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4
	15.1.2 Loss of TIS-B augmented ADS-B information from multiple aircraft and surface vehicles.	F4, L1	An aircraft experiencing reception or processing failures will not provide the pilot with awareness of ADS-B equipped aircraft or surface vehicles. Would result in no more than inconvenience.	*No Safety Effect*	TIS-B augmented ADS-B in this case is an aid only, used to enhance pilot awareness of traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect.	Notes: NT2 (with addition of surface vehicle system failures). Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**15 Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	15.1.3 Hazardously misleading TIS-B augmented ADS-B information for a single aircraft or surface vehicle.	F4, L1	An aircraft or surface vehicle broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots will not be aided in awareness of aircraft/vehicle with failed system, or may erroneously see aircraft as occupying the approach path or runway and may call for unnecessary missed approach. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	TIS-B augmented ADS-B in this case is an aid only, used to enhance pilot awareness of traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect. If a malfunction indicates a false occupancy, communication with ATC would likely eliminate erroneous missed approach action.	Notes: NT3 (with addition of surface vehicle system failures). Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**15 Runway and Final Approach Occupancy Awareness (Using ADS-B and TIS-B)**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	15.1.4 Hazardously misleading TIS-B augmented ADS-B information for multiple aircraft and surface vehicles.	F4, L1	An aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. The pilot may erroneously assume that a CDTI target is occupying the approach path or runway and call for an unnecessary missed approach. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	TIS-B augmented ADS-B in this case is an aid only, used to enhance pilot awareness of traffic. Visual and instrument approach and landing procedures remain in effect. Standard surveillance and approach control remains in effect. If a malfunction indicates a false occupancy, communication with ATC would likely eliminate erroneous missed approach action.	Notes: NT4 (with addition of surface vehicle system failures). Recommendations: RH1, RH2 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**16 Airport Surface Situational Awareness**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
16.1 ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.	16.1.1 Loss of ADS-B information for a single aircraft or surface vehicle.	S1	An aircraft or surface vehicle experiencing broadcast failures will not show up on other aircraft CDTI. Surface traffic awareness for other pilots will be unenhanced for a single aircraft or surface vehicle. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of surface traffic. Surface maneuvering procedures remain in effect. Standard surveillance and airport surface control remains in effect.	Notes: NA1 (with addition of surface vehicle system failures). Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4
	16.1.2 Loss of ADS-B information from multiple aircraft and surface vehicles.	S1	An aircraft experiencing reception or processing failures will not provide the pilot with awareness of ADS-B equipped aircraft or surface vehicles. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of surface traffic. Surface maneuvering procedures remain in effect. Standard surveillance and airport surface control remains in effect.	Notes: NA2 (with addition of surface vehicle system failures). Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**16 Airport Surface Situational Awareness**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	16.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	S1-VMC or IMC, not with zero visibility	An aircraft or surface vehicle broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Other pilots will not be aided in awareness of aircraft/vehicle with failed system, or may erroneously see aircraft as occupying surface path. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of surface traffic. Surface maneuvering procedures remain in effect. Standard surveillance and airport surface control remains in effect.	Notes: NA3 (with addition of surface vehicle system failures). Recommendations: RH2 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**16 Airport Surface Situational Awareness**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	16.1.4 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	S1-zero visibility at an uncontrolled airport or a controlled airport without surface radar	An aircraft or surface vehicle broadcasting HMI will appear on other aircraft CDTI in the wrong position or with other incorrect data. Relying on erroneous data, without reference to ATC control, in "zero" visibility, pilot would likely make an erroneous maneuver, possibly striking another aircraft or surface vehicle, or being struck on incursion resulting in fatalities and aircraft loss.	*Catastrophic*		Notes: NA3 (with addition of surface vehicle system failures). Recommendations: RH2 Candidate Reqs: CP1, CL1

Operational Objective /Intention /Capability:	**16 Airport Surface Situational Awareness**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	16.1.5 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	S1- VMC or IMC, not with zero visibility	An aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an aid only, used to enhance pilot awareness of surface traffic. Surface maneuvering procedures remain in effect. Standard surveillance and airport surface control remains in effect.	Notes: NA4 (with addition of surface vehicle system failures). Recommendations: RH2 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**16 Airport Surface Situational Awareness**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	16.1.6 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	S1- zero visibility at an uncontrolled airport or a controlled airport without surface radar	An aircraft receiving or experiencing HMI due to on-board equipment failure will have multiple erroneously positioned targets on its CDTI or other erroneous data. Relying on erroneous data, without reference to ATC control, in "zero" visibility, pilot would likely make an erroneous maneuver, possibly striking another aircraft or surface vehicle, or being struck on incursion resulting in fatalities and aircraft loss.	*Catastrophic*		Notes: NA4 (with addition of surface vehicle system failures). Recommendations: RH2 Candidate Reqs: CP1, CL1
	16.1.7 Loss of map function.	S1	Pilot will not be aided by the map display. Would result in no more than inconvenience.	*No Safety Effect*		Notes: Failures of the map display function or map database, but not necessarily the ADS-B target data. Recommendations: RH1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**16 Airport Surface Situational Awareness**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	16.1.8 Hazardously misleading map display.	S1 - VMC or IMC, not with zero visibility	Pilot could experience confusion or make an erroneous maneuver based on bad map information. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Airport map is an aid only. Surface maneuvering procedures remain in effect. Lane markings. Standard surveillance and airport surface control remains in effect. One-in-one-out procedures limit vulnerability.	Notes: Malfunctions of the map display or corrupted but correct looking map database, but not necessarily the ADS-B target data. Recommendations: RH2 Candidate Reqs: CA1, A2, A3, A4, CL4
	16.1.9 Hazardously misleading map display.	S1 - zero visibility at an uncontrolled airport or a controlled airport without surface radar	Relying on erroneous data, without reference to ATC control or lane markings, in "zero" visibility, pilot would likely make an erroneous maneuver based on bad map information, possibly striking another aircraft or surface vehicle, or being struck on incursion resulting in fatalities and aircraft loss.	*Catastrophic*		Notes: Malfunctions of the map display or corrupted but correct looking map database, but not necessarily the ADS-B target data. Recommendations: RH2 Candidate Reqs: CP1, CL1

Operational Objective /Intention /Capability:	**17 Enhanced IMC airport surface operations**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
17.1 ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.	See assessment for service 16.1 for operating phase conditions of VMC or IMC and not with zero visibility - Operational Hazards 16.1.1, 16.1.2, 16.1.3, 16.1.5, 16.1.7, and 16.1.8.					

Operational Objective /Intention /Capability:	**18 Enhance Existing Surface Surveillance with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
18.1 ADS-B augmented surface surveillance for surface traffic management.	18.1.1 Loss of ADS-B information for a single aircraft or surface vehicle.	S1	An aircraft or surface vehicle experiencing broadcast failures will not show up on the ground displays when in surface radar shadow. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Standard surveillance and airport surface control remains in effect.	Notes: NA1 (with addition of surface vehicle system failures). Candidate Reqs: CA1, A2, A3, A4
	18.1.2 Loss of ADS-B information from multiple aircraft and surface vehicles.	S1	Multiple aircraft and surface vehicles will not show up on the ground displays when in surface radar shadow. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Standard surveillance and airport surface control remains in effect.	Notes: NG1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**18 Enhance Existing Surface Surveillance with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	18.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	S1	An aircraft or surface vehicle broadcasting HMI will appear on the ground display in an erroneous position if in surface radar shadow, or as a dual target on the ground display. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, with appropriate action taken by the controller and pilot.	Notes: NA3 (with addition of surface vehicle system failures). Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**18 Enhance Existing Surface Surveillance with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	18.1.4 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	S1	Multiple aircraft and surface vehicles will appear on the ground display in an erroneous positions if in surface radar shadow, or as a dual targets on the ground display. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, with appropriate action taken by facilities operations.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**19 Surveillance Coverage at Airports without Existing Surface Surveillance**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
19.1 ADS-B for surface traffic management.	19.1.1 Loss of ADS-B information for a single aircraft or surface vehicle.	S1	An aircraft or surface vehicle experiencing broadcast failures will not show up on the ground displays. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an augmentation only. Standard surveillance and airport surface control remains in effect.	Notes: NA1 (with addition of surface vehicle system failures). Candidate Reqs: CA1, A2, A3, A4
	19.1.2 Loss of ADS-B information from multiple aircraft and surface vehicles.	S1	Multiple aircraft and surface vehicles will not show up on the ground displays. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an augmentation only. Standard surveillance and airport surface control remains in effect.	Notes: NG1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**19 Surveillance Coverage at Airports without Existing Surface Surveillance**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	19.1.3 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	S1	An aircraft or surface vehicle broadcasting HMI will appear on the ground display in an erroneous position or with other erroneous data. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an augmentation only. Standard surveillance and airport surface control remains in effect. Condition would likely be noticed, as ADS-B information will not be consistent with reported information from pilots.	Notes: NA3 (with addition of surface vehicle system failures). Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**19 Surveillance Coverage at Airports without Existing Surface Surveillance**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	19.1.4 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	S1	Multiple aircraft and surface vehicles will appear on the ground display in erroneous positions or with other erroneous data. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Dependent surveillance in this case is an augmentation only. Standard surveillance and airport surface control remains in effect. Condition would likely be noticed, as ADS-B information will not be consistent with reported information from pilots.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**20 Center situational awareness with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
20.1 ADS-B for center traffic situational awareness in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.	20.1.1 Loss of ADS-B information for a single aircraft.	F1-F3	An aircraft experiencing broadcast failures will not show up on the ground displays. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an augmentation only. Position reporting requirements remain in effect.	Notes: NA1 Candidate Reqs: CA1, A2, A3, A4
	20.1.2 Loss of ADS-B information from multiple aircraft.	F1-F3	Multiple aircraft will not show up on the ground displays. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an augmentation only. Position reporting requirements remain in effect.	Notes: NG1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**20 Center situational awareness with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	20.1.3 Hazardously misleading ADS-B information for a single aircraft.	F1-F3	An aircraft broadcasting HMI will appear on the ground display in an erroneous position or with other erroneous data. This will add to controller workload and possible lag time in ascertaining, based on position reports, that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, based on position reporting, with appropriate action taken by controller and pilot.	Notes: NA3 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**20 Center situational awareness with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	20.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F1-F3	Multiple aircraft will appear on the ground display in erroneous positions or with other erroneous data. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, based on position reporting, with appropriate action taken by controller and facilities operations.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**21 Radar-like Services with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
21.1 ADS-B for radar-like services in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.	21.1.1 Loss of ADS-B information for a single aircraft.	F1-F3	An aircraft experiencing broadcast failures will not show up on the ground displays. Controller will likely notice that a controlled A/C is not showing, and will initiate reversion to procedural management with position reporting. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Noticeable effect; however, see recommendation.	Notes: NA1 Recommendations: RH3 Candidate Reqs: CL4, Reversion to standard non-radar procedures: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**21 Radar-like Services with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	21.1.2 Loss of ADS-B information from multiple aircraft.	F1-F3	Multiple aircraft will not show up on the ground displays. Controllers will likely notice that multiple controlled A/C are not showing, and will initiate reversion to procedural management with position reporting. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Noticeable effect; however, see recommendation.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CL4, Reversion to standard non-radar procedures: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**21 Radar-like Services with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	21.1.3 Hazardously misleading ADS-B information for a single aircraft.	F1-F3	An aircraft broadcasting HMI will appear on the ground display in an erroneous position or with other erroneous data. Results may include a significant reduction in safety margins or significant increase in operator workload. This effect would be similar to that of an A/C navigation malfunction (resulting in erroneous position reports), which, by guidance in AC 25-11, is considered to be a major failure condition for considered flight phases.	*Major*		Notes: NA3 Recommendations: RH3 Candidate Reqs: CP3, CL3

Operational Objective /Intention /Capability:	**21 Radar-like Services with ADS-B**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	21.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F1-F3	Multiple aircraft will appear on the ground display in erroneous positions or with other erroneous data. Erroneous clearances or instructions would likely be issued by ATC based on misleading data. This effect is similar to an aircraft navigation malfunction; however, considering multiple aircraft, erroneous clearances and instructions would be expected to reduce the ability of one or more flight crews to cope with adverse operating conditions to the extent that there would be a large reduction in safety margins for some aircraft.	*Hazardous*		Notes: NG1 Recommendations: RH3 Candidate Reqs: CP2, CL2

Operational Objective /Intention /Capability:	**22 Tower Situational Awareness Beyond Visual Range**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
22.1 ADS-B for traffic awareness beyond tower visual range.	22.1.1 Loss of ADS-B information for a single aircraft.	F1-F3	An aircraft experiencing broadcast failures will not show up on the ground displays. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Position reporting and visual acquisition requirements remain in effect.	Notes: NA1 Candidate Reqs: CA1, A2, A3, A4
	22.1.2 Loss of ADS-B information from multiple aircraft.	F1-F3	Multiple aircraft will not show up on the ground displays. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Position reporting and visual acquisition requirements remain in effect.	Notes: NG1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**22 Tower Situational Awareness Beyond Visual Range**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	22.1.3 Hazardously misleading ADS-B information for a single aircraft.	F1-F3	An aircraft broadcasting HMI will appear on the ground display in an erroneous position or with other erroneous data. This will add to controller workload and possible lag time in ascertaining, based on position reports, that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. Actions required by operators are well within their capabilities. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, based on position reporting, with appropriate action taken by controller and facilities operations.	Notes: NA3 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**22 Tower Situational Awareness Beyond Visual Range**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	22.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F1-F3	Multiple aircraft will appear on the ground display in erroneous positions or with other erroneous data. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, based on position reporting, with appropriate action taken by controller and facilities operations.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
23.1 ADS-B augmented radar surveillance for terminal area air traffic management.	23.1.1 Loss of ADS-B information for a single aircraft.	F1, F3, F4	An aircraft experiencing broadcast failures will not show up on ground ADS-B listening stations, but will remain tracked on standard terminal area radar. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Standard surveillance and control remains in effect.	Notes: NA1 Candidate Reqs: CA1, A2, A3, A4
	23.1.2 Loss of ADS-B information from multiple aircraft.	F1, F3, F4	Multiple aircraft will not be processed by ground ADS-B system, but will remain tracked on standard terminal area radar. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Standard surveillance and control remains in effect.	Notes: NG1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	23.1.3 Hazardously misleading ADS-B information for a single aircraft.	F1, F3, F4	An aircraft broadcasting HMI will appear on the ground display as a dual target, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, with appropriate action taken by the controller and pilot.	Notes: NA3 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	23.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F1, F3, F4	Multiple aircraft will appear on the ground displays as dual targets, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, with appropriate action taken by facilities operations.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
23.2 ADS-B augmented radar surveillance for terminal area reduced separation.	23.2.1 Loss of ADS-B information for a single aircraft.	F1, F3, F4	An aircraft experiencing broadcast failures will not show up on ground ADS-B listening stations, but will remain tracked on standard terminal area radar. If position resolution is degraded, reversion to standard separation minima will be required. In trail aircraft speed reduction or holding patterns would be expected to occur. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Reversion to unenhanced radar surveillance, with routine flight changes.	Notes: NA1 Candidate Reqs: CA12, CL4

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	23.2.2 Loss of ADS-B information from multiple aircraft.	F1, F3, F4	Multiple aircraft will not be processed by ground ADS-B system, but will remain tracked on standard terminal area radar. If position resolution is degraded, reversion to standard separation minima will be required. In trail aircraft speed reduction or holding patterns would be expected to occur. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Reversion to unenhanced radar surveillance, with routine flight changes.	Notes: NG1 Candidate Reqs: CA12, CL4

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	23.2.3 Hazardously misleading ADS-B information for a single aircraft.	F1, F3, F4	An aircraft broadcasting HMI will appear on the ground display as a dual target or target resolution will degrade, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. With reduced separation, safety margins would be expected to degrade more rapidly than with standard separation minima.	*Major*	Effect would likely be noticeable, with appropriate action taken by the controller and pilot. However, with already reduced margins, lag time in ascertaining the malfunction and taking action reduces this mitigation relative to its effectiveness in operational hazard 23.1.3.	Notes: NA3 Recommendations: RH3 Candidate Reqs: CA12, CP3, CL3

Operational Objective /Intention /Capability:	**23 Radar Augmented with ADS-B in Terminal Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	23.2.4 Hazardously misleading ADS-B information for multiple aircraft.	F1, F3, F4	Multiple aircraft will appear on the ground displays as dual targets or target resolutions will degrade, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. With reduced separation, safety margins would be expected to degrade more rapidly than with standard separation minima.	*Major*	Effect would likely be noticeable, with appropriate action taken by facilities operations. However, with already reduced margins, lag time in ascertaining the malfunction and taking action reduces this mitigation relative to its effectiveness in operational hazard 23.1.4.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA12, CP3, CL3

Operational Objective /Intention /Capability:	**24 Radar Augmentation with ADS-B to achieve existing separation standards in terminal airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
24.1 ADS-B augmented radar surveillance for terminal area air traffic separation.	See assessment of service 23.1					

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
25.1 ADS-B augmented radar surveillance for en-route air traffic management.	25.1.1 Loss of ADS-B information for a single aircraft.	F2	An aircraft experiencing broadcast failures will not show up on ground ADS-B listening stations, but will remain tracked on standard radar. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Standard surveillance and control remains in effect.	Notes: NA1 Candidate Reqs: CA1, A2, A3, A4
	25.1.2 Loss of ADS-B information from multiple aircraft.	F2	Multiple aircraft will not be processed by ground ADS-B system, but will remain tracked on standard radar. Would result in no more than inconvenience.	*No Safety Effect*	Dependent surveillance in this case is an enhancement only. Standard surveillance and control remains in effect.	Notes: NG1 Candidate Reqs: CA1, A2, A3, A4

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	25.1.3 Hazardously misleading ADS-B information for a single aircraft.	F2	An aircraft broadcasting HMI will appear on the ground display as a dual or reduced resolution target, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, with appropriate action taken by the controller and pilot.	Notes: NA3 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	25.1.4 Hazardously misleading ADS-B information for multiple aircraft.	F2	Multiple aircraft will appear on the ground displays as dual or reduced resolution targets, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Effect would likely be noticeable, with appropriate action taken by facilities operations.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA1, A2, A3, A4, CL4

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
25.2 ADS-B augmented radar surveillance for en-route reduced separation.	25.2.1 Loss of ADS-B information for a single aircraft.	F2	An aircraft experiencing broadcast failures will not show up on ground ADS-B listening stations, but will remain tracked on standard radar. If position resolution is degraded, reversion to standard separation minima will be required. Aircraft speed reductions or level changes would be expected to occur to increase separation to standard minima. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Reversion to unenhanced radar surveillance, with routine flight changes.	Notes: NA1 Candidate Reqs: CA12, CL4

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	25.2.2 Loss of ADS-B information from multiple aircraft.	F2	Multiple aircraft will not be processed by ground ADS-B system, but will remain tracked on standard radar. If position resolution is degraded, reversion to standard separation minima will be required. Aircraft speed reductions or level changes would be expected to occur to increase separation to standard minima. Actions required by operators are well within their capabilities. Results may include a slight reduction in safety margins or slight increase in operator workload.	*Minor*	Reversion to unenhanced radar surveillance, with routine flight changes.	Notes: NG1 Candidate Reqs: CA12, CL4

