ADS-B

Implementation Guidance

Surveillance Applications for ATS within the Muscat FIR

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Pursuant to ICAO Critical Element 5 (CE-5) – Technical Guidance, Tools and Provision of Safety-Critical Information – and in accordance with the applicable Civil Aviation Regulations of the Sultanate of Oman, the Directorate General of Civil Aviation Regulations hereby approves the following document as Acceptable Means of Compliance and Guidance Material (AMC/GM):

- **Title:** ADS-B Implementation Guidance – Surveillance Applications for ATS within the Muscat FIR
- **Revision:** Initial
- **Effective Date:** 01 May 2026

This document provides guidance for the implementation and operational use of ADS-B in support of ATS surveillance services, including, where specifically approved, ATS surveillance-based separation, in accordance with ICAO provisions and applicable national regulations.

This approval is issued under the authority of the Directorate General of Civil Aviation Regulations and shall take effect on the date indicated above. It supersedes any previous versions, where applicable, and shall remain valid unless amended, suspended, or withdrawn by the Authority.

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Foreword

1) This Guidance Material (GM) provides guidance and acceptable means of compliance for the implementation and operational approval of ADS-B within the Muscat FIR in support of ATS surveillance applications, including ATS surveillance services and, where specifically approved, ATS surveillance based-separation.
2) This document is issued by DGCAR to ensure that ADS-B is introduced using a performance-based and safety-driven approach, such that operational use is permitted only where surveillance performance has been demonstrated, monitored, and accepted as adequate for the intended ATS application and associated separation minima.
3) This GM is aligned with:
   a) Applicable national regulations, including CAR-172, CAR-100, and CAR-171; and
   b) Relevant ICAO provisions, including Annex 11, Annex 19, Annex 10, Volume IV, and ICAO Doc 4444.
4) It is further supported by applicable ICAO guidance material, including ICAO Circular 326 and ICAO Doc 9924 (Aeronautical Surveillance Manual).
5) It establishes key principles for:
   a) Operational approval and implementation;
   b) Safety assessment and performance validation;
   c) Application of ATS surveillance services and separation; and
   d) Monitoring, oversight, and continuous compliance.
6) This initial edition supports the progressive integration of ADS-B, including **terrestrial** and **space-based** surveillance, within the Muscat FIR.
7) DGCAR retains responsibility for approval, oversight, and periodic review of this GM.

Corrigendum of Amendments

Rev.	Date	Description
Initial	01 May 2026	First issue

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Chapter 1- Introduction

1. Purpose

1.1 This Guidance Material (GM) provides guidance and acceptable means of compliance for the implementation and operational use of ADS-B within the Muscat FIR to support ATS surveillance services and ATS surveillance separation where approved.

1.2 This GM supports compliance with:

a) CAR-172 (Air Traffic Services);
b) CAR-171 (Communication, Navigation and Surveillance);
c) CAR-100 (Safety Management System);
d) ICAO Annex 10 — Volume IV — Surveillance and Collision Avoidance Systems;
e) ICAO Annex 11 — Air Traffic Services;
f) ICAO Annex 19 — Safety Management;
g) ICAO Doc 4444 (PANS-ATM); and
h) ICAO Doc 9924 —Aeronautical Surveillance Manual.

1.3 ADS-B surveillance services shall be limited to areas of validated coverage and verified performance suitable for the intended ATS application.

1.4 Operational use shall comply with ICAO Doc 4444 (Chapter 8) and ICAO document as applicable.

1.5 ADS-B shall be used for ATS surveillance services, including ATS surveillance based-separation where specifically approved, only where surveillance performance has been demonstrated, monitored, and accepted as adequate for the intended ATS application and associated separation minima.

1.6 ADS-B shall not be used as the sole basis for separation where system resilience or independent verification is not assured, unless specifically approved by the Authority.

2. Scope

2.1 This Guidance Material applies to:

a) ATS airspace within the Muscat FIR where ADS-B is used, including en-route and terminal airspace (e.g. TMAs and CTRs), as applicable;
b) Applications including situational awareness, ATS surveillance services, and approved ATS surveillance-based separation;
c) Mixed-equipage and transition environments; and
d) ATS Provider(s) operating within the Muscat FIR.

2.2 ADS-B services shall be limited to validated coverage and performance, subject to Authority approval and AIP promulgation.

2.3 This GM shall be applied in conjunction with CAR-172; CAR-100; CAR-171; and ICAO Document 4444.

3. Regulatory Status

3.1 This document is issued as Civil Aviation Authority (CAA) Guidance Material compliance.

3.2 This GM:

a) Does not replace, amend, or supersede CAR-172; CAR-171; or CAR-100;
b) Does not constitute standalone regulatory authority;
c) Provides acceptable means and structured guidance to demonstrate compliance; and
d) Where conflict exists, Civil Aviation Regulations shall prevail.

4. Interpretation and Use of Mandatory Language

a) "Shall" indicates a mandatory requirement;
b) "Should" indicates a recommended practice;
c) "May" indicates optional action subject to Authority acceptance or approval.

5. ICAO and International Reference Framework

5.1 Primary references for this GM include, as applicable:

a) ICAO Annex 11 (Air Traffic Services);
b) ICAO Annex 19 (Safety Management);
c) ICAO Annex 10 (Surveillance and related provisions);
d) ICAO Doc 4444 (PANS-ATM), Chapter 8 – ATS Surveillance Services;
e) ICAO Doc 9869 Performance-Based Communication and Surveillance (PBCS);
f) ICAO Circular 256 (ADS-B Concept);
g) ICAO Circular 326 (ADS-B Implementation Guidance).
h) ICAO Doc 9924 Aeronautical Surveillance Manual

5.2 Additional international best practices may be used provided they do not conflict with ICAO provisions or Civil Aviation Regulations.