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	25.2.3 Hazardously misleading ADS-B information for a single aircraft.	F2	An aircraft broadcasting HMI will appear on the ground display as a dual target or target resolution will degrade, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an instruction to the A/C or vehicle to shut off ADS-B. With reduced separation, safety margins would be expected to degrade more rapidly than with standard separation minima.	*Major*	Effect would likely be noticeable, with appropriate action taken by the controller and pilot. However, with already reduced margins, lag time in ascertaining the malfunction and taking action reduces this mitigation relative to its effectiveness in operational hazard 25.1.3.	Notes: NA3 Recommendations: RH3 Candidate Reqs: CA12, CP3, CL3

Operational Objective /Intention /Capability:	**25 Radar Augmented with ADS-B in En Route Airspace**					
A **Air Traffic Service**	**B** **Operational Hazard**	**C** **Operating phase**	**D** **Effect of Operational Hazard**	**E** **Operational Hazard Severity Classification**	**F** **Assumed Operational Hazard Severity Mitigators**	**G** **Notes, Recommendations, & Candidate Requirements**
	25.2.4 Hazardously misleading ADS-B information for multiple aircraft.	F2	Multiple aircraft will appear on the ground displays as dual targets or target resolutions will degrade, or other erroneous data will be displayed. This will add to controller workload and possible lag time in ascertaining that an error exists, and would ultimately result in an ATC operations initiated shut off of ground ADS-B processing. With reduced separation, safety margins would be expected to degrade more rapidly than with standard separation minima.	*Major*	Effect would likely be noticeable, with appropriate action taken by facilities operations. However, with already reduced margins, lag time in ascertaining the malfunction and taking action reduces this mitigation relative to its effectiveness in operational hazard 25.1.4.	Notes: NG1 Recommendations: RH3 Candidate Reqs: CA12, CP3, CL3

Operational Objective /Intention /Capability:	**26 Radar Augmentation with ADS-B to achieve existing separation standards in en route airspace**					
A Air Traffic Service	**B Operational Hazard**	**C Operating phase**	**D Effect of Operational Hazard**	**E Operational Hazard Severity Classification**	**F Assumed Operational Hazard Severity Mitigators**	**G Notes, Recommendations, & Candidate Requirements**
26.1 ADS-B augmented radar surveillance for en-route separation.	See assessment of service 25.1					

Operational Objective /Intention /Capability:	**27 Reduced separation standards with ADS-B**					
A Air Traffic Service	**B Operational Hazard**	**C Operating phase**	**D Effect of Operational Hazard**	**E Operational Hazard Severity Classification**	**F Assumed Operational Hazard Severity Mitigators**	**G Notes, Recommendations, & Candidate Requirements**
27.1 ADS-B augmented radar surveillance for reduced separation.	See assessment of service 25.2, with notice that 27.1 pertains to flight phases F1-F4.					

3. Allocation of Safety Objectives and Requirements (ASOR)

ASOR Contents:

3. Allocation of Safety Objectives and Requirements (ASOR) 154
3.1. Introduction 156
3.1.1. Purpose and Scope 156
3.1.2. Background 156
3.1.3. Acronyms 156
3.2. Chapter Organization 157
3.3. Referenced Documents and Bibliography 158
3.3.1. Referenced Documents 158
3.3.2 Additional Bibliographical Material 158
3.4. Stakeholder Identification 159
3.5. Allocation of Safety Objectives and Requirements Methodology 159
3.6. Services and Their Most Severe Hazard Categories 160
3.7. Allocation Results 162
3.8. Allocation of Requirements Not Needing Fault Tree Analysis 165
3.9. Allocation of Failure Probability and Development Assurance Level Requirements to Systems, Equipment, and Components 165
3.10. Fault Tree Analyses 174
3.11. Requirements - Full Text Listing 215
3.11.1. Candidate Requirements Allocated to Airborne ADS-B Systems 215
3.11.2. Candidate Requirements Allocated to ADS-B Systems for Surface Vehicles Operating on Ramps, Taxi-ways, and Runways 218
3.11.3. Candidate Requirements Allocated to Ground-based ATC ADS-B Systems 219
3.11.4. Candidate Requirements Allocated to Ground-based ATC TIS-B Systems 220
3.11.5. Candidate Requirements for Airport Moving Map Display Systems 221
3.11.6. Candidate Procedural Requirements Related to Operations Using ADS-B and TIS-B 221
3.11.7. Integrity check for signal corruption during transmission in space 222

ASOR Tables:

Table 3.6-1: Most Severe Hazard Classifications for Each ATS 160
Table 3.7-1: Allocation of Requirements by Service and Systems 162
Table 3.9-1: Allocation of Probability and Development Assurance Requirements for catastrophic hazards 167
Table 3.9-2: Allocation of Probability and Development Assurance Requirements for hazardous hazards 168
Table 3.9-3: Allocation of Probability and Development Assurance Requirements for major hazards 170

ASOR Fault Trees:

FTA 3.10-1: Hazardously Misleading ADS-B Information for a Single Aircraft 176
FTA 3.10-2: Hazardously Misleading ADS-B Information for Multiple Aircraft 179
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle 183
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles 189
FTA 3.10-5: Hazardously Misleading ADS-B Information for Multiple Aircraft - Conflict Detection 196
FTA 3.10-6: Hazardously Misleading ADS-B Information for Multiple Aircraft - Conflict Detection and Resolution 197
FTA 3.10-7: Hazardously Misleading Map Display 198
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft 199
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft 205
FTA 3.10-10: Hazard Combinations 212

3.1. Introduction

3.1.1. Purpose and Scope

An Allocation of Safety Objectives and Requirements (ASOR), per the guidance in **References a**, **b**, and **j**, is an analysis of operational hazard causes and contributions related to operational services that are documented in an Operational Services and Environment Definition (OSED). An analysis is made in order to identify causes and contributions to hazards identified in the Operational Hazard Assessment (OHA), **Reference g**. Based on these hazard causes and contributions, the ASOR process allocates safety objectives and candidate requirements to components and/or operational procedures related to the systems and equipment that make up a Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM) system that provides Air Traffic Services (ATS) captured in the OSED, as well as the institutions tasked with developing the system components and operational procedures.

The purpose and scope of this ASOR is to allocate safety objectives and requirements related to air traffic services (ATS) supported by Automatic Dependent Surveillance-Broadcast (ADS-B), in some cases augmented by Traffic Information System-Broadcast (TIS-B), as documented in **Reference c**. This ASOR was developed using the guidance provided in **References a**, **b**, and **j**.

3.1.2. Background

The Federal Aviation Administration (FAA), in the interests of enhancing safety and air traffic management, and in response to the expressed desires of the aviation community, have concurred with the need to consider dependent surveillance and traffic information capabilities for the National Airspace System (NAS) CNS/ATM system. The **Reference d** Minimum Aviation System Performance Standards (MASPS) has been written to describe ADS-B system performance standards. The Safe Flight 21 and Free Flight initiatives (see **References e and f**) have developed initial operational concepts incorporating dependent surveillance capability. The Capstone project was initiated to provide ADS-B capability as an aid to visual acquisition, improve traffic flow, and enhance traffic awareness and surveillance capabilities in adverse weather conditions, especially on geographically challenging routes and at minimally equipped airports in Alaska. The Ohio Valley project was initiated to demonstrate and evaluate the capability of ADS-B to aid visual acquisition, enhance traffic awareness and surveillance capabilities, and provide conflict detection aid. This OHA was initiated to provide a basis for determining operational safety requirements related to the establishment of an FAA infrastructure for NAS-wide ADS-B and TIS-B augmented ADS-B use.

3.1.3. Acronyms

A/C	Aircraft
ADS-B	Automatic Dependent Surveillance Broadcast
ASOR	Allocation of Safety Objectives and Requirements
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services

CDTI	Cockpit Display of Traffic Information
CNS	Communication, Navigation, and Surveillance
CNS/ATM	Communication, Navigation, and Surveillance/Air Traffic Management
HMI	Hazardously Misleading Information
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MASPS	Minimum Aviation System Performance Standards
NAS	National Airspace System
OHA	Operational Hazard Assessment
OSA	Operational Safety Assessment
OSED	Operational Services and Environment Definition
SIS	Signal in Space
TIS-B	Traffic Information System Broadcast
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

3.2. Chapter Organization

This chapter is organized into eight sections as follows:

- Section 3.1 provides an introduction, including purpose and scope, background, and acronyms used in the chapter.
- Section 3.2 explains the organization of the chapter.
- Section 3.3 provides a list of documents referenced in this chapter and additional bibliographical material used in the development of this chapter.
- Section 3.4 identifies the stakeholders for this effort.
- Section 3.5 describes the methodology used to perform the ASOR.
- Section 3.6 lists each service with the most severe hazard category identified as relevant to a service.
- Section 3.7 provides the allocation results.
- Section 3.8 discusses requirements that can be allocated for the implementation of a service, but for which a fault tree analysis is not necessary for determining allocations.

- Section 3.9 consists of worksheets used to capture allocated probability and development assurance level requirements for major system components, based on fault tree analyses of operational hazards.

- Section 3.10 contains all the fault trees used to decompose operational hazards into contributing events for determining allocations of probability and development assurance levels.

- Section 3.11 provides the full text of each ADS-B related candidate requirement with identifiers for cross-referencing to the listings for each service in Section 3.7.

3.3. Referenced Documents and Bibliography

3.3.1. Referenced Documents

o. RTCA document DO-264, Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications

p. FAA, System Safety Handbook: Practices and Guidelines for Conducting System Safety Engineering and Management

q. FAA, Automatic Dependent Surveillance-Broadcast (ADS-B) Operational Services and Environment Definition (OSED), Final Draft, September 27, 2001

r. RTCA document DO-242, Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)

s. FAA Safe Flight 21 Functional Specification, and Surveillance Vision Plan

t. RTCA Joint Government/Industry Roadmap for Free Flight Enhancements

u. FAA, Automatic Dependent Surveillance-Broadcast (ADS-B) Operational Hazard Assessment (OHA) , Final Draft, September 27, 2001

v. FAA, Operational Safety Assessment Report, August 13, 2000

w. Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems

x. FAA, NAS Modernization, System Safety Management Program, FAA Acquisition Management System

3.3.2 Additional Bibliographical Material

a. FAA AC 25-11, Transport Category Electronic Display Systems

b. FAA NAS CONOPS 2005, NAS Architecture, Version 4

c. FAA ADS-B Mission Need Statement #326

d. FAA ADS-B Plan

e. ICAO Manual of ATS Data Link Applications

f. ICAO Doc 4444, Annex 11, Appendix 5, Aeronautical Data Quality Requirements

g. SAE ARP 4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

3.4. Stakeholder Identification

As this OHA is developed primarily as a basis for capturing safety requirements for the FAA infrastructure required to support operations using ADS-B and TIS-B, the stakeholders include the FAA, all potential ADS-B/TIS-B equipped aircraft operators and service providers, equipment manufacturers, and equipment installers (including airframe manufacturers). As the stakeholder community is both broad and inclusive, and not limited by the requirements of a specific applicant's project, a more specific enumeration of stakeholders is not provided.

3.5. Allocation of Safety Objectives and Requirements Methodology

The ASOR was developed using information from the OHA and OSED as input. From the OHA, each operational hazard was assessed for causes. Safety objectives and candidate requirements from the OHA were then allocated to systems on a per-service basis. Candidate requirements captured in **Reference h**, which were assessed in **Reference h** across all services in a cumulative manner, were re-assessed in this ASOR for further allocation related to each service captured in the OSED **(Reference c)**. The ASOR was developed according to the following steps:

l. Worst case hazard severities were identified for each service. This was a gross identification for orientation. In some case, hazard severities are variable for the same service, depending on flight phase or operating environment. In later steps, finer breakouts were done from details documented in the OHA, prior to the allocation of requirements.

m. Catastrophic, hazardous, and major operational hazards were analyzed for causal events using fault trees.

n. Safety objectives from the OHA were allocated to major systems, equipment, and components in terms of qualitative probability requirements using the worksheets in **Section 3.9,** according to the results of the fault trees.

o. Development assurance level requirements were allocated to major systems, equipment, and components using the worksheets in **Section 3.9,** according to the results of the fault trees.

p. The hazard by hazard allocations from the worksheets in **Section 3.9** were assessed to determine the appropriate probability and development assurance level requirements for each service, and were then allocated to airborne, ground, and surface vehicle systems on a per-service basis in **Table 3.7-1**. In building **Table 3.7-1**, requirements allocated to system components in the **Section 3.9** worksheets, such as the conflict detection or resolution components of the airborne ADS-B system, were simply grouped as requirements on the system as a whole, with the most stringent component requirement determining the system level requirement in **Table 3.7-1**. Any potential partitioning within a system would be determined by a manufacturer in their specific design, and was therefore not assumed in this analysis.

q. Procedural requirements from **Reference g** were allocated on a per-service basis in **Table 3.7-1**. Fault trees were not applicable for this allocation. These types of requirements were allocated by inspection.

r. Functional, performance, and interoperability requirements from **Reference h** were assessed for their respective applicability to airborne, ATC ground, and surface vehicle systems, and then allocated on a per-service basis in **Table 3.7-1**. Fault trees were not applicable for this allocation. These types of requirements were allocated by inspection.

s. As part of the process of the assessments in the steps above, more formal requirements text was developed from the abbreviated candidate requirements text in **Reference g**. For probability and development assurance level candidate requirements, the abbreviated text from **Reference g** was expanded to account for the allocations at equipment levels captured in the worksheets in **Section 3.9**. The expanded formal text is documented in **Section 3.11**.

3.6. Services and Their Most Severe Hazard Categories

Table 3.6-1 identifies the most severe hazard classification for hazardously misleading information and loss of function related to each service. Worst case hazard severities are identified for each service. This is a gross identification for orientation only. In some case, hazard severities are variable for the same service, depending on flight phase or operating environment. For example, a hazard might be more severe on takeoff than in cruise. Only the most severe hazards for each service were considered for this section, simply to provide a look at which services have more critical aspects to be aware of when determining service implementation details. A finer breakout, from consideration of information in the OHA, is captured in **Section 3.7**.

Table 3.6-1: Most Severe Hazard Classifications for Each ATS

	ADS-B related Air Traffic Services (from the OSED)	Most Severe Hazard Classifications for Each ATS	
		Loss of Function	Hazardously Misleading Information
1.1	ADS-B for enhanced visual acquisition of aircraft during visual approach.	No Safety Effect	Minor
2.1	ADS-B for enhanced visual acquisition of aircraft during visual approach using call signs.	No Safety Effect	Minor
3.1	TIS-B augmented ADS-B for enhanced visual acquisition of aircraft during visual approach.	No Safety Effect	Minor
4.1	ADS-B for achieving and maintaining desired in-trail spacing during visual approach.	No Safety Effect	Minor
5.1	ADS-B for achieving and maintaining desired in-trail spacing during instrument approaches with ATC monitoring.	Minor	Major
6.1	ADS-B for achieving and maintaining desired in-trail spacing during visual departure with ATC monitoring.	No Safety Effect	Minor
7.1	ADS-B for proximate traffic awareness on instrument approach to closely spaced parallel runways.	Major	Hazardous
7.2	ADS-B for conflict detection/alerting/resolution aid.	Major	Hazardous
8.1	ADS-B for aided "see and avoid."	No Safety Effect	Minor

Table 3.6-1: Most Severe Hazard Classifications for Each ATS (continued)

	ADS-B related Air Traffic Services (from the OSED)	Most Severe Hazard Classifications for Each ATS	
		Loss of Function	Hazardously Misleading Information
9.1	TIS-B augmented ADS-B for aided "see and avoid."	No Safety Effect	Minor
10.1	ADS-B for conflict detection.	Major	Hazardous
11.1	ADS-B for conflict detection and tactical resolution.	Major	Hazardous
12.1	TIS-B augmented ADS-B for traffic awareness beyond visual range.	No Safety Effect	Minor
13.1	ADS-B for awareness of A/C traffic in non-radar airspace. (self separation at take off)	No Safety Effect	Major
14.1	ADS-B for awareness of traffic in final approach path and on runway surface.	No Safety Effect	Minor
15.1	TIS-B augmented ADS-B for awareness of traffic in final approach path and on runway surface.	No Safety Effect	Minor
16.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.	No Safety Effect	Catastrophic
17.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways.	No Safety Effect	Minor
18.1	ADS-B augmented surface surveillance for surface traffic management.	No Safety Effect	Minor
19.1	ADS-B for surface traffic management.	No Safety Effect	Minor
20.1	ADS-B for center traffic situational awareness in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.	No Safety Effect	Minor
21.1	ADS-B for radar-like services in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.	Minor	Hazardous
22.1	ADS-B for traffic awareness beyond tower visual range.	No Safety Effect	Minor
23.1	ADS-B augmented radar surveillance for terminal area air traffic management.	No Safety Effect	Minor
23.2	ADS-B augmented radar surveillance for terminal area reduced separation.	Minor	Major
24.1	ADS-B augmented radar surveillance for terminal area air traffic separation.	No Safety Effect	Minor
25.1	ADS-B augmented radar surveillance for en-route air traffic management.	No Safety Effect	Minor
25.2	ADS-B augmented radar surveillance for en-route reduced separation.	Minor	Major
26.1	ADS-B augmented radar surveillance for en-route separation.	No Safety Effect	Minor
27.1	ADS-B augmented radar surveillance for reduced separation.	Minor	Major

3.7. Allocation Results

Table 3.7-1 provides the complete allocation of candidate requirements, as proposed for consideration when developing requirements for ADS-B systems and operations, including Safety and Performance Requirements (SPR). Requirements allocated hazard by hazard in **Section 3.9** were filtered to determine the most appropriate allocation per service, with "worst case" for an expected typical service scenario being the deciding factor. Service implementers, and requirements and standards developers should determine, using the information in the OHA and ASOR, whether some aspects of an ADS-B related service offer an unacceptable risk in the form in which they are generally stated in the OSED and referenced source documents, and decide whether to apply mitigations or "design" the service details to reduce risk.

Requirements are listed by number which can be cross-referenced with the requirements text in **Section 3.11**.

The full text of each requirement can be found in **Section 3.11**.