6. Fundamental Principle

6.1 ADS-B shall be approved for ATS use only where safety assessment and performance validation demonstrate that surveillance performance is adequate to support the intended ATS application and applicable separation minima

7. Operational Limitation

7.1 ADS-B use shall be limited to areas and conditions for which coverage, performance, and operational suitability have been validated and accepted by the Authority.

Chapter 2- safety and Operational Principles

1. General

1.1 ADS-B implementation shall be treated as a significant safety-related ATS operational change and managed in accordance with CAR-172 and CAR-100.

1.2 ADS-B shall be treated as an operational surveillance capability whose use affects safety, controller workload, operational complexity, and system resilience.

1.3 Operational use, including ATS surveillance based-separation where specifically approved, shall require Authority approval based on validated performance, accepted safety assessment, approved procedures, and completed training.

1.4 Surveillance data shall not be used for the application of separation where its reliability or integrity is in doubt.

2. Safety Management System Integration

2.1 ADS-B implementation shall be subject to a Safety Risk Management (SRM) process in accordance with CAR-100.

2.2 The SRM shall:

a) Identify hazards, including GNSS dependency and common-mode failures;
b) Assess and mitigate risks to an acceptable level;
c) Address degraded and contingency scenarios;
d) Ensure traceability between hazards, mitigations, and performance requirements; and
e) Be supported by validation and formal Authority Acceptance.

2.3 Technical validation alone shall **not** constitute operational approval.

3. System Integration and Operational Use

3.1 ADS-B shall be implemented as part of an integrated CNS/ATM system, with surveillance performance assessed across the end-to-end chain, including airborne source data, transmission path, receiving infrastructure, processing systems, controller HMI, and monitoring and alerting functions.

3.2 Failure or degradation of any element shall be treated as operationally significant and shall trigger defined mitigation or reversion procedures.

3.3 This chapter complements ICAO Doc 4444 by establishing safety, performance, validation, and approval expectations for ADS-B implementation within the Muscat FIR.

4. Performance-Based Surveillance

4.1 ADS-B operational use shall be supported by defined, documented, and Authority-accepted surveillance performance requirements appropriate to the intended ATS application.

4.2 Operational use shall be conditional upon defined and monitored performance parameters, including:

a) Accuracy;
b) Integrity;

c) Continuity;
d) Availability; and
e) Timeliness

4.3 ATS Surveillance-based separation shall not be applied unless performance requirements are met and maintained.

5. GNSS Dependency

5.1 GNSS shall be treated as a critical dependency for ADS-B operations where applicable.

5.2 The safety assessment shall address:

a) GNSS degradation, jamming, spoofing, and other interference;
b) Satellite constellation anomalies, signal degradation, or loss of service;
c) Common-mode failures affecting multiple aircraft.
d) The availability and use of regional and national reporting, notification, and NOTAM arrangements for GNSS degradation and interference.

5.3 Operational procedures shall ensure that GNSS-related degradation is detected, assessed, and managed without delay.

6. Progressive Operational Implementation and Assurance

6.1 ADS-B implementation shall be conducted in a phased manner, as follows:

a) **Phase 1**: **Facility Operational Approval (ATM Integration system)**
- End-to-End technical, procedural, and safety readiness demonstrated;
- Activities shall be limited to validation, familiarization, and readiness;
- ATS surveillance-based separation shall not be applied.

b) **Phase 2: Limited operational use**
- Use restricted to situational awareness and ATS surveillance service;
- ATS surveillance-based separation shall not be applied.

c) **Phase 3: ATS Surveillance separation (subject to approval)**
- Surveillance-based separation minima shall be applied in accordance with ICAO Doc 4444;
- Application shall be subject to validated surveillance performance, an approved safety assessment, and explicit Authority approval;
- Aircraft shall be identified and continuously monitored; and
- Where an ADS-B equipage requirement is established for the applicable airspace, only compliant aircraft shall be eligible for ADS-B surveillance-based separation.

6.2 Progression between phases shall be supported by documented entry and exit criteria, including surveillance performance evidence, validated procedures, controller training and competency, workload acceptability, degraded-mode performance, and Authority acceptance of the updated safety assessment

7. Operational Resilience and Reversion

7.1 ADS-B operations shall include validated degraded-mode and reversion procedures.

7.2 Where performance is not met:

a) ADS-B Surveillance based- separation shall be suspended;
b) Alternate separation shall be applied; and
c) Appropriate coordination and notification shall be initiated, and contingency procedures shall be implemented as required.

8. Human Factors and Workload

8.1 ADS-B implementation shall address controller workload and operational complexity.

9. Accountability and Authority Oversight

9.1 Responsibilities for surveillance performance shall be clearly defined.

9.2 The Authority shall:

a) Review and approve safety and performance evidence;
b) Audit operational performance and compliance;
c) Impose operational limitations where necessary; and
d) Suspend or withdraw approval where safety is not maintained.

CHAPTER 3 - Use of ADS-B in ATS Surveillance Services

1. General Requirement

1.1 ADS-B shall be used as an ATS surveillance system in accordance with CAR172, ICAO Doc 4444 (PANS-ATM), Chapter 8, and Civil Aviation Regulations as applicable.