Table 3.7-1: Allocation of Requirements by Service and Systems

	ADS-B related Air Traffic Services (from the OSED)		Requirements Allocation
1.1	ADS-B for enhanced visual acquisition of aircraft during visual approach.	Airborne	15-20
		Ground	None
		Surface Vehicle	None
		General Procedures	53
2.1	ADS-B for enhanced visual acquisition of aircraft during visual approach using call signs.	Airborne	15-20
		Ground	None
		Surface Vehicle	None
		General Procedures	53, 55, 62
3.1	TIS-B augmented ADS-B for enhanced visual acquisition of aircraft during visual approach.	Airborne	15-20
		Ground	39-43, 47-49
		Surface Vehicle	None
		General Procedures	53, 55
4.1	ADS-B for achieving and maintaining desired in-trail spacing during visual approach.	Airborne	15-20
		Ground	None
		Surface Vehicle	None
		General Procedures	53, 56
5.1	ADS-B for achieving and maintaining desired in-trail spacing during instrument approaches with ATC monitoring.	Airborne	9-12, 17-23, 64
		Ground	44-46, 64
		Surface Vehicle	None
		General Procedures	57
6.1	ADS-B for achieving and maintaining desired in-trail spacing during visual departure with ATC monitoring.	Airborne	15-20
		Ground	None
		Surface Vehicle	None
		General Procedures	53

Table 3.7-1: Allocation of Requirements by Service and Systems (continued)

	ADS-B related Air Traffic Services (from the OSED)		Requirements Allocation
7.1	ADS-B for proximate traffic awareness on instrument approach to closely spaced parallel runways.	Airborne	5-8, 13-14, 17-20, 64
		Ground	None
		Surface Vehicle	None
		General Procedures	59
7.2	ADS-B for conflict detection/alerting/resolution aid.	Airborne	5-8, 13-14, 17-20, 64
		Ground	None
		Surface Vehicle	None
		General Procedures	59, 63
8.1	ADS-B for aided "see and avoid."	Airborne	15-20
		Ground	None
		Surface Vehicle	None
		General Procedures	53
9.1	TIS-B augmented ADS-B for aided "see and avoid."	Airborne	15-20
		Ground	39-43, 47-49
		Surface Vehicle	None
		General Procedures	53
10.1	ADS-B for conflict detection.	Airborne	5-8, 13-14, 17-20, 64
		Ground	None
		Surface Vehicle	None
		General Procedures	59, 63.a
11.1	ADS-B for conflict detection and tactical resolution.	Airborne	5-8, 13-14, 17-20, 64
		Ground	None
		Surface Vehicle	None
		General Procedures	59, 63
12.1	TIS-B augmented ADS-B for traffic awareness beyond visual range.	Airborne	15-20
		Ground	39-43, 47-49
		Surface Vehicle	None
		General Procedures	53
13.1	ADS-B for awareness of A/C traffic in non-radar airspace.	Airborne	9-12, 17-20, 64
		Ground	None
		Surface Vehicle	None
		General Procedures	54, 60, 62
14.1	ADS-B for awareness of traffic in final approach path and on runway surface.	Airborne	15-20
		Ground	None
		Surface Vehicle	31-33
		General Procedures	53
15.1	TIS-B augmented ADS-B for awareness of traffic in final approach path and on runway surface.	Airborne	15-20
		Ground	39-43, 47-49
		Surface Vehicle	31-33
		General Procedures	53
16.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways. (for surface operations in VMC or IMC but not in zero visibility)	Airborne	15-20, 52
		Ground	None
		Surface Vehicle	31-33
		General Procedures	53
16.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways. (for surface operations in zero visibility at an uncontrolled airport or a controlled airport without surface radar)	Airborne	1-4, 17-20, 50-51, 64
		Ground	None
		Surface Vehicle	24-25, 32-33, 64
		General Procedures	

Table 3.7-1: Allocation of Requirements by Service and Systems (continued)

	ADS-B related Air Traffic Services (from the OSED)		Requirements Allocation
17.1	ADS-B for awareness of A/C and surface vehicle traffic for maneuvering on ramps, taxiways, and runways. (for surface operations in VMC or IMC but not in zero visibility)	Airborne	15-20, 52
		Ground	None
		Surface Vehicle	31-33
		General Procedures	53
18.1	ADS-B augmented surface surveillance for surface traffic management.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	31-33
		General Procedures	53
19.1	ADS-B for surface traffic management.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	31-33
		General Procedures	53
20.1	ADS-B for center traffic situational awareness in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	None
		General Procedures	53
21.1	ADS-B for radar-like services in non-radar areas of domestic airspace, including low altitude airspace, remote airspace (e.g., mountainous areas), and coastal waters.	Airborne	9, 11, 17-20, 64
		Ground	34-35, 41-43, 64
		Surface Vehicle	None
		General Procedures	60.c
22.1	ADS-B for traffic awareness beyond tower visual range.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	None
		General Procedures	53
23.1	ADS-B augmented radar surveillance for terminal area air traffic management.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	None
		General Procedures	53
23.2	ADS-B augmented radar surveillance for terminal area reduced separation.	Airborne	9, 11, 17-20, 64
		Ground	36-38, 41-43, 64
		Surface Vehicle	None
		General Procedures	61
24.1	ADS-B augmented radar surveillance for terminal area air traffic separation.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	None
		General Procedures	53
25.1	ADS-B augmented radar surveillance for en-route air traffic management.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	None
		General Procedures	53
25.2	ADS-B augmented radar surveillance for en-route reduced separation.	Airborne	9, 11, 17-20, 64
		Ground	36-38, 41-43, 64
		Surface Vehicle	None
		General Procedures	61

Table 3.7-1: Allocation of Requirements by Service and Systems (continued)

	ADS-B related Air Traffic Services (from the OSED)		Requirements Allocation
26.1	ADS-B augmented radar surveillance for en-route separation.	Airborne	15, 17-20
		Ground	39-43
		Surface Vehicle	None
		General Procedures	53
27.1	ADS-B augmented radar surveillance for reduced separation.	Airborne	9, 11, 17-20, 64
		Ground	36-38, 41-43, 64
		Surface Vehicle	None
		General Procedures	61

3.8. Allocation of Requirements Not Needing Fault Tree Analysis

Fault tree analysis is particularly useful for allocating probability and development assurance requirements. For certain other types of requirements, fault tree analysis may not be necessary or even applicable. These other types may include candidate functional features, performance, interoperability, and procedural requirements. These types of requirements were allocated by inspection. In **Section 3.11**, the textual descriptions for these requirements are organized separately from probability and development assurance requirements.

3.9. Allocation of Failure Probability and Development Assurance Level Requirements to Systems, Equipment, and Components

This section contains tabulated worksheets used in conjunction with the fault tree analyses of **Section 3.10**, to determine the allocation of failure probability requirements and development assurance level requirements to systems which would implement the ATS described in the OSED. Probability requirements in the ASOR are expressed in qualitative terms. A general relationship of qualitative and quantitative probability measures is provided in **Reference g**, **Table 2.5-3**.

Signal integrity coding was considered in the fault tree analysis, even though it may not be implemented. This was done to determine it's relationship to the operational hazard, if integrity coding is implemented. It is not, at this time, construed as a requirement, unless specified in standards, but due to the severity of some hazards for specific services, and the potential protection provided from EMI corruption of a signal during transmission, it is recommended that integrity encoding be considered by standards developers.

In the worksheet column titled " Fault Tree Ref & Notes," the term FTA 3.10-*nn* refers to the fault tree figure of that number in **Section 3.10**. In the same column, the terms HMI-*nnn* or LOSS-*nnn* refer to the gate number in the respective fault tree in **Section 3.10**. If there is no gate number designated, then the entire fault tree applies. The reason for designating applicable gates is that for each hazard, all causes related to airborne, ground, and surface vehicle systems were documented, thus generalizing the usability of the fault tree. For example, depending on the service description from the OSED, the hazard "hazardously misleading ADS-B information for a single aircraft" might apply to the display of hazardously misleading information in the aircraft cockpit, or at the controllers console, or both. However, for some services the hazards only apply to, for example, the aircraft system. In that case, only a portion of the generalized fault tree applies, and that portion can be designated by the appropriate gate

number. The designation of a gate in the allocation worksheets indicates that, for that particular service, the related hazard is accounted for by the analysis from the designated gate downward.

The reader will notice that there are essentially no allocated reductions from the operational hazard level candidate probability and development assurance requirements. This is because the fault tree analyses show that contributing system failures are all essentially related by Boolean OR gates throughout each fault tree. Two exceptions are the Boolean AND relationship between signal corruption in space and a hypothetical signal integrity check, and the system combinatorial fault trees in FTA 3.10-10. The EMI portion of the model was developed in the fault tree simply to highlight the potential effect of an EMI event and does not affect the allocation of requirements to basic system elements. The combinatorial fault tree in FTA 3.10-10 does allow for reductions from the top level requirements for hazards related to ADS-B failures in combination with radar and communications failures.

For the requirements allocation worksheets, the legend is as follows:

Qualitative Probability Requirements:

1 = must be extremely improbable
2 = must be extremely remote
3 = must be remote

Development Assurance Level Requirements:

A = must be Level A
B = must be at least Level B
C = must be at least Level C

A blank cell indicates that the system, equipment, or component is not applicable for the operational hazard and ATS.

cca = Common Cause Analysis, i.e., common cause failures should be considered. These might include such things as common navigation signal sources such as Global Navigation Satellite System (GNSS). There are no specific requirements written for the cca designations as this would require a specific design to perform the cca against. The symbol is provided as an indicator that systems and ATS developers should perform a common cause analysis at the operational level when specific designs are developed in order to determine whether mitigation is required for common cause failure sources integrated into a specific ADS-B technical environment.

Table 3.9-1: Allocation of Probability and Development Assurance Requirements for catastrophic hazards

Catastrophic Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Extremely Improbable** and system-level development assurance shall be **Level A** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

			ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
Operational Hazard	**ATS**	**Fault Tree Ref & Notes**	ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
16.1.4 Hazardously misleading ADS-B information for a single aircraft or surface vehicle.	16.1	FTA 3.10-3 HMI-020							1 A				1 A	1 A				1 A		1 A	
16.1.6 Hazardously misleading ADS-B information for multiple aircraft and surface vehicles.	16.1	FTA 3.10-4 HMI-023							1 A cca	1 A			1 A	1 A cca				1 A cca		1 A cca	
16.1.9 Hazardously misleading map display.	16.1	FTA 3.10-7							1 A	1 A		1 A		1 A							

Table 3.9-2: Allocation of Probability and Development Assurance Requirements for hazardous hazards

Hazardous Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Extremely Remote** and system-level development assurance shall be **Level B** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

Operational Hazard	ATS	Fault Tree Ref & Notes	ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
			ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
7.1.3 Hazardously misleading ADS-B information for a single aircraft.	7.1	FTA 3.10-1 HMI-014							2 B				2 B	2 B							
7.1.4 Hazardously misleading ADS-B information for multiple aircraft.	7.1	FTA 3.10-2 HMI-017							2 B cca	2 B			2 B	2 B cca							
10.1.5 Hazardously misleading ADS-B information for a single aircraft.	10.1	FTA 3.10-1 HMI-014							2 B				2 B	2 B							
10.1.6 Hazardously misleading ADS-B information for multiple aircraft.	10.1	FTA 3.10-5							2 B cca	2 B			2 B	2 B cca	2 B						

Table 3.9-2: Allocation of Probability and Development Assurance Requirements for hazardous hazards (continued)

Hazardous Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Extremely Remote** and system-level development assurance shall be **Level B** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

Operational Hazard	ATS	Fault Tree Ref & Notes	ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
			ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
11.1.3 Hazardously misleading ADS-B information for a single aircraft.	11.1	FTA 3.10-1 HMI-014							2 B				2 B	2 B							
11.1.4 Hazardously misleading ADS-B information for multiple aircraft.	11.1	FTA 3.10-6							2 B cca	2 B			2 B	2 B cca	2 B	2 B					
21.1.4 Hazardously misleading ADS-B information for multiple aircraft.	21.1	FTA 3.10-2 HMI-016	2 B			2 B	2 B		cca					cca							

Table 3.9-3: Allocation of Probability and Development Assurance Requirements for major hazards

Major Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Remote** and system-level development assurance shall be **Level C** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

Operational Hazard	ATS	Fault Tree Ref & Notes	ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
			ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
5.1.2 Hazardously misleading ADS-B information for a single aircraft.	5.1	FTA 3.10-1 HMI-014							3 C				3 C	3 C							
5.1.3 Hazardously misleading ADS-B information for multiple aircraft..	5.1	FTA 3.10-2 HMI-017							3 C cca	3 C			3 C	3 C cca							
5.1.4 Loss of aircraft ADS-B information with loss of radar surveillance capability	5.1	FTA 3.10-10 CMB-002	Aircraft ADS-B component failures may be probable with Level D development assurance where surveillance has been historically shown to be acceptably reliable without ADS-B usage, or where loss of new radar system functions and loss of new transponder system functions are shown to be improbable and these new systems are developed to Level C development assurance requirements or equivalent.																		
5.1.5 Loss of aircraft ADS-B information with loss of communications capability.	5.1	FTA 3.10-10 CMB-003	Aircraft ADS-B component failures may be probable with Level D development assurance where air-ground communications have historically been shown to be acceptably reliable without ADS-B usage, or where loss of new communication systems functions is shown to be improbable and these new systems are developed to Level C development assurance requirements or equivalent.																		
5.1.6 Aircraft ADS-B hazardously misleading information with loss of communications capability.	5.1	FTA 3.10-10 CMB-004	Aircraft ADS-B component failures may be probable with Level D development assurance where communications combined with surveillance has been historically shown to be acceptably reliable without ADS-B usage, or where functional loss related failures of new radar systems, new transponder systems, and new communication systems are shown to be improbable and these new systems are developed to Level C development assurance requirements or equivalent.																		

Table 3.9-3: Allocation of Probability and Development Assurance Requirements for major hazards (continued)

Major Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Remote** and system-level development assurance shall be **Level C** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

			ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
Operational Hazard	**ATS**	**Fault Tree Ref & Notes**	ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
7.1.1 Loss of ADS-B information for a single aircraft.	7.1	FTA 3.10-8 LOSS-005							3 C					3 C							
7.1.2 Loss of ADS-B information from multiple aircraft.	7.1	FTA 3.10-9 LOSS-025							3 C cca	3 C				3 C cca							
10.1.2 Loss of ADS-B information for a single aircraft.	10.1	FTA 3.10-8 LOSS-005							3 C					3 C							
10.1.4 Loss of ADS-B information from multiple aircraft.	10.1	FTA 3.10-9 LOSS-025							3 C cca	3 C				3 C cca							
11.1.1 Loss of ADS-B information for a single aircraft.	11.1	FTA 3.10-8 LOSS-005							3 C					3 C							
11.1.2 Loss of ADS-B information from multiple aircraft.	11.1	FTA 3.10-9 LOSS-025							3 C cca	3 C				3 C cca							

Table 3.9-3: Allocation of Probability and Development Assurance Requirements for major hazards (continued)

Major Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Remote** and system-level development assurance shall be **Level C** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

			ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
Operational Hazard	**ATS**	**Fault Tree Ref & Notes**	ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
13.1.3 Hazardously misleading ADS-B information for a single aircraft.	13.1	FTA 3.10-1 HMI-014							3 C				3 C	3 C							
13.1.6 Hazardously misleading ADS-B information for multiple aircraft.	13.1	FTA 3.10-2 HMI-017							3 C cca	3 C			3 C	3 C cca							
21.1.3 Hazardously misleading ADS-B information for a single aircraft.	21.1	FTA 3.10-1 HMI-013					3 C		3 C					3 C							
23.2.3 Hazardously misleading ADS-B information for a single aircraft.	23.2	FTA 3.10-1 HMI-013					3 C		3 C					3 C							
23.2.4 Hazardously misleading ADS-B information for multiple aircraft.	23.2	FTA 3.10-2 HMI-016	3 C			3 C	3 C		cca					cca							

Table 3.9-3: Allocation of Probability and Development Assurance Requirements for major hazards (continued)

Major Hazards - For the operational hazards listed in this table, when providing the listed ATS for the listed operating phases, aircraft types, and airport types, the operational hazard shall be **Remote** and system-level development assurance shall be **Level C** (system-level includes the combination of both the ground-based, airborne, and surface vehicle components that together provide the ATS and whose failures contribute to the hazard).

			ALLOCATED COMPONENT-LEVEL PROBABILITY AND DEVELOPMENT ASSURANCE LEVELS																		
			Ground Components						Airborne Components									Surface Vehicle Components			
Operational Hazard	**ATS**	**Fault Tree Ref & Notes**	ADS-B system	TIS-B system	Radar for appl service	Traffic display system	Integrity check	Communication system	ADS-B system	Traffic display system	FAR transponder	Map display system	Integrity check	Navigation & altitude source	Conflict detection	Conflict resolution	Communication system	ADS-B system	Integrity check	ADS-B position source	Communications system
25.2.3 Hazardously misleading ADS-B information for a single aircraft.	25.2	FTA 3.10-1 HMI-013					3 C		3 C					3 C							
25.2.4 Hazardously misleading ADS-B information for multiple aircraft.	25.2	FTA 3.10-2 HMI-016	3 C			3 C	3 C		cca					cca							

3.10. Fault Tree Analyses

The figures in this section show the fault tree analyses developed to help the allocation process. Fault trees were developed only for catastrophic, hazardous, and major operational hazards. A gross allocation at the highest system level was deemed adequate for minor failure conditions. The following discussion is provided to help in the interpretation of the fault trees.

The fault trees represent a top-level generic architecture, and were developed only to a level that allows requirements allocation between major ground, airborne, and surface vehicle system or functional components utilized to implement ADS-B related services. Architectures below this level may vary between installations and manufacturers, and system safety assessment requirements below this level are either provided by regulation and guidance material in the case of aircraft, or policy and contract requirements for ground systems and surface vehicles. For example, where the fault trees show an aircraft navigation system failure as a basic event in a fault tree, no underlying navigation system architecture is assumed. If an ASOR derived requirement is allocated to the ADS-B navigation source, it is expected to apply to the navigation input as a whole, with lower level allocations being the work of an institutional safety assessment per regulation, contract, or policy.

Larger fault trees are paginated for the sake of text readability, and page transfer references (a triangle with a number by it, connected to an event box) within the fault tree refer to the FTA figure page number, not the document page number. In other words, a transfer symbol showing continuation on page 3 refers to the third page of that particular FTA figure. Transfer symbols indicate either that an event's decomposition is continued on another page, or that the event shows up in multiple places in the fault tree.

Each unique event in a fault tree has a unique identifier, typically called a gate number, associated with it (see the fault tree symbol legend). Identical gate numbers in multiple places within a tree indicate that the same event contributes to multiple areas in the hazard decomposition.

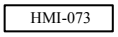
The fault trees were generated using a computer aided analysis tool which limits the number of characters for event descriptions. Therefore, generous use of both grammatical and word abbreviations had to be employed. An attempt was made to abbreviate in a manner that would be obvious in context. However, the following is a non-exhaustive list of word abbreviations that may occur in the fault trees:

&	= and
A/C	= aircraft
alt	= altitude
dep	= dependent
EMI	= electromagnetic interference
indep	= independent
GRND	= ground
nav	= navigation
rcv	= receive
rcvg	= receiving
rcvr	= receiver(s)
rcvs	= receives
surf	= surface
sys	= system(s)
veh	= vehicle(s)

xmt = transmit
xmtg = transmitting
xmtr = transmitter(s)
xmts = transmits

Fault tree symbology is as follows:

Event descritpion

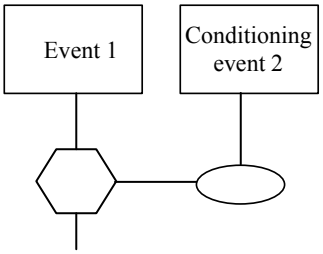


Gate number (can be viewed alternatively as an event number).