1.2 Operational use of ADS-B shall be limited to:

a) Airspace and operational conditions defined in the approved Concept of Operations (CONOPS);
b) Validated surveillance performance; and
c) Approved ATS applications.

1.3 ADS-B shall not be used for ATS surveillance-based separation unless explicitly approved by the Authority.

2. CONOPS Content Requirements

2.1 Prior to implementation or expansion of ADS-B operations, the ATS Provider shall submit a CONOPS for Authority approval.

2.2 The CONOPS shall define, as a minimum:

A. Airspace and Operational Context

a) Airspace scope, including lateral and vertical limits;
b) Traffic characteristics, density, operational complexity, and capacity impact assessment;

B. Surveillance Concept and Applications

a) Intended ATS surveillance applications for each implementation phase;
b) Surveillance performance monitoring arrangements, including coverage modelling and validation results;
c) Proposed separation minima and associated operational conditions, where applicable;

C. System Operations and Procedures

a) Defined ATS operational procedures for each intended application, as published in the applicable operations manuals,
b) Mixed-equipage operational concept;
c) Degraded mode operations and reversion procedures; including triggers for reversion.

Note: Mixed-equipage *refers to an operational environment where aircraft with different ATS surveillance or navigation capabilities operate together in the* ***same*** *airspace.*

D. Implementation and Validation

a) Transition and phased implementation strategy;
b) Scope, objectives, and conduct of trials, including detailed description of proposed changes;

E. Coordination and Interfaces

a) Coordination arrangements with adjacent ATS units and FIRs;

2.3 The CONOPS shall clearly identify the applicable implementation phase(s), together with the associated operational limitations and constraints.

2.4 The CONOPS shall not constitute a safety assessment; a separate safety assessment shall be developed in accordance with CAR-100 and Chapter 5 of this Guidance Material.

3. Surveillance Display and data use

3.1 ADS-B surveillance data shall be presented through an approved Human-Machine Interface (HMI).

3.2 The HMI shall provide:

a) Clear aircraft identification based on ADS-B data;
b) Indication of ATS surveillance capabilities and status;
c) Alerts for degraded performance; integrity issues, or anomalies; and
d) Timely and continuous surveillance data updates.

3.3 Controllers shall:

a) Continuously monitor surveillance data and system indications;
b) Assess data reliability and performance;
c) Not use ADS-B surveillance data for the application of separation where its reliability or validity is in doubt; and
d) Apply appropriate measures, including alternative ATS surveillance (e.g., SSR) or procedural separation, and contingency procedures, as applicable.

4. Approved Operational Applications

4.1 ADS-B may support the following ATS surveillance applications, subject to Authority approval:

a) Situational Awareness

- Enhances controller awareness of aircraft position, traffic situation, and operational environment;
- Supports mitigation of surveillance gaps;
- Extends effective surveillance coverage;
- Contributes to improved safety and operational efficiency;
- Does not constitute ATS surveillance service and shall not be used for the application of separation minima;
- ADS-B information may support aircraft identification in accordance with CAR172 & ICAO Doc 4444, where applicable.

b) ATS Surveillance Service

- Provides traffic information and surveillance-based monitoring to aircraft;
- Enables aircraft identification and tracking;
- Supports the provision of alerting service;
- May support the provision of ATS surveillance-based separation only where such separation is separately approved and applied in accordance with the requirements of this Guidance;

- Does not, in itself, constitute the application of ATS surveillance-based separation minima.

c) ATS Surveillance-Based Separation

- Application of approved separation minima in accordance with CAR 172 and ICAO Doc 4444 (PANS-ATM);
- Subject to validated surveillance performance and explicit Authority approval;
- Requires continuous aircraft identification and monitoring;
- Shall not be applied where surveillance performance or aircraft eligibility cannot be assured.

4.2 Each application shall be implemented in accordance with the approved operational phase as defined in Chapter 2 of this Guidance Material and accepted by the Authority.

5. Separation Application Principles

5.1 ATS surveillance-based separation using ADS-B shall be applied only when:

a) Aircraft are identified and continuously monitored;
b) Surveillance performance meets defined requirements;
c) Both aircraft meet the eligibility criteria for ADS-B surveillance-based separation, as specified in paragraph 6;
d) Surveillance data is reliable and suitable for the intended ATS application; and
e) Where ADS-B equipage is required for the applicable airspace, only compliant aircraft shall be considered eligible for ADS-B surveillance-based separation, in accordance with the AIP.

5.2 Where these conditions are not met:

a) ADS-B surveillance-based separation shall not be applied or shall be suspended without delay; and
b) Alternative ATS surveillance (SSR) or procedural separation shall be applied, as appropriate.

5.3 Separation shall be based only on verified and reliable surveillance data.

6. Mixed-Equipage Operations

6.1 The application of separation in mixed-equipage environments shall be in accordance with CAR-172, other applicable CARs, and ICAO Doc 4444, and supported by relevant ICAO provisions, including ICAO Annex 11 and ICAO Doc 9924.

a) It shall also comply with the principles defined in this Chapter;
b) Illustrative scenarios are provided in Appendix F for guidance.

6.2 The operational actions specified in Tables 6.5 and 6.6 are indicative and not exhaustive and shall not preclude the application of other approved separation or contingency measures, as appropriate, in accordance with applicable regulations, including ICAO Doc 4444, and locally agreed procedures.