AND gate

OR gate

Exclusive OR gate (XOR)



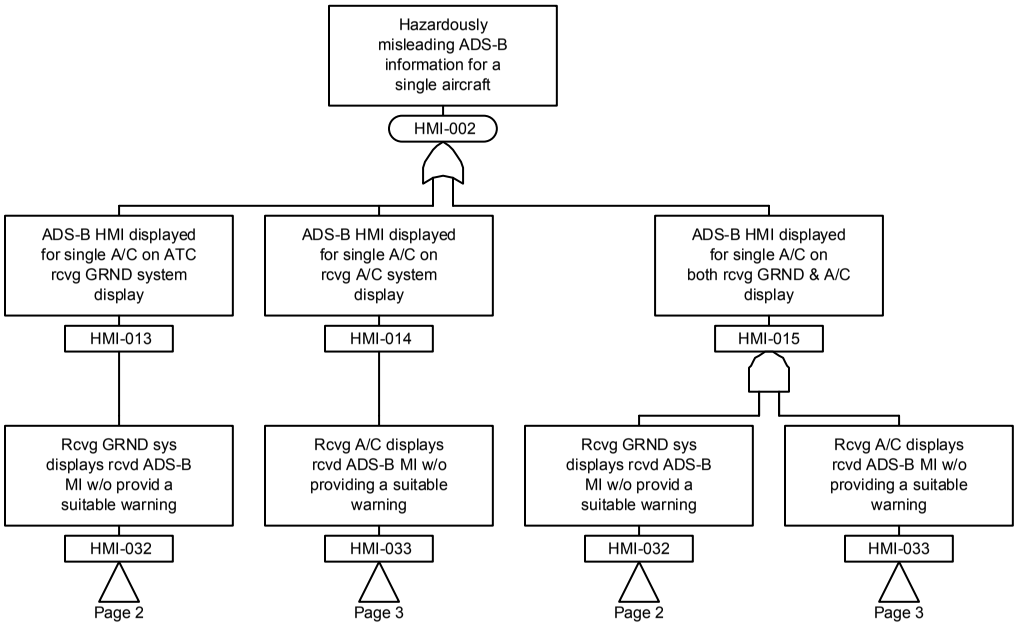
Conditional AND gate (hex) with conditioning event (oval)
Event 1 will only occur ifconditioning event 2 occurs.
(This can, in a manner, be viewed as a note that event 1 and its subtree is a factor only under specific circumstances shown as event 2.)

Undeveloped event

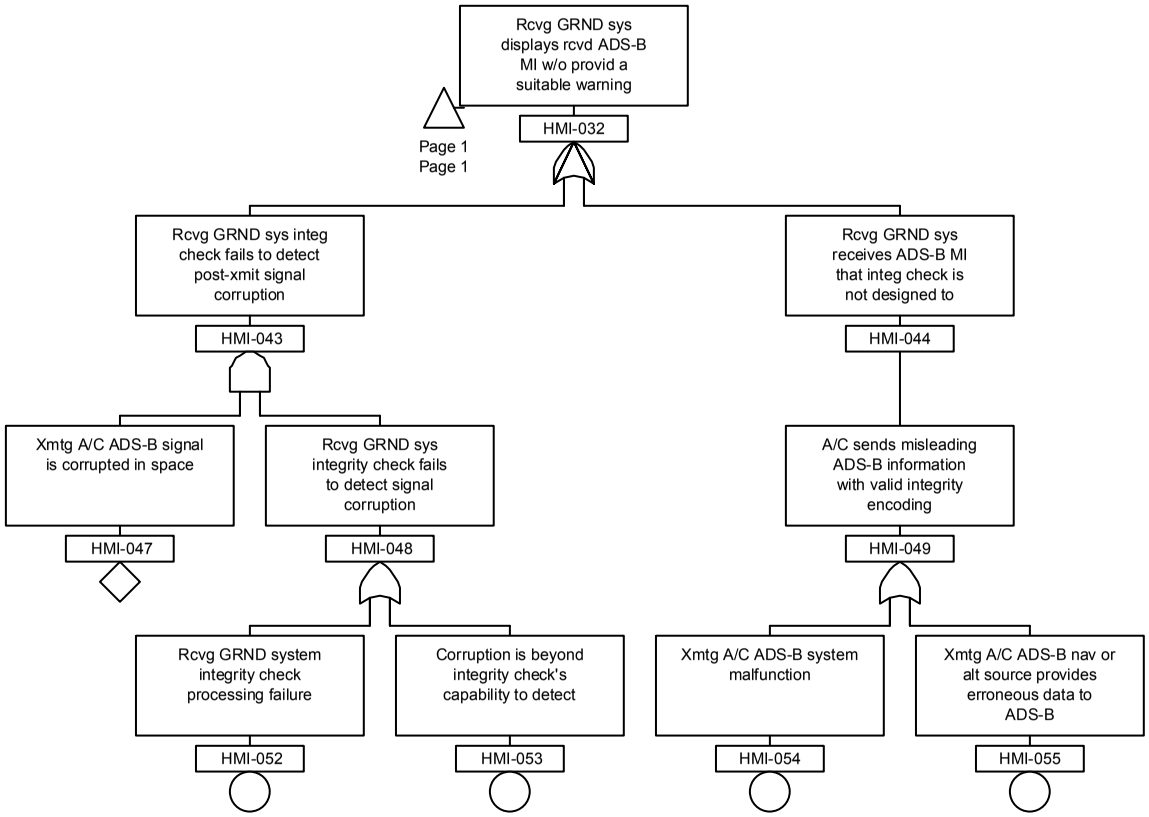
Basic event

Transfer (continued on or from another page or different area of the same page).

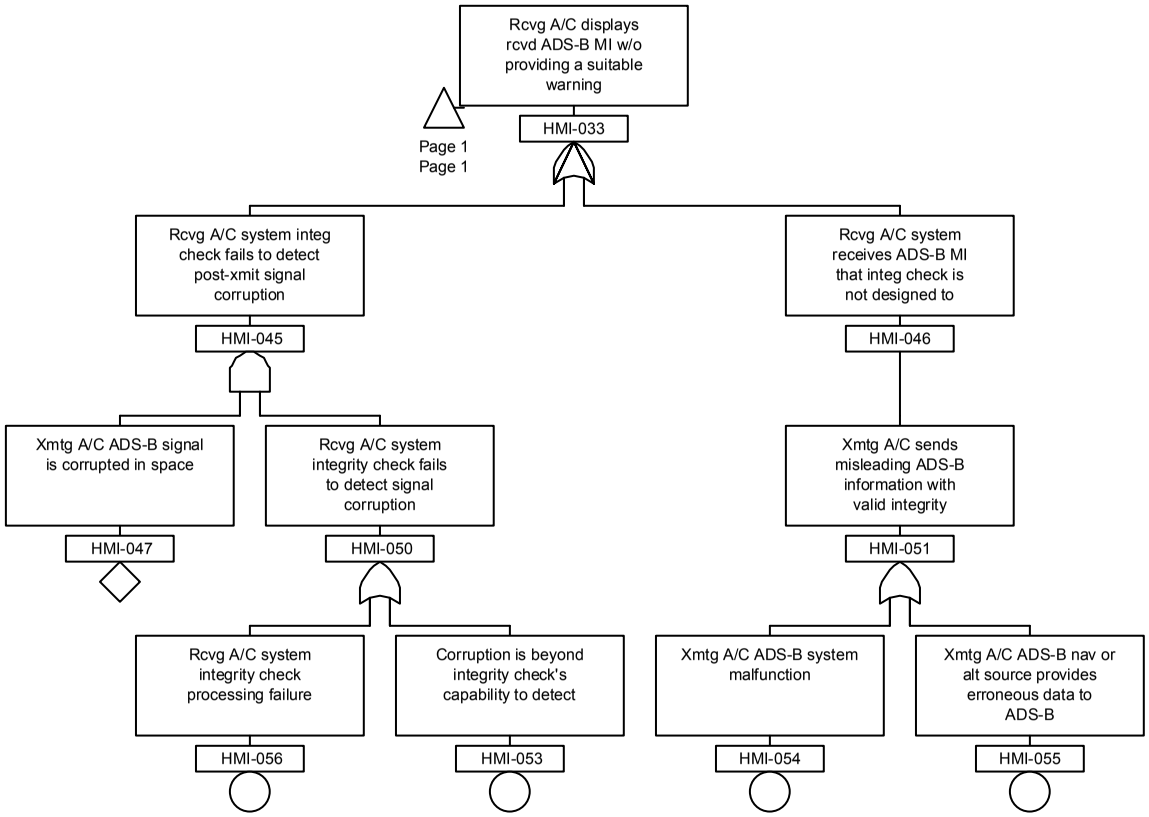
FTA 3.10-1: Hazardously Misleading ADS-B Information for a Single Aircraft - PAGE 1



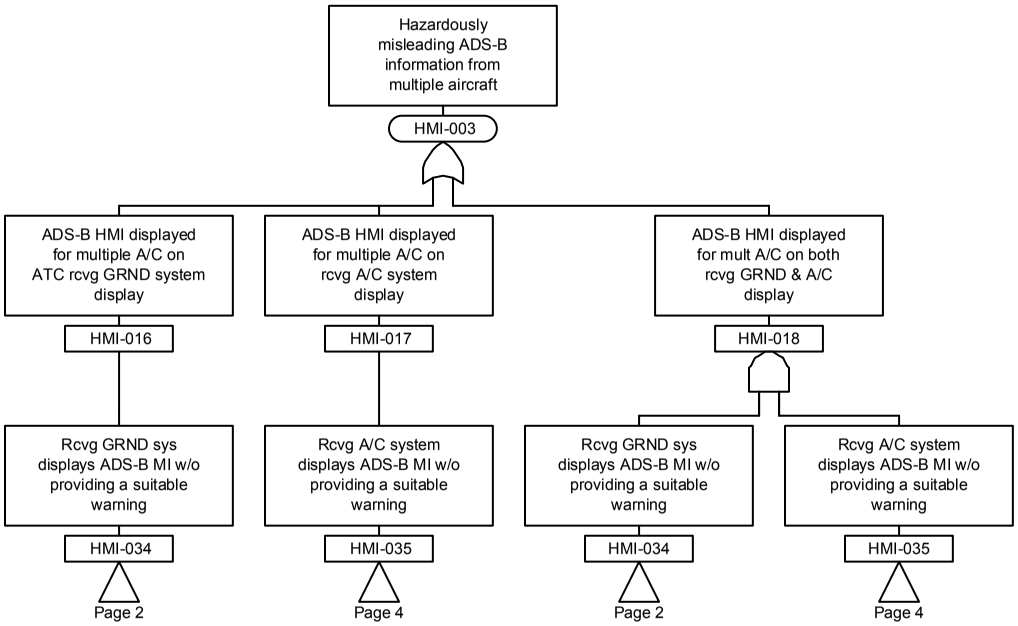
FTA 3.10-1: Hazardously Misleading ADS-B Information for a Single Aircraft - PAGE 2



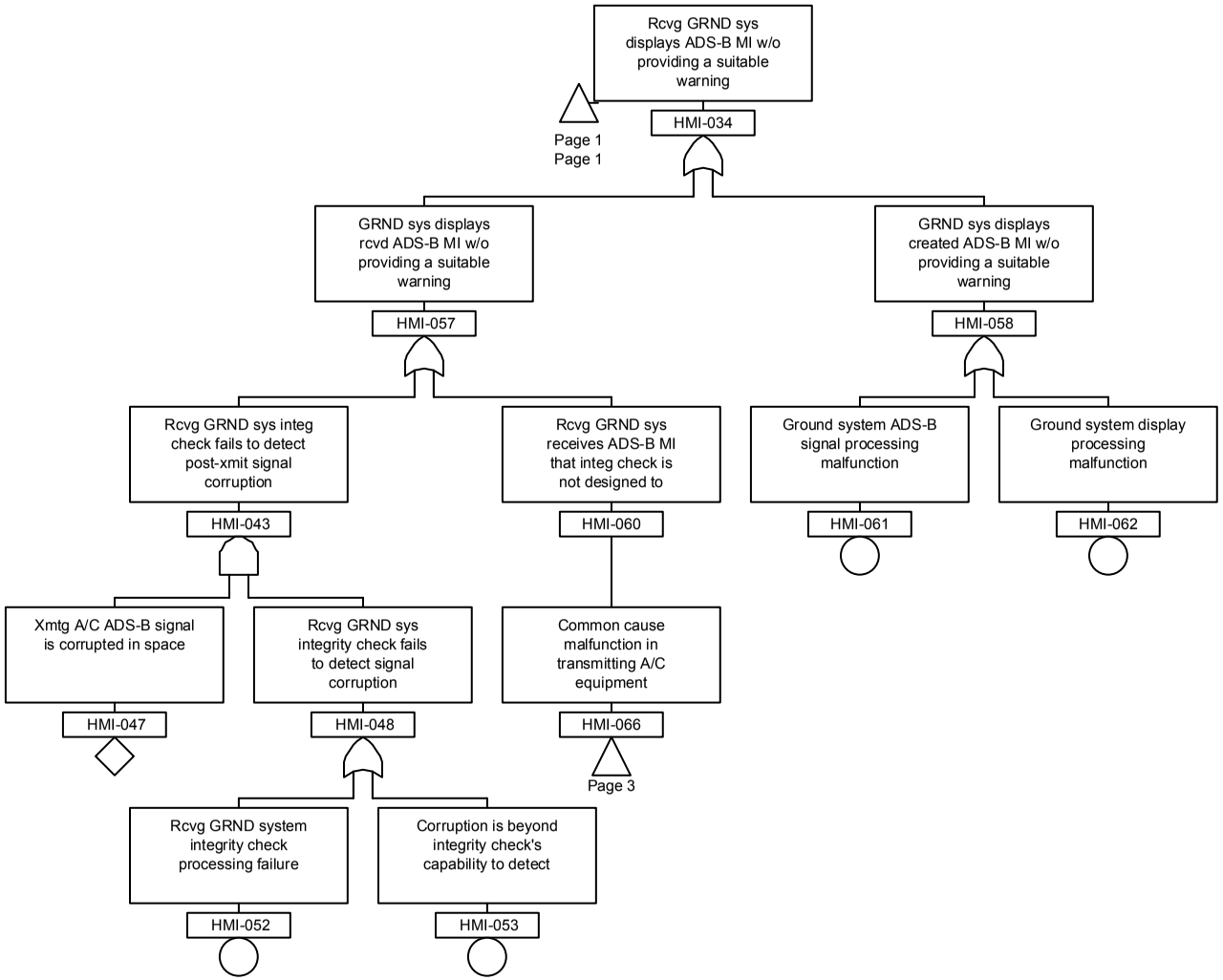
FTA 3.10-1: Hazardously Misleading ADS-B Information for a Single Aircraft - PAGE 3



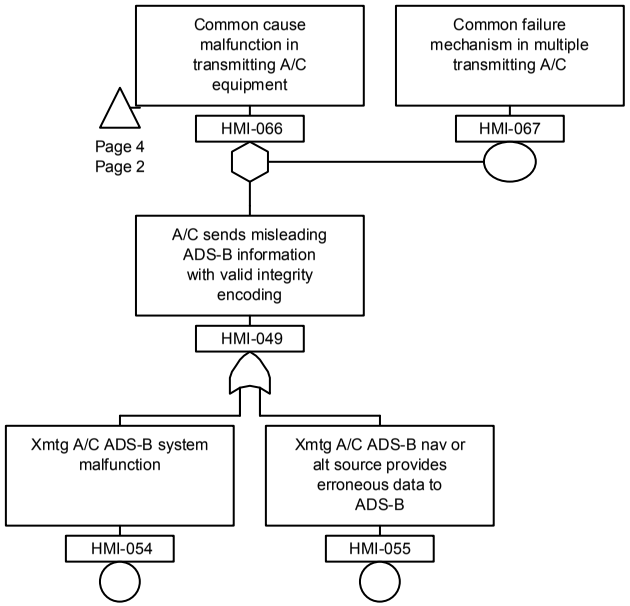
FTA 3.10-2: Hazardously Misleading ADS-B Information for Multiple Aircraft - PAGE 1



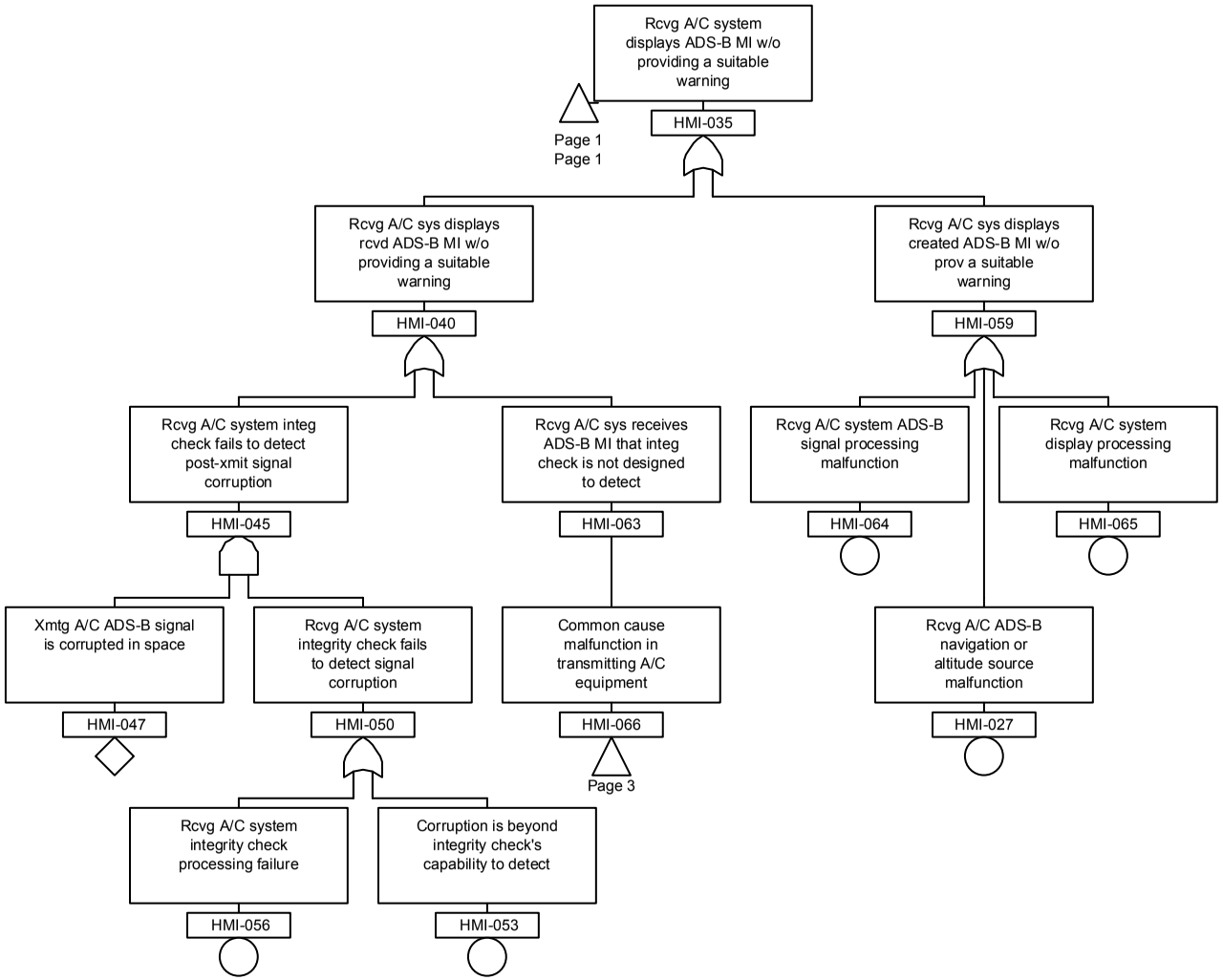
FTA 3.10-2: Hazardously Misleading ADS-B Information for Multiple Aircraft - PAGE 2