6.3 The Muscat FIR operates in a mixed-equipage surveillance environment, where aircraft equipped with ADS-B may operate together with aircraft using radar surveillance or procedural separation.

6.4 ADS-B operations shall be conducted in a mixed-equipage environment, unless otherwise specifically approved by the Authority.

6.5 Aircraft shall be classified as:

Category	Definition	Operational Action
1. ADS-B Eligible	Aircraft equipped with and transmitting valid ADS-B OUT data in accordance with ICAO Annex 10, Volume IV, and for which surveillance data is reliable and suitable for use in ATS surveillance services in accordance with ICAO Doc 4444 (Chapter 8).	- ADS-B surveillance services may be provided; - Application of ADS-B surveillance-based separation shall be conducted in accordance with Chapter 5.
2. ADS-B Degraded	ADS-B data is available but is not reliable or suitable for the provision of ATS surveillance services or the application of surveillance-based separation.	- Verify and cross-check using alternative sources; - Do not apply ADS-B surveillance-based separation; - Apply alternative ATS surveillance (SSR) or procedural separation, as appropriate.
3. Not Eligible for ADS-B Surveillance-Based Separation	Aircraft not equipped with ADS-B, not transmitting ADS-B data, or transmitting data that is not valid for use in ATS surveillance services.	- ADS-B surveillance-based separation shall not be applied; - Apply alternative ATS surveillance (SSR) or procedural separation, as appropriate.
4. Eligibility Basis	Eligibility shall be determined in accordance with CAR-172, ICAO Annex 10, Volume IV, and ICAO Doc 4444.	- Forms the basis for operational approval and application of ADS-B surveillance services and separation.

6.6. Separation shall be based on the aircraft with the most limiting surveillance capability, in accordance with the applicable conditions and scenarios defined below:

Scenario	Aircraft A	Aircraft B	Capability Condition	ADS-B Surveillance-Based Separation	Operational Action
1	ADS-B Eligible	ADS-B Eligible	Both aircraft meet required performance	**May be applied**	Apply ADS-B surveillance-based separation minima, subject to applicable conditions.
2	ADS-B Eligible	ADS-B Degraded	One aircraft does not meet performance requirements	**Shall not be applied**	Apply **alternative ATS surveillance (SSR) or procedural separation**, as appropriate.
3	ADS-B Eligible	Not eligible for ADS-B	Mixed equipage	**Shall not be applied**	Apply separation based on the **most limiting surveillance**

		surveillance-based separation			**capability or performance** (SSR or procedural).
4	ADS-B Degraded	ADS-B Degraded	Both aircraft do not meet performance requirements	**Shall not be applied**	Do not use ADS-B for separation; apply **alternative ATS surveillance (SSR) or procedural separation**, as appropriate.
5	ADS-B Degraded	Not eligible for ADS-B surveillance-based separation	Mixed degraded capability	**Shall not be applied**	Apply separation based on the **most limiting surveillance capability or performance** (SSR or procedural).
6	Not eligible for ADS-B surveillance-based separation	Not eligible for ADS-B surveillance-based separation	No ADS-B capability	**Not applicable**	Apply **ATS surveillance (SSR) or procedural separation**, as appropriate.
7	ADS-B Eligible → Degraded (in-flight)	ADS-B Eligible	Loss of performance during operation	**Shall be suspended without delay**	Consider the aircraft **not eligible for ADS-B surveillance-based separation** and apply **alternative ATS surveillance (SSR) or procedural separation** without delay.
8	ADS-B Eligible	ADS-B Eligible (GNSS affected)	System-wide degradation (e.g. GNSS interference)	**Shall be suspended without delay**	Treat the **surveillance environment as degraded**; suspend ADS-B surveillance-based separation and apply **alternative ATS surveillance (SSR) or procedural separation** for affected traffic.

7. Eligibility Determination

7.1 Eligibility for ADS-B separation shall be determined based on:

a) Aircraft equipage compliance;
b) Real-time surveillance performance; and
c) Applicable Operational conditions.

7.2 Aircraft with degraded or unverified surveillance performance shall not be considered eligible for ADS-B surveillance-based separation

7.3 Eligibility status shall be continuously monitored and updated during flight.

7.4 The operational actions specified in Table 7.6 are indicative and not exhaustive and shall not preclude the application of other approved separation or contingency measures, as appropriate, in accordance with applicable regulations, including ICAO Doc 4444, and locally agreed procedures.

7.5 Operational procedures shall ensure timely detection and response to degraded performance.

7.6 Eligibility for the application of ADS-B surveillance-based separation shall be determined in accordance with the criteria and conditions defined in the table below:

Ref	Verification Element	Requirement	Source / Method	Operational Outcome
1	Flight plan capability declaration	- Aircraft capability is declared in accordance with ICAO provisions (e.g. Item 10 and Item 18), indicating ADS-B equipage and capability.	Flight plan data / ATM system	- Confirms declared ADS-B capability.
2	ATS automation verification	- Consistency between surveillance data and flight plan information is verified.	ATM automation system (correlation / validation tools) and/or pilot notification	- Confirms correct aircraft correlation and data consistency.
3	Real-time surveillance performance monitoring	- Surveillance data meets the required performance thresholds (accuracy, integrity, continuity, and timeliness) in accordance with Chapter 4 of the GM.	Surveillance system monitoring tools / indicators and/or pilot notification	- Confirms data is suitable for operational use.
4	Absence of system alerts	- No active alerts affecting surveillance reliability (e.g. integrity, continuity, timeliness, or data quality).	System alerts / HMI indications	- Confirms system is operating within acceptable limits.
5	Controller operational assessment	- The controller confirms the reliability of surveillance data, positive identification of the aircraft, and suitability for the intended ATS surveillance service or separation. - Pilot notification, where received, may be used as supplementary information but shall not replace system-based verification of surveillance suitability.	Controller assessment based on HMI, procedures, and/or pilot notification	- Final operational decision to apply or not apply ADS-B surveillance-based separation.