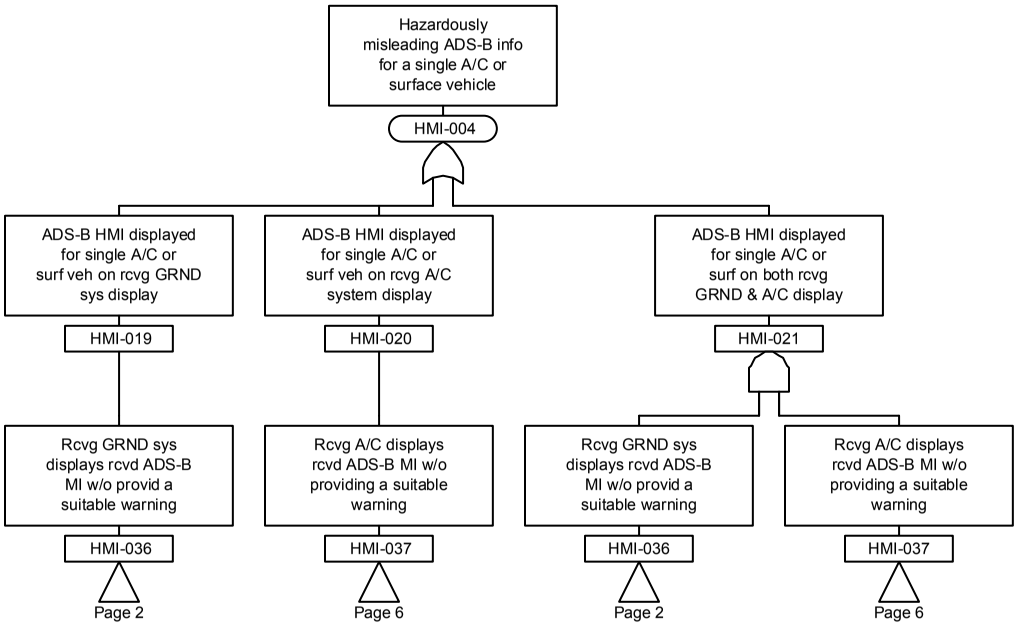
FTA 3.10-2: Hazardously Misleading ADS-B Information for Multiple Aircraft - PAGE 3



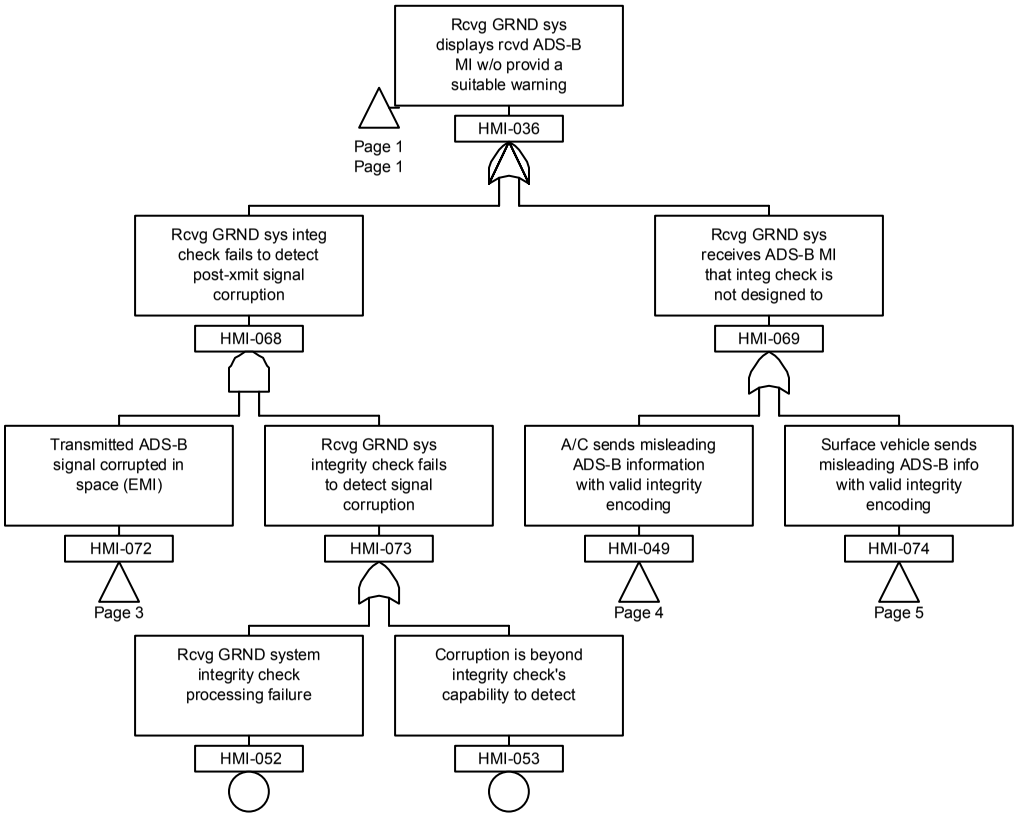
FTA 3.10-2: Hazardously Misleading ADS-B Information for Multiple Aircraft - PAGE 4



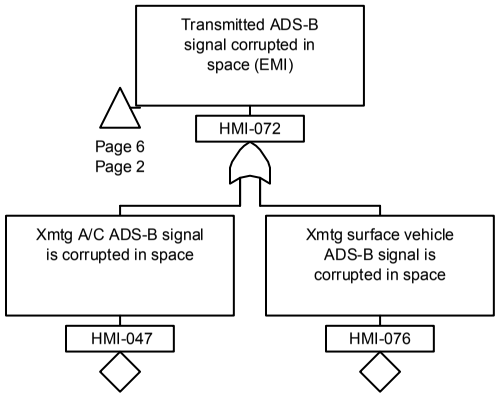
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle - PAGE 1



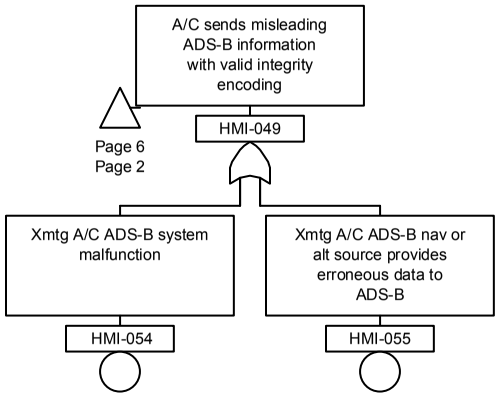
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle - PAGE 2



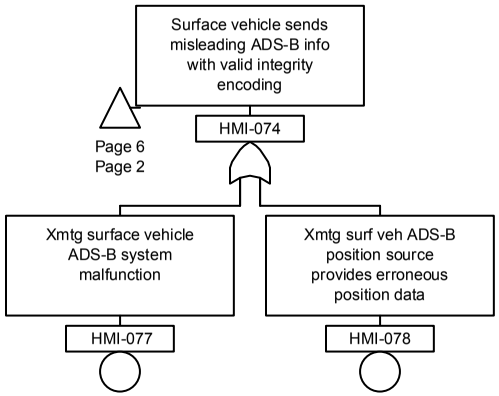
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle - PAGE 3



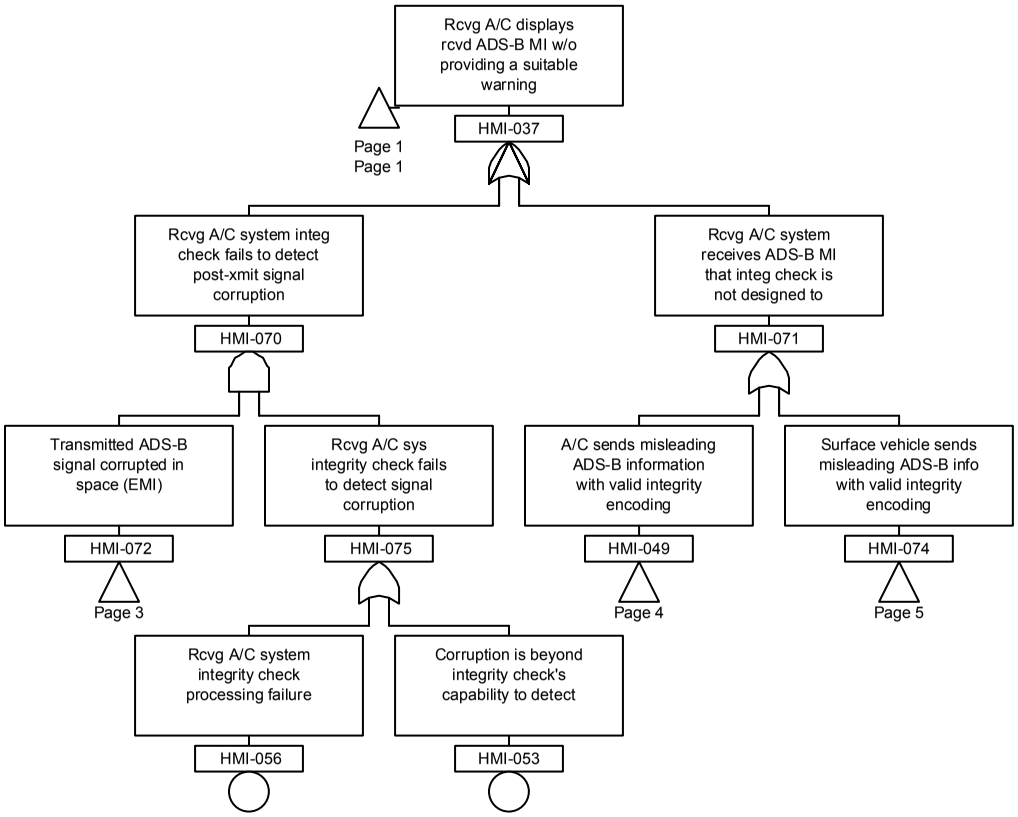
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle - PAGE 4



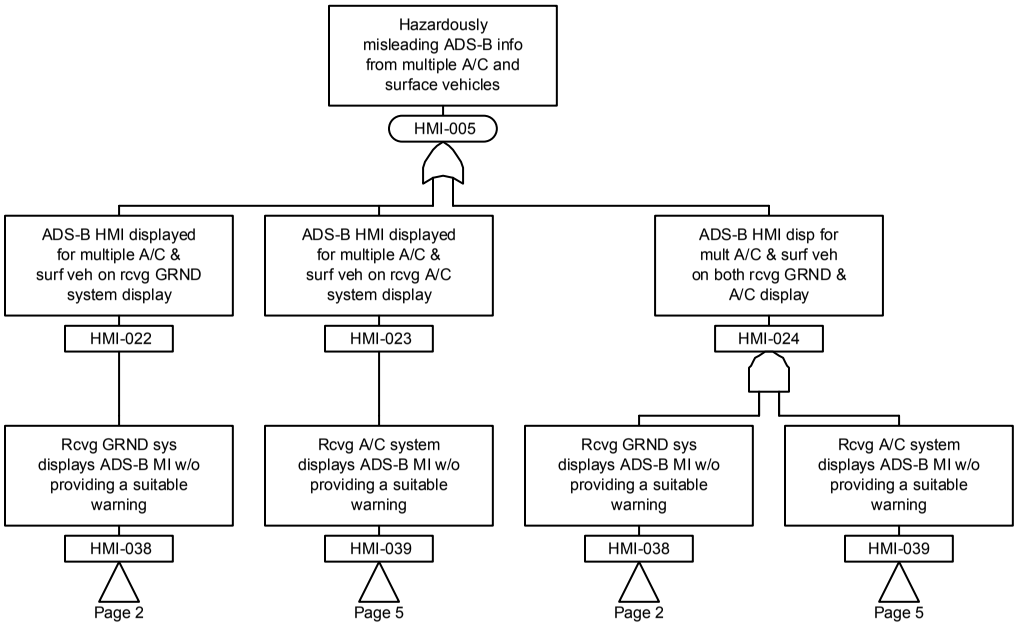
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle - PAGE 5



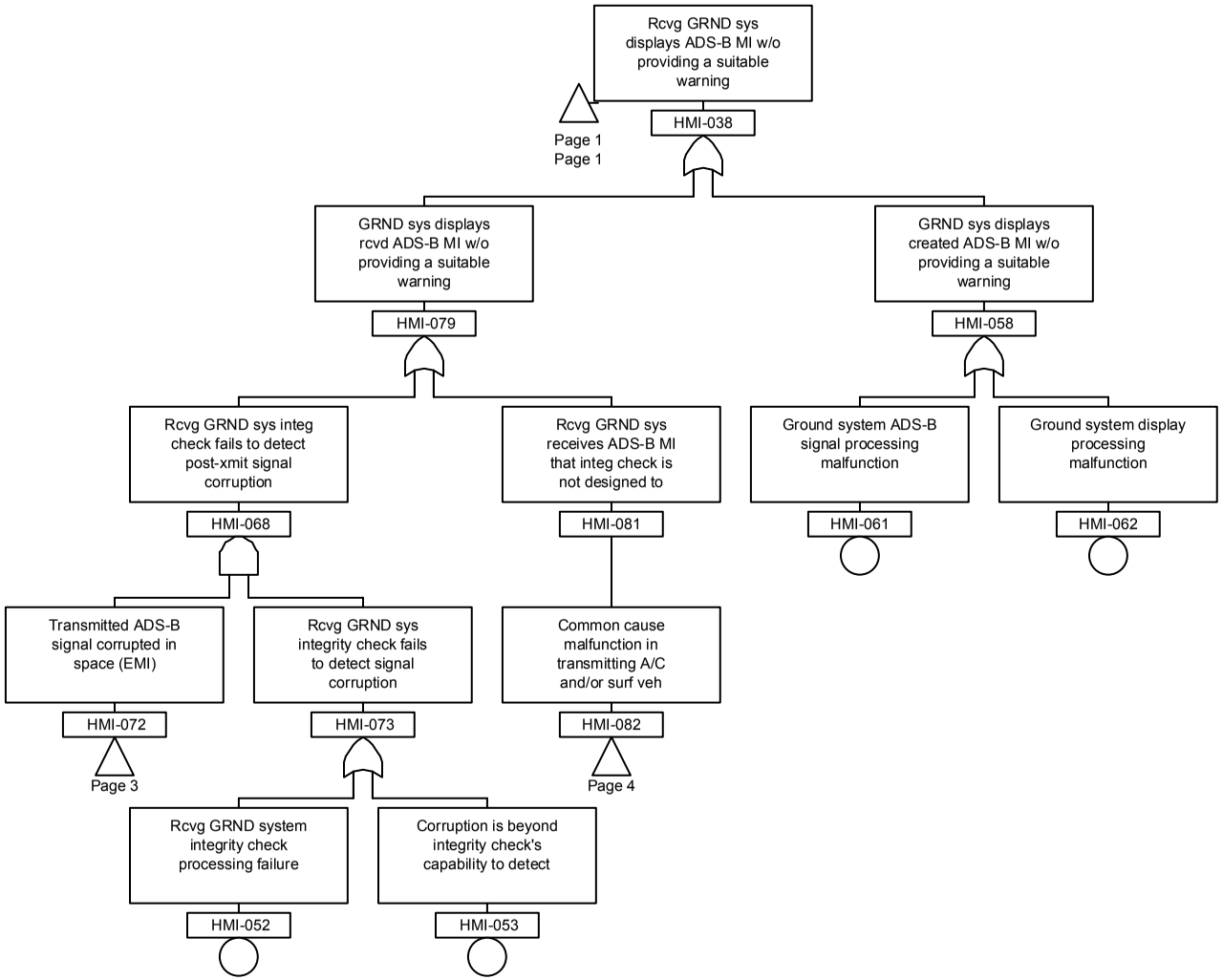
FTA 3.10-3: Hazardously Misleading ADS-B Information for a Single Aircraft or Surface Vehicle - PAGE 6



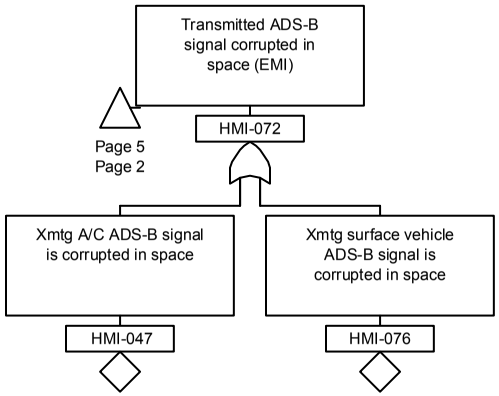
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 1



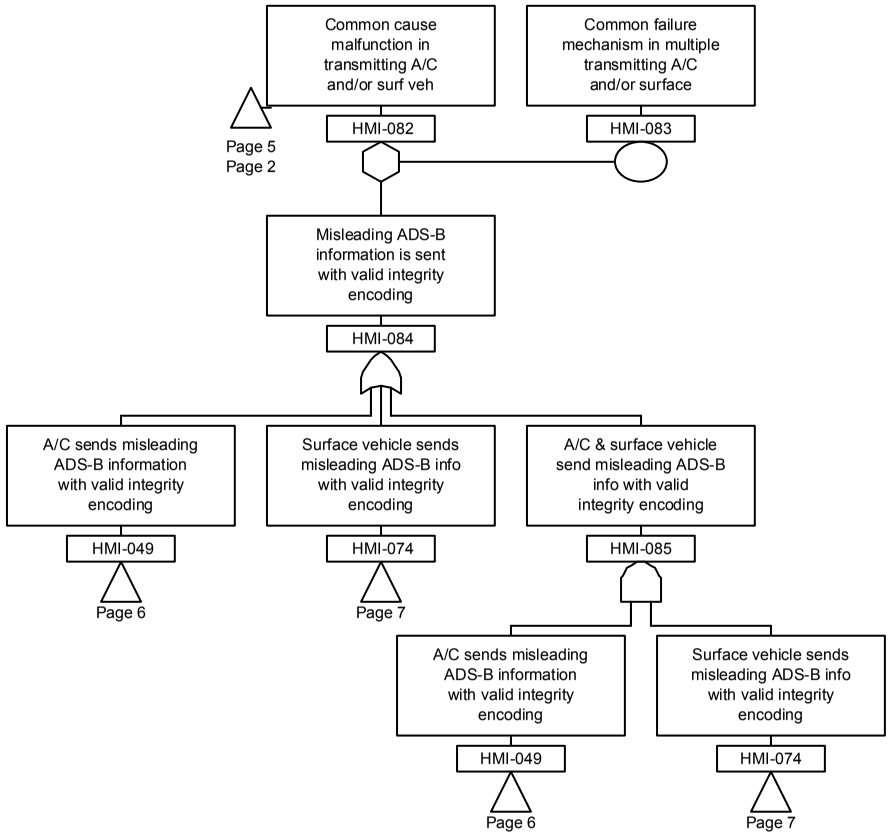
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 2