8. Operational Limitations

8.1 ADS-B use shall be subject to operational limitations, including as minimum, those related to:

a) Coverage constraints;
b) Surveillance performance limitations;
c) GNSS dependency; and
d) System and network reliability.
e) Other identified or emerging limitations.

9. Degraded Mode and Reversion

9.1 Reversion procedures shall be implemented where surveillance performance is degraded or unavailable.

9.2 Reversion shall ensure:

a) Immediate preservation of separation;
b) Safe transition to alternate surveillance or procedural separation; and

c) Coordination with affected ATS units.

9.3 Where doubt exists regarding surveillance performance or GNSS reliability, ATS surveillance-based separation shall not be applied.

Chapter 4 - Surveillance Performance Requirements

1. Regulatory Basis

1.1 ADS-B surveillance shall comply with:

a) CAR-172 — Air Traffic Services;
b) CAR-171 — Communication, Navigation and Surveillance;
c) ICAO Annex 10, Volume IV — Surveillance
d) ICAO Doc 4444 (PANS-ATM), Chapter 8; and
e) ICAO Doc 9924 Aeronautical Surveillance Manual.

1.2 ATS surveillance-based separation shall only be applied where surveillance performance is validated and demonstrated to be sufficient to support the applicable separation minima.

2. Performance Framework

2.1 ADS-B operational use shall be based on defined, measurable, and monitored surveillance performance parameters.

2.2 The surveillance performance framework shall include, as a minimum:

a) Accuracy;
b) Integrity;
c) Continuity;
d) Availability; and
e) Timeliness.

2.3 Performance requirements shall be:

a) Defined in the Surveillance Performance Specification;
b) Validated prior to operational use; and
c) Continuously monitored during operations.

3. Data Validity and Timeliness

3.1 Surveillance data shall be timely and suitable for the ATS function in accordance with ICAO Doc 4444

3.2 Only current and valid surveillance data shall be used for ATS surveillance services and separation.

3.3 Where surveillance data is not current, not valid, or its reliability cannot be assured ADS-B surveillance-based separation shall not be applied or shall be suspended without delay.

3.4 Controllers shall ensure continuous monitoring and identification before applying surveillance-based separation

4. Accuracy

4.1 Surveillance data shall be sufficiently accurate for the intended ATS surveillance application in accordance with ICAO Doc 4444(PANS-ATM).

4.2 ADS-B surveillance-based separation shall only be applied where surveillance performance, including accuracy, is validated and continuously monitored for operational use.

4.3 Accuracy performance shall be verified prior to implementation and monitored in operation.

5. Integrity

5.1 Surveillance data shall maintain high integrity, ensuring extremely low probability of undetected errors, in line with ICAO Doc 4444 (PANS-ATM).

5.2 Integrity monitoring shall be implemented to detect anomalies, data inconsistencies, or degradation affecting surveillance performance.

5.3 Where surveillance data integrity cannot be assured:

a) ADS-B surveillance-based separation shall not be applied or shall be suspended without delay; and

b) The aircraft shall not be considered eligible for ADS-B surveillance-based separation.

6. Continuity

6.1 Surveillance data shall be continuous and reliable during the application of separation, in accordance with ICAO Doc 4444 (PANS-ATM).

6.2 Loss of continuity shall trigger degraded mode and reversion procedures.

6.3 Where continuity cannot be assured, ADS-B surveillance-based separation shall be suspended and alternative separation methods shall be applied, as appropriate.

7. Availability

7.1 Surveillance system shall be operationally available to support the intended ATS function, in accordance with ICAO Doc 4444(PANS-ATM).

7.2 Availability shall consider infrastructure, communications, processing systems, and GNSS performance

7.3 Where system availability is degraded or cannot be assured:

a) ADS-B surveillance-based separation shall not be applied or shall be suspended without delay; and

b) Appropriate mitigation measures, including fallback procedures and/or increased separation, shall be applied.

7.4 Significant degradation or loss of availability affecting ATS operations shall be reported to the Authority in accordance with applicable reporting requirements.

8. Operational Degradation and Service Limitation

8.1 Where surveillance performance does not meet defined requirements:

a) ATS surveillance-based separation shall be suspended immediately;

b) Alternate surveillance or procedural separation shall be applied; and

c) Appropriate Operational limitations shall be implemented as necessary, in accordance with applicable regulations and locally agreed procedures.

8.2 Operational procedures shall ensure timely detection and response to performance degradation.

9. Monitoring and Oversight

9.1 The ATS Provider shall implement continuous surveillance performance monitoring in accordance with Appendix C.

9.2 Monitoring shall include:

a) Compliance with performance parameters;
b) Detection of degradation and anomalies;
c) Reporting and analysis of performance trends; and
d) Recording and monitoring of surveillance data update frequency, as applicable.

9.3 Performance degradation shall trigger:

a) Safety review;
b) Corrective action; and
c) Authority notification where required.
d) Operational mitigation measures, including restriction or suspension of ADS-B surveillance-based separation; and
e) Implementation of contingency procedures, as appropriate.

10. Recording and Retention

10.1 Surveillance data shall be recorded and retained to support:

a) Investigation;
b) Safety analysis;
c) Trend monitoring; and
d) Regulatory oversight.

10.2 Records shall be made available to the Authority upon request.

Chapter 5 - Safety Assessment and Continuous Safety Assurance

1. General

1.1 ADS-B implementation shall be subject to a formal Safety Risk Management (SRM) process in accordance with CAR-100 and ICAO Annex 19.

1.2 The Safety Assessment defined in this Chapter shall constitute the formal Safety Risk Management process for ADS-B implementation.

1.3 Operational approval shall require:

a) An accepted Safety Assessment; and

b) Demonstration that risks have been reduced to an acceptable level.

1.4 Technical validation alone shall not constitute operational approval.

1.5 The Safety Assessment shall be developed based on the approved CONOPS and shall provide the safety justification for the proposed ADS-B operational use.

2. Scope of Safety Assessment

2.1 The Safety Assessment shall evaluate the end-to-end ADS-B system, including as a minimum:

a) Aircraft systems (ADS-B and GNSS);

b) Ground-based and/or space-based infrastructure;

c) Communication and network systems;

d) Surveillance data processing and automation systems;

e) Human-Machine Interface (HMI); and

f) Operational procedures and human performance

g) Post- Implementation Monitoring

2.2 The assessment shall address as minimum:

a) Nominal operations;

b) Degraded conditions; and

c) Contingency and failure scenarios.

3. Hazard Identification

3.1 Hazards shall be systematically identified and documented in a hazard log.

3.2 Hazards shall include, **as a minimum**:

a) **Technical hazards**, including:

- GNSS degradation or interference;
- Surveillance data latency or validity exceedance;
- Integrity degradation or undetected position error;
- Continuity interruption;
- Ground or space system failure;
- Automation or processing failure

b) **Operational hazards**, including:

- Misidentification of aircraft;
- Inappropriate application of separation;

- Mixed-equipage misclassification;
- Controller over-reliance on surveillance displays;
- Delayed or incorrect reversion actions;
- operational environment

c) **Human factors and training hazards,** including:

- Inadequate training or competency in ADS-B operations;
- Misinterpretation of surveillance information;
- Reduced situational awareness;
- Human-machine interface (HMI) usability issues; and
- High workload or fatigue affecting controller performance.

d) **Systemic hazards**, including:

- Common-mode GNSS failure affecting multiple aircraft;
- Cybersecurity threats or data manipulation;
- Interdependency between surveillance and supporting systems.

3.3 Each hazard shall include:

a) Cause;
b) Consequence;
c) Initial risk;
d) Mitigation measures; and
e) Residual risk.

4. Performance Assumptions and Safety Linkage

4.1 The Safety Assessment shall be supported by defined surveillance performance assumptions, including:

a) Accuracy;
b) Integrity;
c) Continuity;
d) Availability; and
e) Timeliness;

4.2 Performance assumptions shall be:

a) Consistent with Chapter 4 requirements; and
b) Traceable to operational procedures and safety mitigations.

4.3 Residual risk shall be considered acceptable only where performance requirements are met and maintained.

5. Risk Assessment and Residual Risk Acceptance

5.1 Risks shall be assessed in accordance with CAR-100 using an approved risk assessment methodology.

5.2 Risk assessment shall:

a) Evaluate severity and likelihood;
b) Identify required mitigation measures; and
c) Determine residual risk levels.

5.3 Residual risk shall:

a) Be demonstrated as acceptable; and
b) Be formally endorsed by the accountable manager prior to submission to the Authority.

6. Operational Validation and Trials

6.1 Operational validation shall be conducted for each implementation phase in accordance with CAR 172 and Chapter 2 & Chapter 8 of the guidance material.

6.2 Validation shall:

a) Confirm surveillance performance assumptions;
b) Validate operational procedures under normal and degraded conditions;
c) Demonstrate safe application of the intended ATS surveillance function; and
d) Be conducted against defined success criteria, including performance thresholds, operational acceptability, and safety objectives.

6.3 Where surveillance-based separation is proposed, validation shall include:

a) Performance monitoring;
b) Degraded mode and contingency testing; and
c) Evaluation of controller workload and operational complexity against acceptability criteria.

6.4 Operational expansion or progression between phases shall require:

a) Documented validation results;
b) Updated Safety Assessment; and
c) Authority approval

7. Mixed-Equipage Risk Management

7.1 Mixed-equipage operations shall address the risks associated with such operations and shall include, as a minimum:

a) Interaction between ADS-B and Not eligible for ADS-B surveillance-based separation aircraft or other surveillance environments;
b) Application of the applicable ATS surveillance separation minima based on the aircraft with the lower surveillance capability or system performance; and
c) Impact on controller workload, decision-making, or other operational factors.

7.2 Mixed-equipage risk shall be periodically reviewed based on operational experience, traffic composition, surveillance performance, and identified safety occurrences or trends.

8. GNSS Vulnerability

8.1 The Safety Assessment shall address GNSS-related risks, including as a minimum:

a) Interference, jamming, and spoofing;
b) Multi-aircraft impact scenarios; and
c) Loss or degradation of GNSS signals.
d) Other GNSS-related hazards or vulnerabilities identified through safety assessment, operational experience, or performance monitoring.

8.2 Mitigation measures shall ensure:

a) Detection of GNSS degradation; and
b) Safe reversion to alternate separation methods.