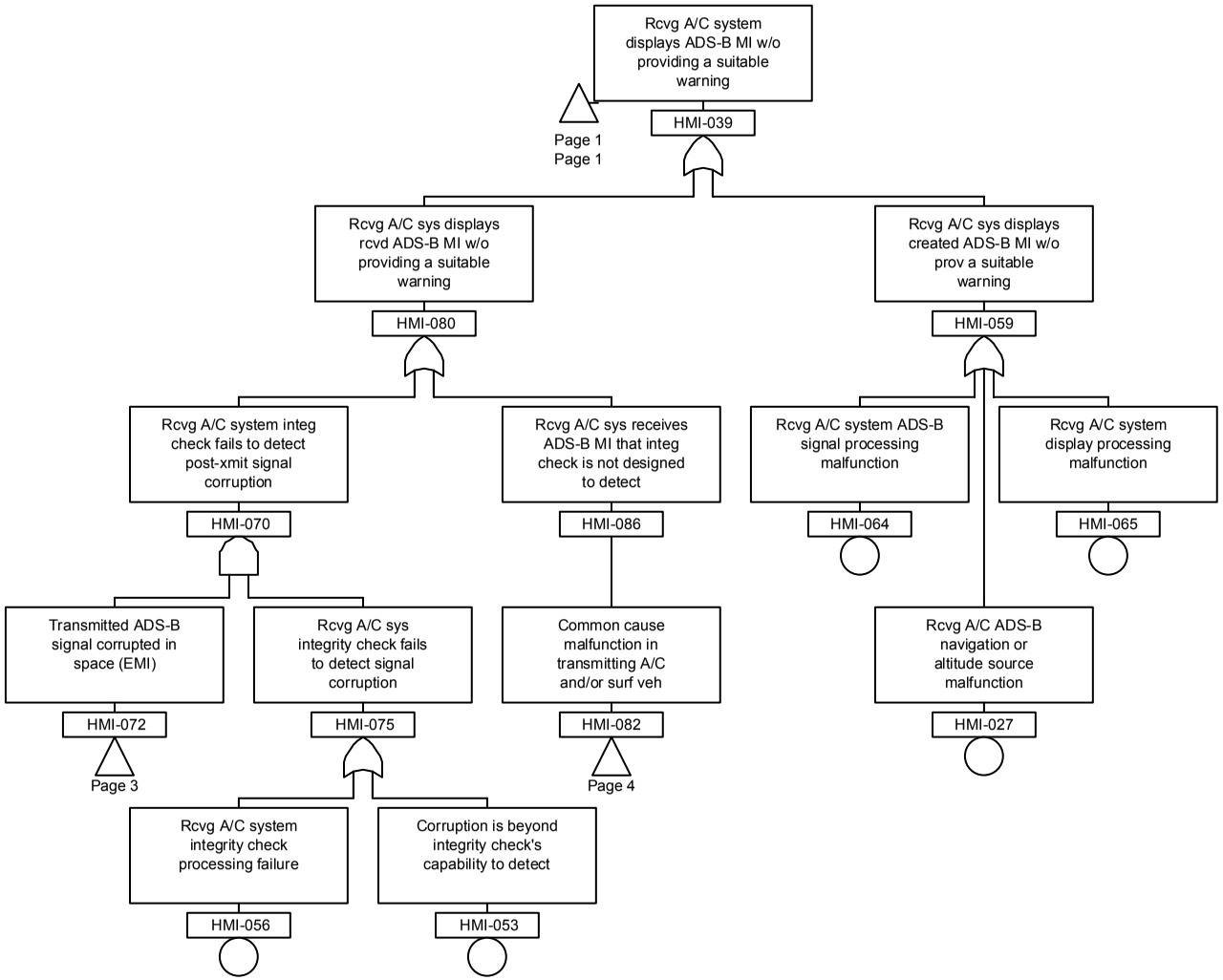
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 3



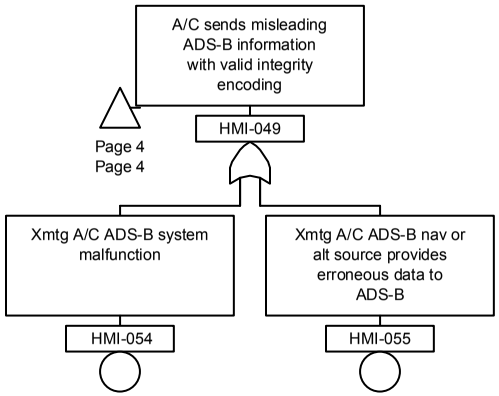
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 4



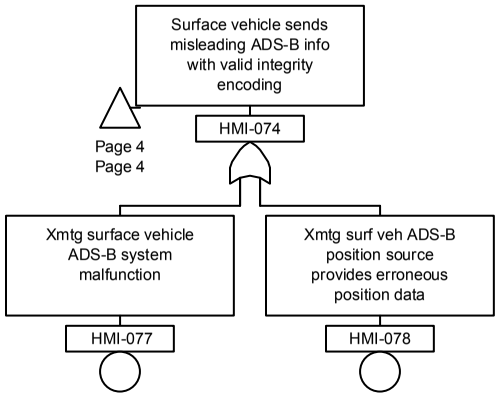
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 5



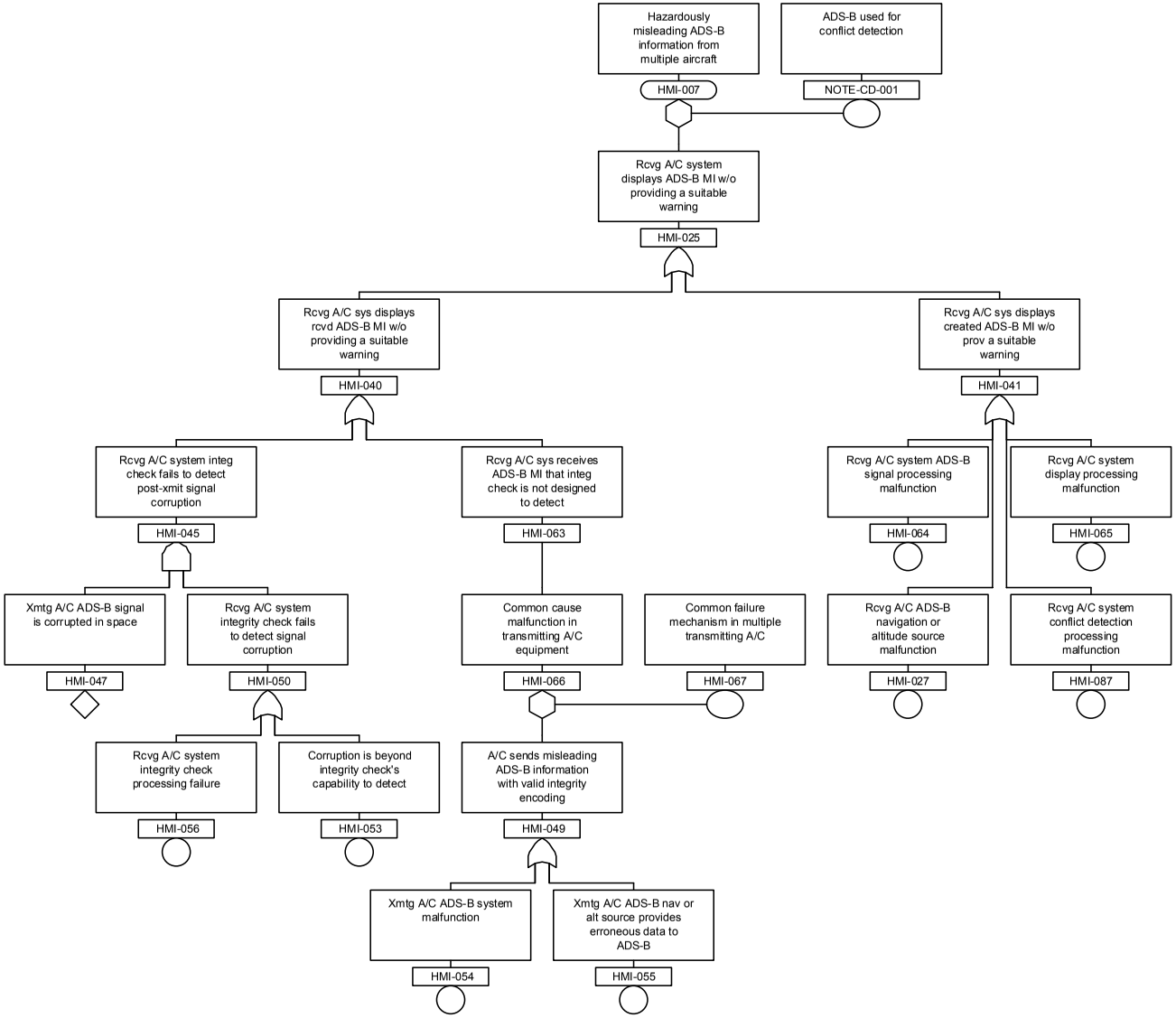
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 6



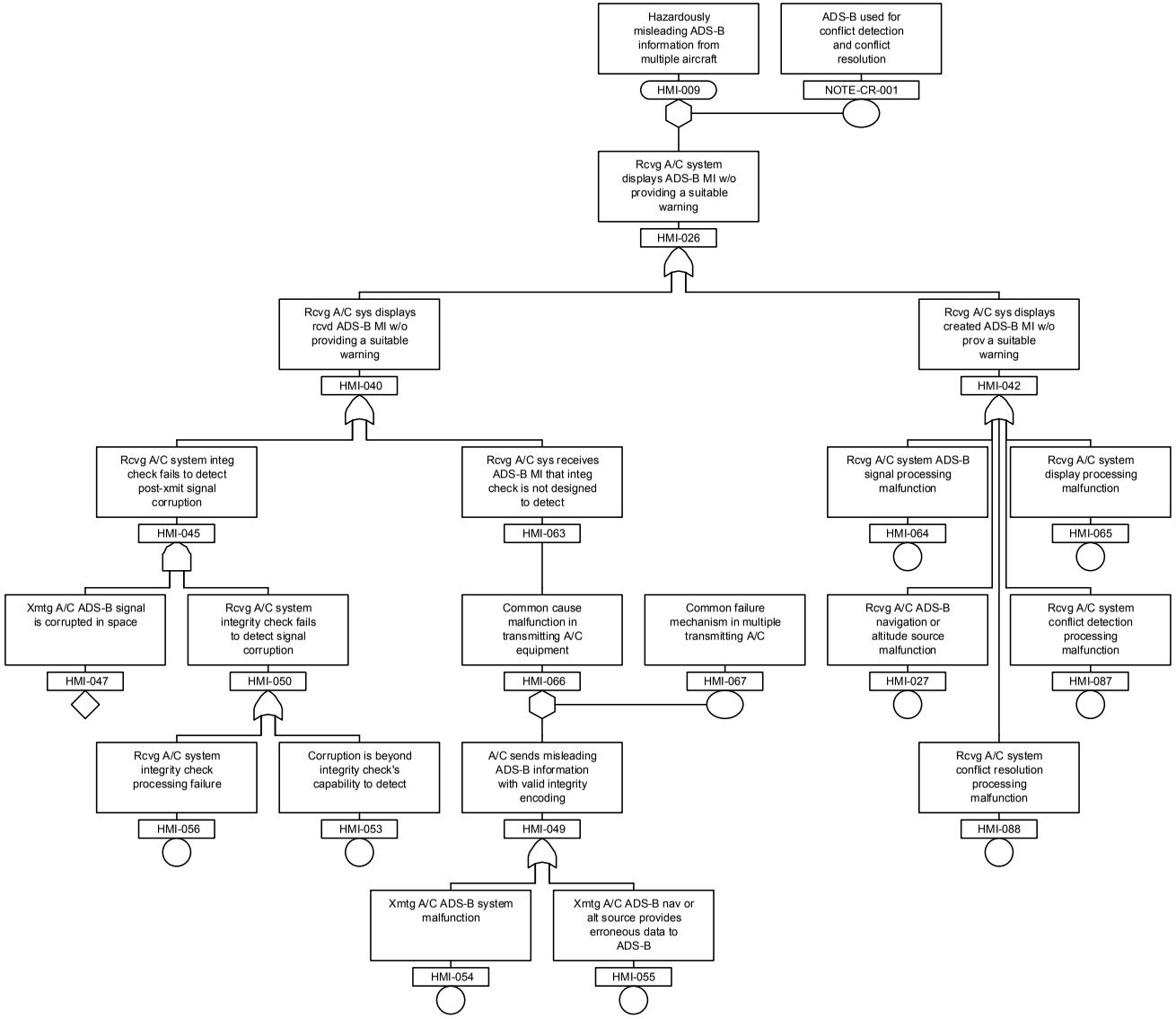
FTA 3.10-4: Hazardously Misleading ADS-B Information for Multiple Aircraft and Surface Vehicles - PAGE 7



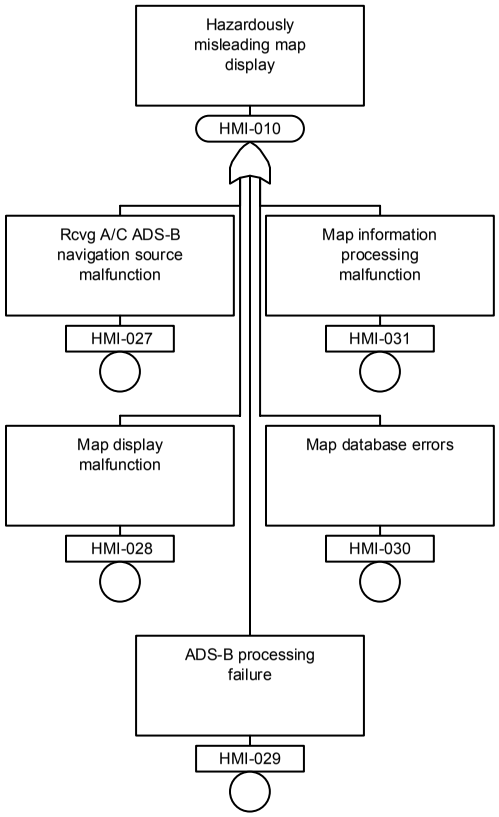
FTA 3.10-5: Hazardously Misleading ADS-B Information for Multiple Aircraft - Conflict Detection



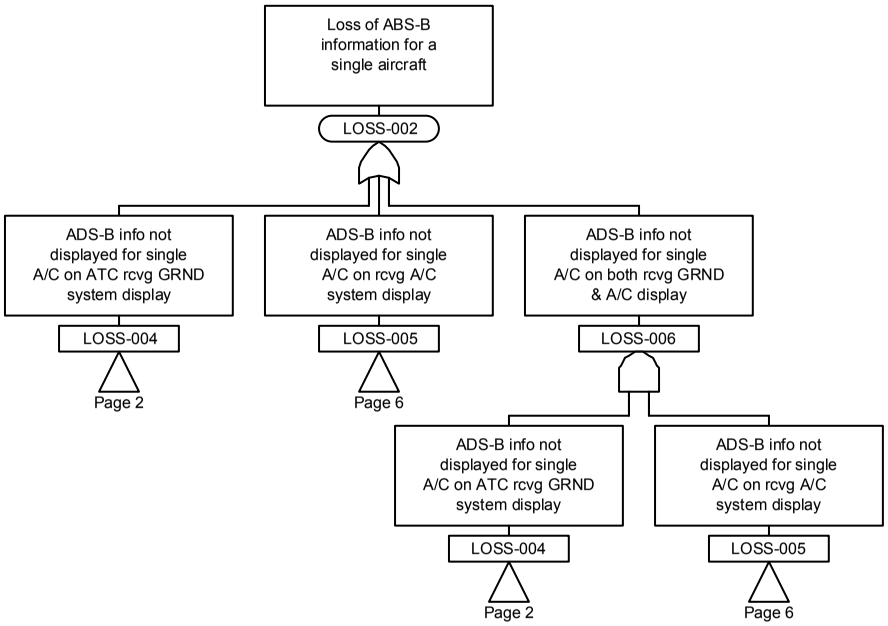
FTA 3.10-6: Hazardously Misleading ADS-B Information for Multiple Aircraft - Conflict Detection and Resolution



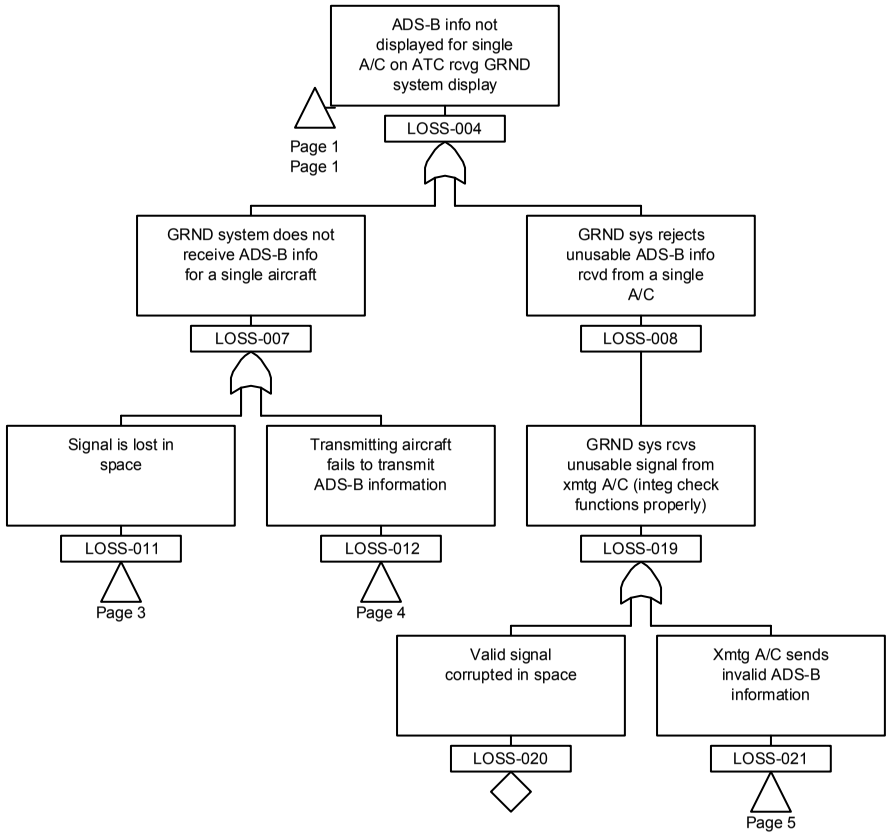
FTA 3.10-7: Hazardously Misleading Map Display