9. Continued Operational Compliance Monitoring

9.1 The ATS Provider shall implement continuous monitoring as part of the Safety Assurance function in accordance with CAR-100.

9.2 Monitoring shall include:

a) Surveillance performance compliance
b) Integrity, continuity, and reversion events; and
c) ADS-B-related occurrences.

9.3 Monitoring shall be conducted in accordance with Appendix C

9.4 Performance degradation or adverse trends shall trigger:

a) Safety review;
b) Corrective actions; and
c) Authority notification where applicable.

10. Oversight

10.1 The Authority shall:

a) Review and approve the Safety Assessment;
b) Audit safety and performance evidence;
c) Impose operational limitations where required; and
d) Suspend or withdraw approval where safety is not maintained.

Chapter 6 - ATS Procedures

1. General Operational Principles

1.1 ADS-B shall be used as an ATS surveillance system in accordance with ICAO Doc 4444 (PANS-ATM), Chapter 8.

1.2 Operational use of ADS-B shall require:

a) Validated surveillance coverage;
b) Approved surveillance performance specification;
c) Accepted Safety Assessment;
d) Defined training and competency requirements;
e) Approved ATS operational procedures for the intended application, published in the applicable operations manuals, including normal, degraded, and contingency procedures governing the use of ADS-B; and;
f) Explicit Authority approval.

1.3 ADS-B may be used to support ATS surveillance applications, including situational awareness, ATS surveillance service, and ATS surveillance-based separation, in accordance with ICAO Doc 4444 (PANS-ATM), Chapter 8.

1.4 ATS surveillance-based separation using ADS-B shall only be applied where surveillance performance is verified, continuously monitored, and maintained within defined operational limits.

2. ATS Surveillance Applications Using ADS-B

2.1 ADS-B shall support ATS surveillance applications in accordance with ICAO Doc 4444 (PANS-ATM), Chapter 8.

2.2 Types of Applications

a) Situational Awareness (SA):

- Use of ADS-B data to enhance controller awareness of aircraft position, traffic situation, and operational environment.
- ADS-B data used for situational awareness shall not be used as the basis for the application of separation.

b) ATS Surveillance Service:

- Provision of traffic information, monitoring, and assistance to aircraft using ADS-B surveillance data.
- ATS surveillance service shall not include the application of ATS surveillance-based separation minima.

c) ATS Surveillance-Based Separation:

- Application of separation minima using ADS-B surveillance data, subject to compliance with all operational, performance, and safety requirements defined in this Chapter.

2.3 Operational Use and Limitations

a) Situational Awareness and ATS Surveillance Service may be provided:

- During initial or limited operational phases;

- In mixed-equipage environments; or
- Where surveillance performance does not support the application of separation.

b) ADS-B surveillance-based separation shall only be applied in accordance with Section 4 of this Chapter.

3. ATS Surveillance Identification Procedures

3.1 Aircraft shall be identified using ADS-B in accordance with ICAO Doc 4444 (Chapter 8).

3.2 Identification shall be:

a) Established prior to the provision of ATS surveillance services; and

b) Maintained continuously throughout the provision of such services.

3.3 Loss or uncertainty of identification shall result in the immediate suspension of ATS surveillance-based separation.

4. Application of ATS Surveillance-Based Separation

4.1 ADS-B surveillance-based separation shall be applied only when:

a) Aircraft are identified and continuously monitored;

b) Surveillance performance meets defined requirements; and

c) Both aircraft are confirmed as ADS-B Eligible.

4.2 Separation shall be applied in accordance with ICAO Doc 4444 and CAR-172.

4.3 Controllers shall ensure continuous monitoring of aircraft position and performance throughout the application of separation.

4.4 In mixed-equipage operations, ADS-B surveillance-based separation shall be applied only when both aircraft are ADS-B Eligible and surveillance data is reliable and suitable; where this condition is not met, controllers shall apply alternative ATS surveillance (SSR) or procedural separation in accordance with approved procedures.

5. Eligibility

5.1 Reduced ATS surveillance separation shall only be applied to aircraft that:

a) Meet applicable ADS-B equipage and performance requirements;

b) Are identified and continuously monitored; and

c) Operate within approved airspace and operational conditions.

5.2 Aircraft with degraded or unverified surveillance performance shall not be considered eligible for ADS-B surveillance-based separation.

5.3 Eligibility shall be continuously verified during flight based on the reliability and suitability of surveillance data.

6. Data Validity

6.1 Controllers shall ensure that surveillance data used for separation is:

a) Timely;

b) Reliable; and

c) Within defined validity limits.

6.2 Surveillance data that exceeds defined validity limits shall not be used for separation.

6.3 Where data validity is not assured:

a) ADS-B surveillance-based separation shall not be applied or shall be suspended without delay;
b) the aircraft shall not be considered eligible for ADS-B surveillance-based separation; and
c) Alternative ATS surveillance (e.g., SSR) or procedural separation shall be applied.

7. Degraded Mode

7.1 Where surveillance performance degrades, controllers shall apply the provisions of Section 6.3.

7.2 Loss of ADS-B capability for an aircraft shall result in the aircraft being considered not eligible for ADS-B surveillance-based separation and the application of alternative separation methods.

8. Reversion to Procedural Separation

8.1 Reversion procedures shall address:

a) ADS-B system failure;
b) GNSS degradation or loss;
c) Automation or network failure; and
d) Loss or uncertainty of aircraft identification, including unidentified or uncorrelated targets.