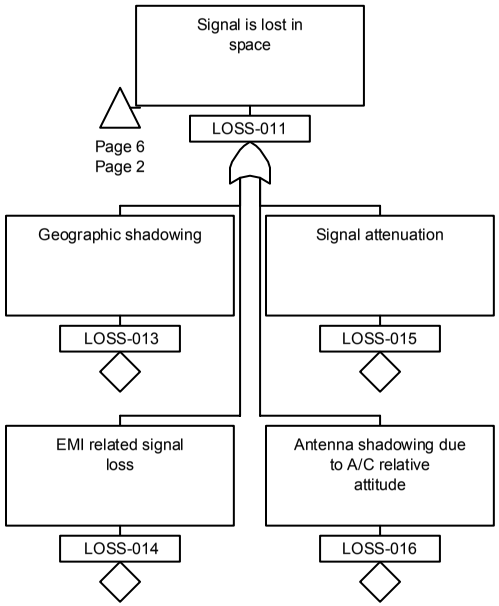
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft - PAGE 1



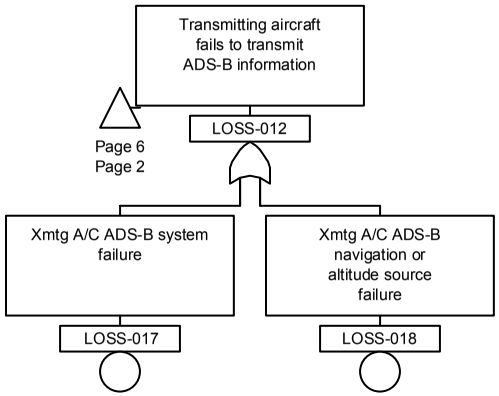
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft - PAGE 2



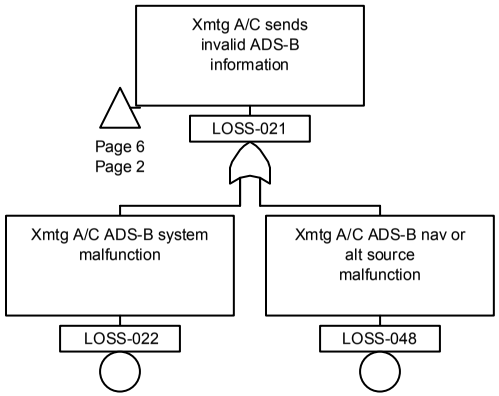
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft - PAGE 3



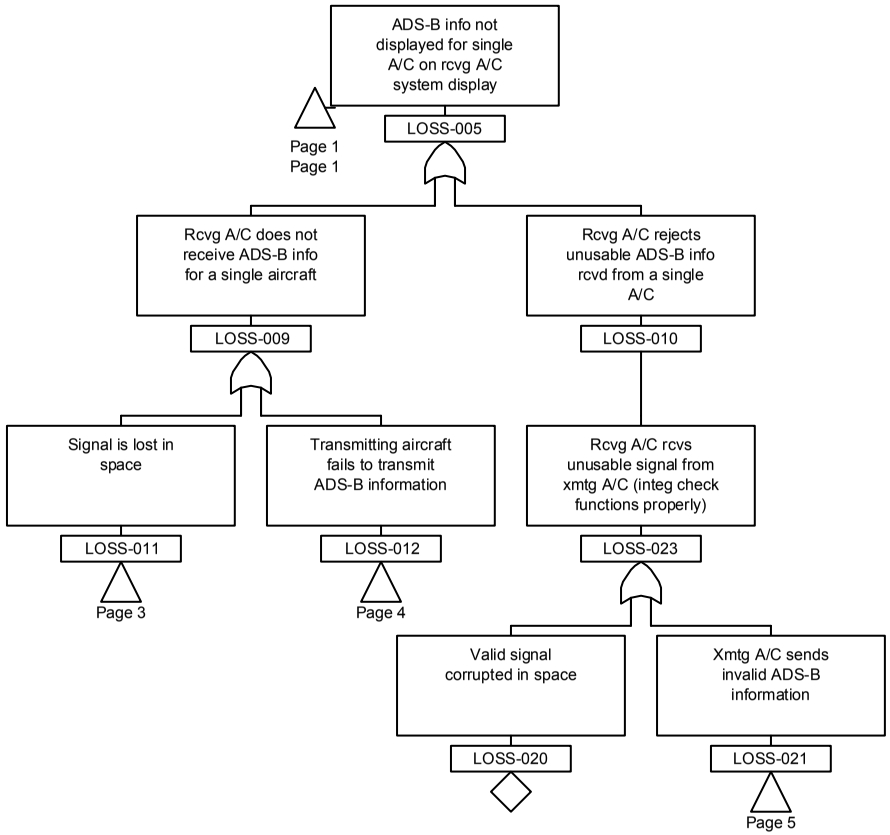
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft - PAGE 4



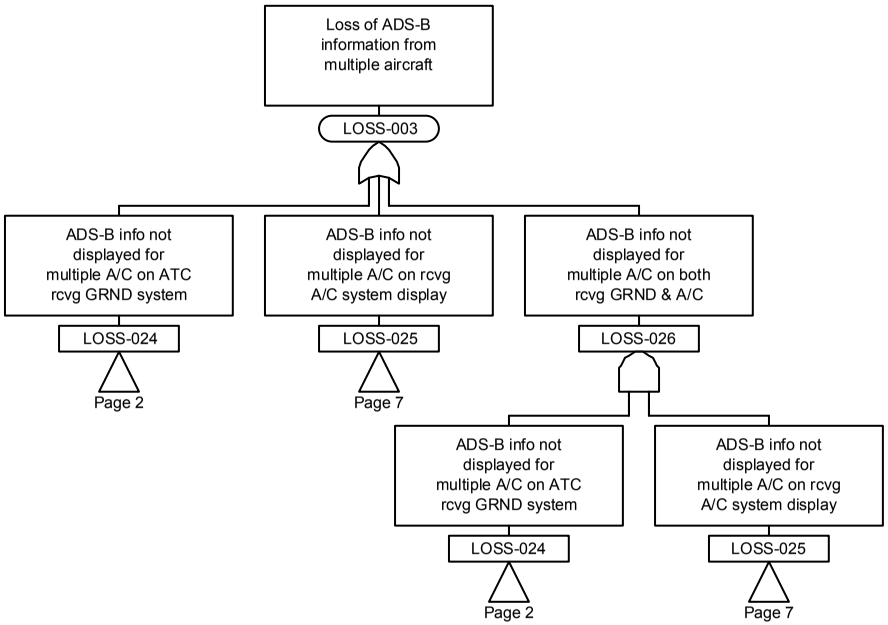
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft - PAGE 5



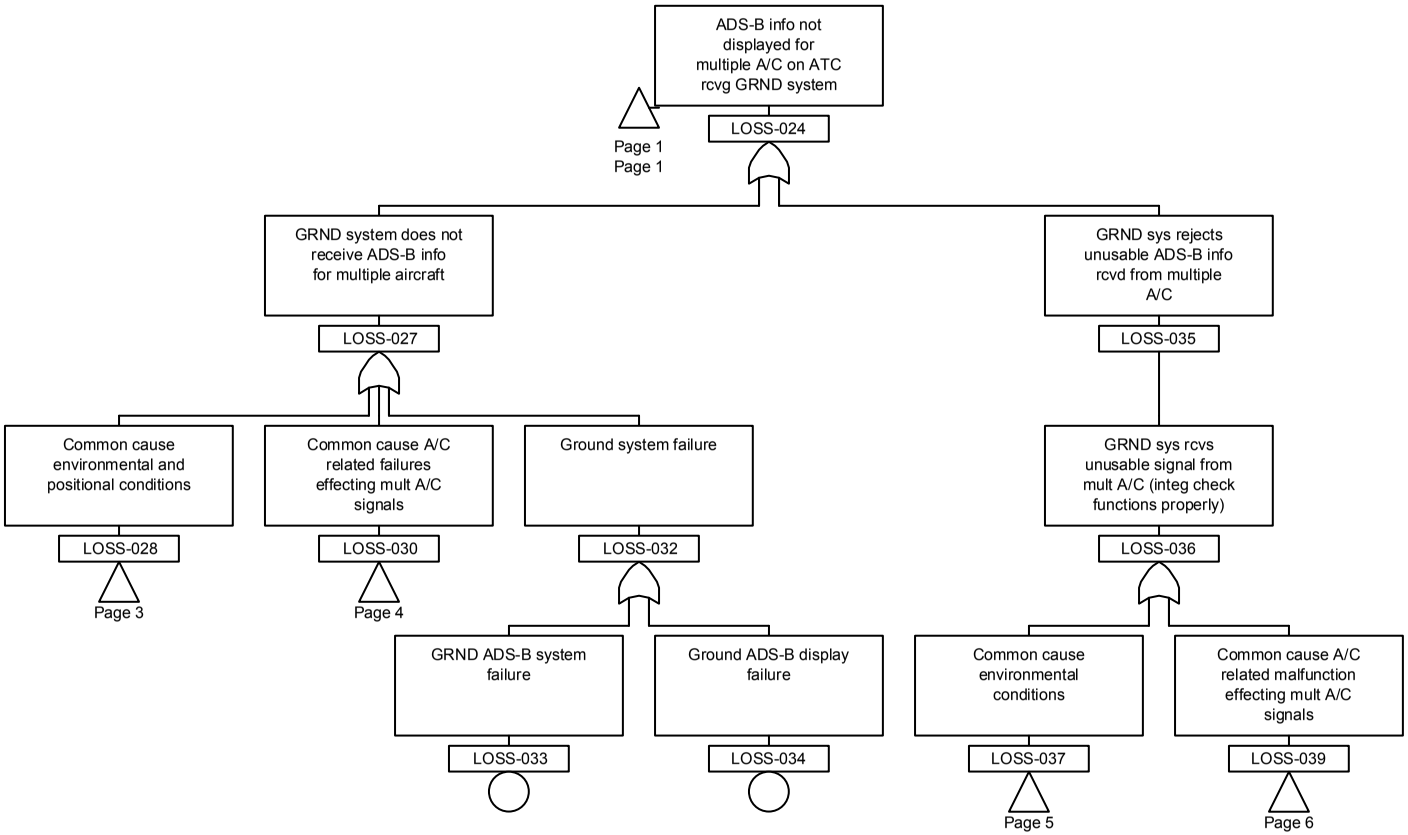
FTA 3.10-8: Loss of ADS-B Information for a Single Aircraft - PAGE 6



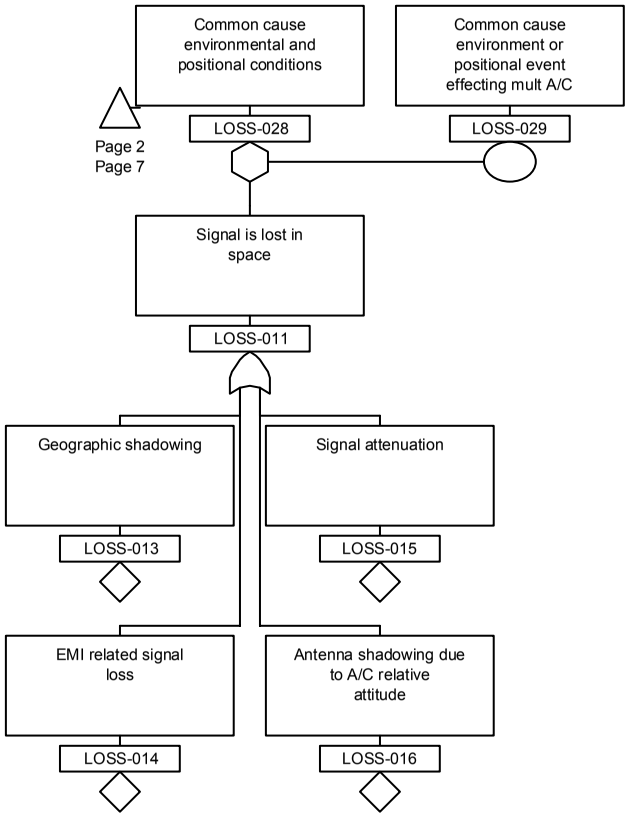
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 1



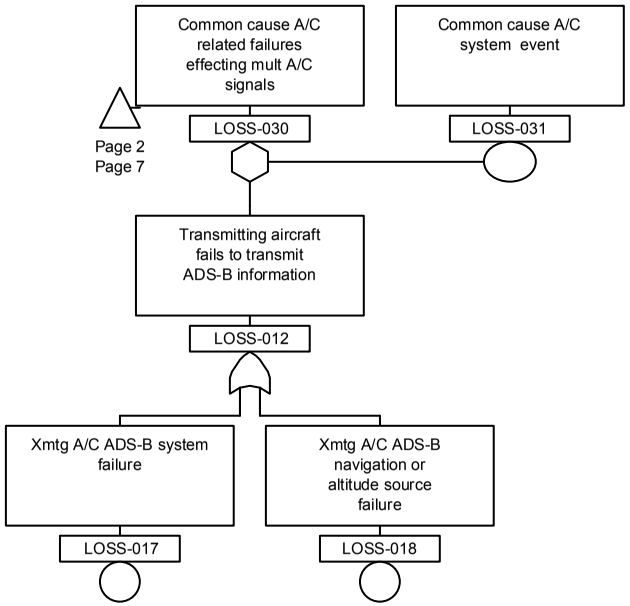
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 2



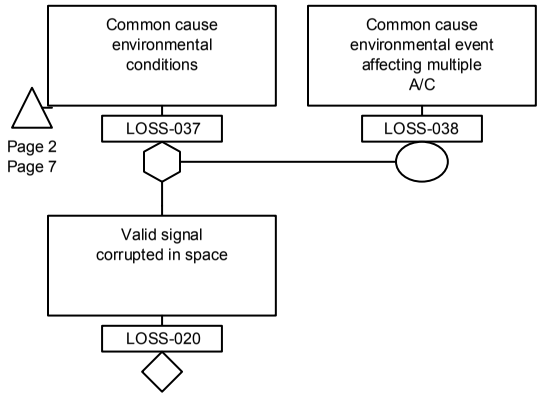
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 3



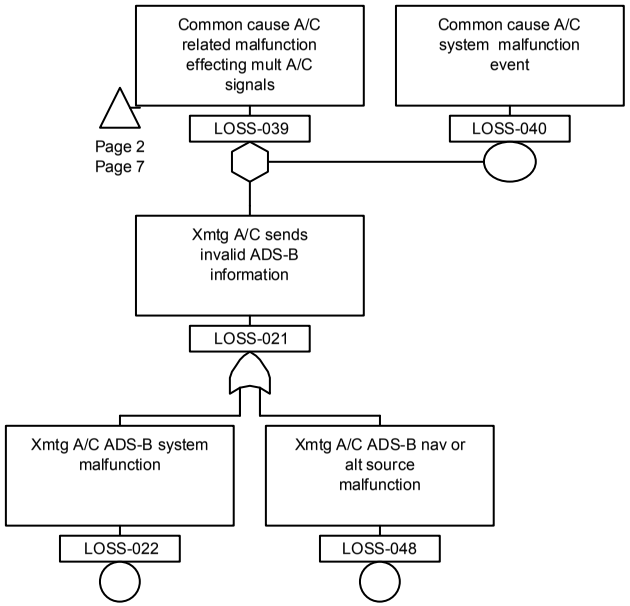
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 4



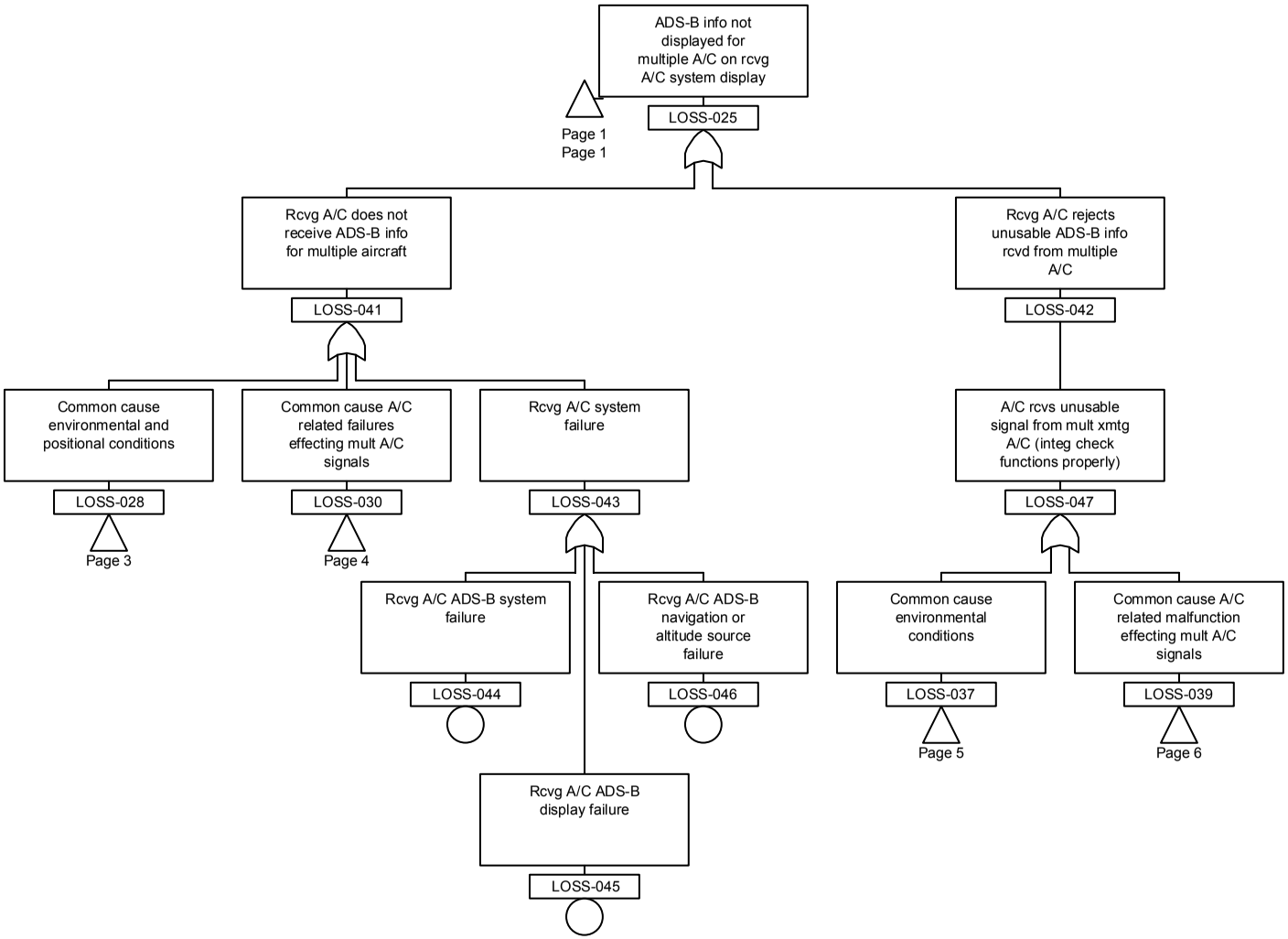
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 5



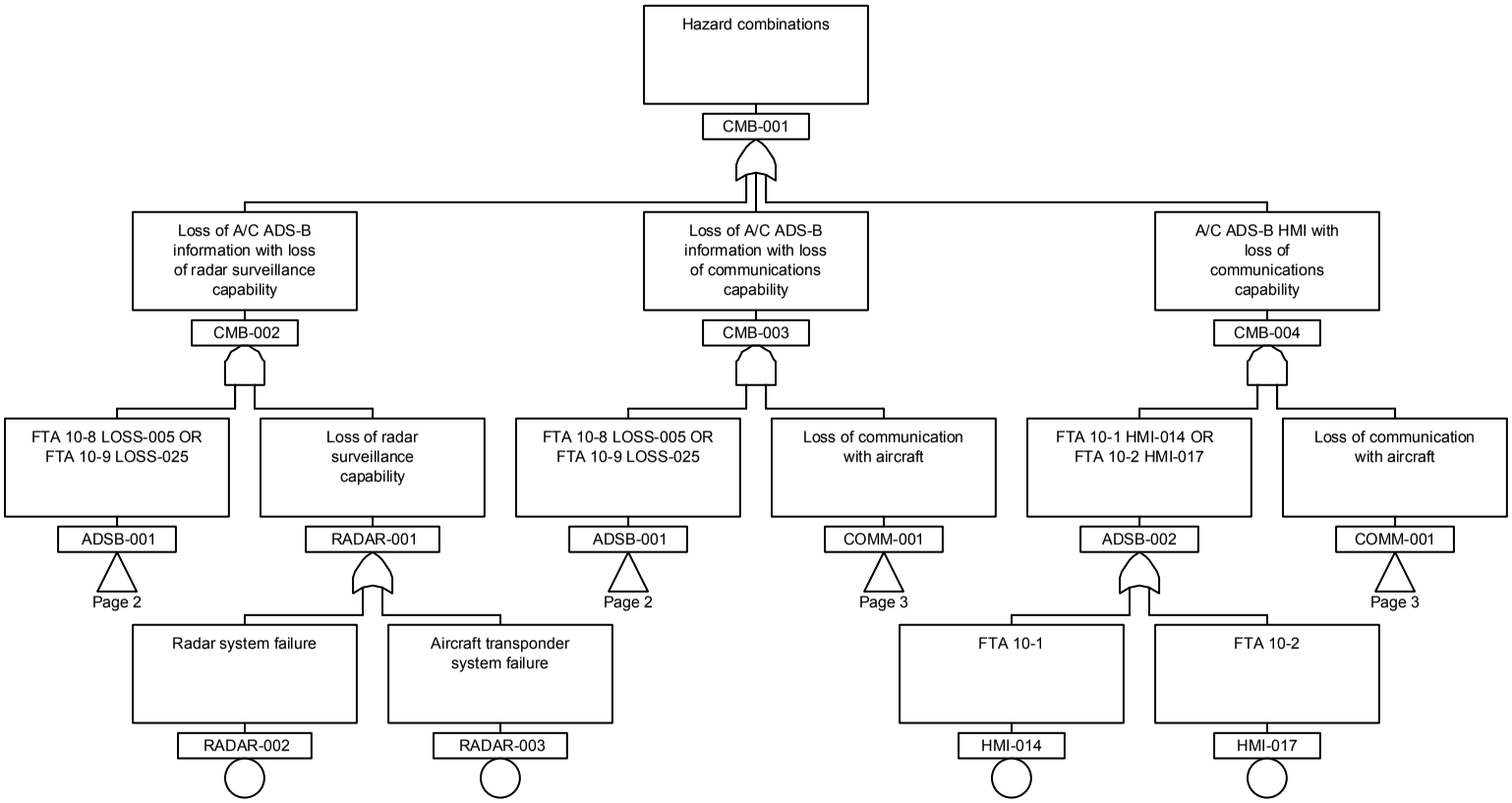
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 6



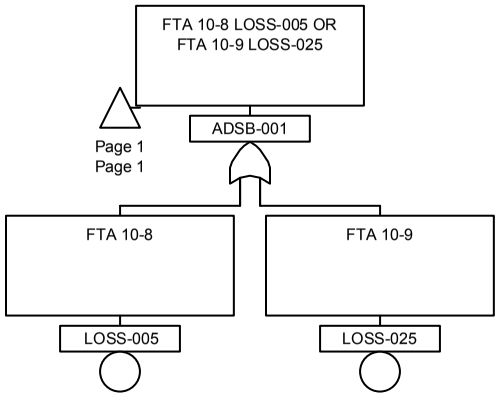
FTA 3.10-9: Loss of ADS-B Information from Multiple Aircraft - PAGE 7



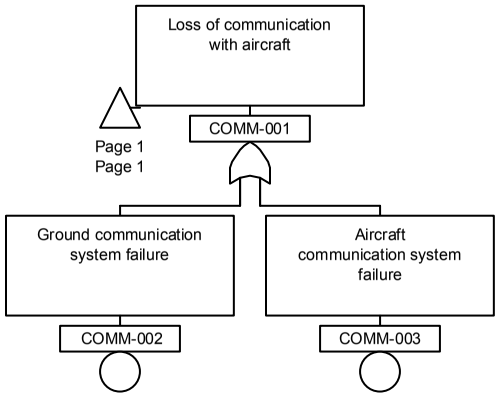
FTA 3.10-10: Hazard Combinations - PAGE 1



FTA 3.10-10: Hazard Combinations - PAGE 2



FTA 3.10-10: Hazard Combinations - PAGE 3



3.11. Requirements - Full Text Listing

This section provides full text candidate operational safety requirements for ADS-B, TIS-B, and procedures utilizing these systems.

In the candidate operational safety requirements, the word "shall" is used. It should be noted that although "shall" is used, these are candidate requirements, and the program managing authority is responsible for deciding whether to use these requirements or not. The use of "shall" in this context, is not intended to indicate a mandatory requirement. The use of "shall" is only used to provide cut and paste convenience for a program requirements developer.

The OHA uses abbreviated requirements text with identifiers. This is because, during the OHA development process, only a gross idea of candidate requirements was formed in order to guide the ASOR, where requirements could be better determined using, for instance, fault tree analysis. In this section of the ASOR, all candidate probability and development assurance requirements have been separated into more specific requirements for airborne, ATC ground based, and non-aircraft surface vehicle system requirements Their text has been expanded to a more formal version than in the OHA. Every probability and development assurance candidate requirement from the OHA has one or more formal equivalents in the **Sections 3.11.1** through **3.11.6**. In addition, candidate requirements from **Reference h** are included in **Sections 3.11.1** through **3.11.6** under the heading of "General candidate requirements." Each candidate procedural requirement from the OHA has a single formal equivalent in **Section 3.11.7**.

3.11.1. Candidate Requirements Allocated to Airborne ADS-B Systems

<u>Probability and development assurance variations for Catastrophic hazards</u>:

1. The transmittal and broadcast of misleading ADS-B information from an aircraft, without suitable warning to the flight crew, shall be shown to be extremely improbable and shall not result from a single failure.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous navigation data, altitude, and aircraft identification to the ADS-B system.

2. The display of misleading ADS-B information on the primary cockpit traffic display system, without suitable warning to the flight crew, shall be shown to be extremely improbable and shall not result from a single failure.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous navigation data, altitude, and aircraft identification to the ADS-B system.

    b. If an integrity check of received ADS-B data is required for assurance of broadcast signal integrity by regulation, compliance with this requirement shall include assessment of the effects of failures of the integrity check.

3. The ADS-B system, and its navigation, altitude, and aircraft identification source systems shall be developed to Level A development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

4. The ADS-B primary cockpit traffic display system shall be developed to Level A development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE)

Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Probability and development assurance variations for Hazardous hazards:

5. The transmittal and broadcast of misleading ADS-B information from an aircraft, without suitable warning to the flight crew, shall be shown to be extremely remote.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous navigation data, altitude, and aircraft identification to the ADS-B system.

6. The display of misleading ADS-B information on the primary cockpit traffic display system, without suitable warning to the flight crew, shall be shown to be extremely remote.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous navigation data, altitude, and aircraft identification to the ADS-B system.

    b. If an integrity check of received ADS-B data is required for assurance of broadcast signal integrity by regulation, compliance with this requirement shall include assessment of the effects of failures of the integrity check

7. The ADS-B system, and its navigation, altitude, and aircraft identification source systems shall be developed to Level B development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

8. The ADS-B primary cockpit traffic display system shall be developed to Level B development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Probability and development assurance variations for Major hazards:

9. The transmittal and broadcast of misleading ADS-B information from an aircraft, without suitable warning to the flight crew, shall be shown to be remote.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous navigation data, altitude, and aircraft identification to the ADS-B system.

10. The display of misleading ADS-B information on the primary cockpit traffic display system, without suitable warning to the flight crew, shall be shown to be remote.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous navigation data, altitude, and aircraft identification to the ADS-B system.

    b. If an integrity check of received ADS-B data is required for assurance of broadcast signal integrity by regulation, compliance with this requirement shall include assessment of the effects of failures of the integrity check.

11. The ADS-B system, and its navigation, altitude, and aircraft identification source systems shall be developed to Level C development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

12. The ADS-B primary cockpit traffic display system shall be developed to Level C development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

13. The loss of ADS-B transmittal and broadcast capability shall be shown to be remote.

    a. Compliance with this requirement shall include assessment of the effects of the loss of navigation data, altitude, and aircraft identification to the ADS-B system.

14. The loss of ADS-B information display capability in the cockpit shall be shown to be remote.

    a. Compliance with this requirement shall include assessment of the effects of the loss of navigation data, altitude, and aircraft identification to the ADS-B system.

Probability and development assurance variations for Minor hazards:

15. The ADS-B system, and its navigation, altitude, and aircraft identification source systems shall be developed to Level D development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

16. The ADS-B primary cockpit traffic display system shall be developed to Level D development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

General candidate requirements:

17. ADS-B systems that broadcast a call sign for flight or aircraft identification shall be designed and installed such that the call sign must be manually confirmed by the flight crew prior to operation.

18. ADS-B broadcast lateral and longitudinal position accuracy shall be within a range specified for runway and taxi area widths in FAA AC 150/5300-13 appropriate to the airfields at which the aircraft operates. Displayed lateral and longitudinal position accuracy for ADS-B systems used for surface guidance by the flight crew shall be within a range specified for runway and taxi area widths in AC 150/5300-13 appropriate to the airfields at which the aircraft operates.

19. The FAA shall evaluate whether ADS-B related operations can be accomplished without adversely affecting flight crew workload, considering the re-allocation of roles and responsibilities proposed in RTCA/DO-242.

20. The FAA shall determine the appropriate update and refresh rates for broadcast and displayed ADS-B data.

Radar Transponder and Communications Systems:

21. The loss of ADS-B broadcast capability in conjunction with the loss of radar transponder capability shall be shown to be remote.

    a. The guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, may be used to determine the failure condition probability requirement and development assurance requirements for the ADS-B system considering the architecture of the ADS-B system and transponder system jointly.

22. The loss of ADS-B broadcast capability in conjunction with the loss of all communication capability shall be shown to be remote.

    a. The guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, may be used to determine the failure condition probability requirement and development assurance requirements for the ADS-B system considering the architecture of the ADS-B system and communication systems jointly.

23. Hazardously misleading ADS-B broadcast information in conjunction with the loss of all communication capability shall be shown to be remote.

    a. The guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, may be used to determine the failure condition probability requirement and development assurance requirements for the ADS-B system considering the architecture of the ADS-B system and communication systems jointly.

3.11.2. Candidate Requirements Allocated to ADS-B Systems for Surface Vehicles Operating on Ramps, Taxi-ways, and Runways

Probability and development assurance variations for Catastrophic hazards:

24. The transmittal and broadcast of misleading ADS-B information from a surface vehicle operating on ramps, taxi-ways, and runways, without suitable warning to the vehicle operator, shall be shown to be extremely improbable and shall not result from a single failure.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous position data and vehicle identification to the ADS-B system.

25. The ADS-B system, and its position and vehicle identification source systems shall be developed to Level A development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Probability and development assurance variations for Hazardous hazards:

26. The transmittal and broadcast of misleading ADS-B information from a surface vehicle operating on ramps, taxi-ways, and runways, without suitable warning to the vehicle operator, shall be shown to be extremely remote.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous position data and vehicle identification to the ADS-B system.

27. The ADS-B system, and its position and vehicle identification source systems shall be developed to Level B development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Probability and development assurance variations for Major hazards:

28. The transmittal and broadcast of misleading ADS-B information from a surface vehicle operating on ramps, taxi-ways, and runways, without suitable warning to the vehicle operator, shall be shown to be remote.

    a. Compliance with this requirement shall include assessment of the effects of providing erroneous position data and vehicle identification to the ADS-B system.

29. The ADS-B system, and its position and vehicle identification source systems shall be developed to Level C development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

30. The loss of ADS-B transmittal and broadcast capability shall be shown to be remote.

a. Compliance with this requirement shall include assessment of the effects of the loss of position data and vehicle identification to the ADS-B system.

Probability and development assurance variations for Minor hazards:

31. The ADS-B system, and its position and vehicle identification source systems shall be developed to Level D development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

General candidate requirements:

32. ADS-B systems that broadcast vehicle identification information shall be designed and installed such that the identification information must be manually confirmed by the vehicle operator prior to operation.
33. ADS-B broadcast lateral and longitudinal position accuracy shall be within a range specified for runway and taxi area widths in FAA AC 150/5300-13 appropriate to the airfields at which the vehicle operates..

3.11.3. Candidate Requirements Allocated to Ground-based ATC ADS-B Systems

Probability and development assurance variations for Hazardous hazards:

34. The display of misleading ADS-B information on the traffic display system, without suitable warning to the controller, shall be shown to be extremely remote.

    a. Compliance with this requirement shall include assurance that correct facility siting information is provided to the ADS-B system.

    b. If an integrity check of received ADS-B data is required for assurance of broadcast signal integrity, compliance with this requirement shall include assessment of the effects of failures of the integrity check.

35. The ADS-B system shall be developed to Level B development assurance requirements. The ADS-B traffic display system shall be developed to Level B development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Probability and development assurance variations for Major hazards:

36. The display of misleading ADS-B information on the traffic display system, without suitable warning to the controller, shall be shown to be remote.

    a. Compliance with this requirement shall include assurance that correct facility siting information is provided to the ADS-B system.

    b. If an integrity check of received ADS-B data is required for assurance of broadcast signal integrity, compliance with this requirement shall include assessment of the effects of failures of the integrity check.

37. The ADS-B system shall be developed to Level C development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.
38. The ADS-B traffic display system shall be developed to Level C development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace

Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Probability and development assurance variations for Minor hazards:

39. The ADS-B system shall be developed to Level D development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

40. The ADS-B traffic display system shall be developed to Level D development assurance requirements. Guidance may be found in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

General candidate requirements:

41. The transmittal and broadcast of hazardously misleading ADS-B information from a fixed obstruction shall be shown to be remote.

42. The FAA shall determine the appropriate update and refresh rates for displayed ADS-B data.

43. The FAA shall evaluate whether ADS-B related operations can be accomplished without adversely affecting air traffic controller workload, considering the re-allocation of roles and responsibilities proposed in RTCA/DO-242.

Radar and Communications Systems:

44. The loss of ADS-B reception capability in conjunction with the loss of radar surveillance capability shall be shown to be remote.

    a. The guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, may be used to determine the failure condition probability requirement and development assurance requirements for the ADS-B system considering the architecture of the ADS-B system and radar system jointly.

45. The loss of ADS-B reception capability in conjunction with the loss of all communication capability shall be shown to be remote.

    a. The guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, may be used to determine the failure condition probability requirement and development assurance requirements for the ADS-B system considering the architecture of the ADS-B system and communication systems jointly

46. The display of hazardously misleading ADS-B information in conjunction with the loss of all communication capability shall be shown to be remote.

    a. The guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, may be used to determine the failure condition probability requirement and development assurance requirements for the ADS-B system considering the architecture of the ADS-B system and communication systems jointly.

3.11.4. Candidate Requirements Allocated to Ground-based ATC TIS-B Systems

47. The TIS-B system shall be developed to Level D development assurance requirements.

48. The ATC ground system shall compare ADS-B and TIS-B locations for each target and display the most accurate source
49. The FAA shall evaluate whether ADS-B related operations can be accomplished without adversely affecting traffic controller workload, considering the re-allocation of roles and responsibilities proposed in RTCA/DO-242.

3.11.5. Candidate Requirements for Airport Moving Map Display Systems

Applicable to Catastrophic Hazards:

50. The display of misleading information on the primary cockpit moving map display system used for surface maneuvering, without suitable warning to the flight crew, shall be shown to be extremely improbable and shall not result from a single failure.
51. The primary cockpit moving map display system shall be developed to Level A development assurance requirements in accordance with guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

Applicable to Minor Hazards:

52. The primary cockpit moving map display system shall be developed to Level D development assurance requirements in accordance with guidance in Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems.

3.11.6. Candidate Procedural Requirements Related to Operations Using ADS-B and TIS-B

53. The pilot in command shall be responsible per FAR 91.113(b) for visually acquiring and tracking other aircraft and obstacles, and shall not rely on ADS-B as a substitute for visual checks.
54. The FAA shall develop procedures for maintaining target awareness and reverting to procedural separation if a target is lost or questionable.
55. FAA shall modify ATC traffic advisory procedures to use call signs for ADS-B equipped aircraft.
56. FAA shall modify procedures to allow variability in approach spacing in relationship to the lead aircraft in VMC and MVMC.
57. The FAA shall modify instrument procedures to enable instructions to the crew to allow variability in approach spacing in relationship to the lead aircraft in IMC and to revert to mitigating procedures without sole reliance on ADS-B for separation in the case of total communications failure.
58. FAA shall develop takeoff and departure procedures for following aircraft to utilize dependent surveillance for takeoff timing.
59. FAA shall develop approach procedures for equipped aircraft to use dependent surveillance for independent approaches. FAA shall develop approach procedures for pairwise equipped aircraft to use dependent surveillance for dependent approaches.
60. FAA shall develop procedures:
    a. to determine when controllers are relieved of current control responsibilities for an ADS-B/CTDI equipped aircraft;

b. for the flight crew assuming its own separation responsibilities; and

c. for action to be taken in the case of failures of the service-enabling systems and equipment.

61. FAA shall develop procedures and requirements for reduced separation and procedures for reversion to standard separation minima in case of service equipage failures.

62. FAA shall establish equipage rules for services requiring the broadcast and display of aircraft call sign designators.

63. FAA shall develop pilot and controller procedures for:

    a. the use of conflict detection information from an ADS-B systems equipped with a conflict detection function; and

    b. the use of conflict resolution information from an ADS-B systems equipped with a conflict resolution function.

3.11.7. Integrity check for signal corruption during transmission in space

64. Systems shall employ a means for assuring that the ADS-B signal information has not been corrupted during transmission in space due to EMI or similar environmental events.