8.2 Reversion shall ensure:

a) Immediate preservation of separation;
b) Safe transition to alternate separation methods;
c) Application of additional approved operational measures, as necessary; and
d) Coordination with adjacent sectors or units.

9. GNSS Interference Contingency

9.1 Where GNSS degradation or interference is suspected:

a) Controllers shall increase monitoring;
b) Surveillance data shall be validated against available sources; and
c) ADS-B DS-B surveillance-based separation shall be managed in accordance with Section 6.3.

9.2 Where GNSS degradation is confirmed:

a) ADS-B surveillance-based separation shall be suspended;
b) Alternative separation methods and appropriate operational measures shall be applied, including reporting and coordination as required.

10. Mixed-Equipage Operations

10.1 Controllers shall:

a) Identify and confirm aircraft surveillance capability;
b) Apply the applicable ATS separation minima based on the most limiting surveillance capability or performance;

c) Avoid assumptions regarding aircraft equipage or capability and rely only on verified surveillance performance, system indications, and approved operational procedures;
d) Apply approved procedures, including contingency procedures, as appropriate; and
e) Continuously assess aircraft capability and surveillance performance during operations;

10.2 ADS-B surveillance-based separation shall not be applied where any aircraft does not meet the eligibility requirements.

11. Phraseology

11.1 Standard phraseology shall be applied in accordance with ICAO Doc 4444 (Chapter 12) and ICAO Doc 9432.

12. Recording and Post-Event Review

12.1 ADS-B surveillance data used for ATS shall be recorded in accordance with CAR-172.

12.2 Events involving:

a) Degraded performance;
b) Reversion actions;
c) Integrity alerts; or
d) GNSS anomalies

shall be:

a) Logged;
b) Subject to safety review; and
c) Monitored for trend analysis.

Chapter 7 - Mixed-Equipage Operation and Transition

1. General

1.1 ADS-B operations within the Muscat FIR shall be conducted in a mixed-equipage environment, unless otherwise specifically approved by the Authority.

1.2 Operational use of ADS-B shall be based on verified real-time surveillance performance, and aircraft capability shall not be assumed.

1.3 Application of ATS surveillance-based separation shall require:

a) Validated surveillance performance meeting defined requirements;
b) An accepted Safety Assessment; and
c) Surveillance data that is reliable and suitable for the intended ATS application.

2. Aircraft classification

2.1 Aircraft shall be dynamically classified for operational purposes as:

a) Eligible ADS-B
b) ADS-B Degraded
c) Not eligible for ADS-B surveillance-based separation

2.2 Classification shall be based on real-time surveillance status and may change during flight.

2.3 Controllers shall ensure that aircraft classification is continuously verified and updated.

3. Application of Separation

2.4 operational control actions

- Aircraft shall be classified and handled in accordance with the applicable ADS-B eligibility status, as follows:

Aspect	Required Action
Eligibility Condition	ADS-B surveillance-based separation shall be applied only when both aircraft are classified as ADS-B Eligible and surveillance data is **reliable and suitable** for the intended application, in accordance with ICAO Doc 4444.
Loss or Degradation of Capability/Performance	Where ADS-B capability or surveillance performance is lost, degraded, or no longer reliable, ADS-B surveillance-based separation shall be **suspended without delay**, and controllers shall apply **alternative ATS surveillance (SSR) or procedural separation**, as appropriate.
Minimum Standard Applied	Separation shall be based on the **most limiting surveillance capability or performance**.

Note: *The required actions are indicative and not exhaustive and shall not preclude the application of other approved separation or contingency measures, as appropriate, in accordance with applicable regulations and locally agreed procedures.*

3 Transition from Surveillance Service to Surveillance-Based Separation

3.1 Transition from ATS surveillance service to ATS surveillance-based separation shall be progressive and controlled.

3.2 Transition shall require:
   a) Validated surveillance performance;
   b) An Updated Safety Assessment;
   c) Approved operational procedures;
   d) Controller training and competency;

3.3 Technical capability alone shall not constitute authorization to apply surveillance-based separation.

4 Mixed-Equipage Complexity Management

4.1 The ATS Provider shall monitor and manage complexity associated with mixed-equipage operations.

4.2 Monitoring shall include:
   a) Capability mismatch between aircraft;
   b) Reversion events and suspension of separation;
   c) Controller workload; and
   d) Sector capacity and traffic complexity.

4.3 Where necessary, mitigation measures shall be implemented, including as minimum:
   a) Flow control measures;
   b) Level allocation or restrictions;
   c) Limitation of ADS-B separation use;
   d) Temporary suspension of reduced separation; and
   e) Other operational or system factors identified through performance monitoring or safety assessment.

5 Non-Compliance and Operational Restrictions

5.1 Aircraft not meeting ADS-B equipage or performance requirements shall be treated as Not eligible for ADS-B surveillance-based separation.

5.2 Operational restrictions may be applied to ensure safety, including:
   a) Denial of reduced separation;
   b) Airspace restrictions; and
   c) Operational limitations as defined in the AIP.

6 Sole-Surveillance Considerations

6.1 ADS-B shall not be used as the sole surveillance source unless explicitly approved in accordance with Appendix G.

6.2 Approval for sole-surveillance operations shall require as a minimum:
   a) Mandatory equipage or equivalent mitigation;
   b) GNSS vulnerability assessment;
   c) Validated reversion capability;
   d) Enhanced performance monitoring;
   e) Updated Safety Assessment; and
   f) AIP promulgation.

6.3 Application principles

a) Use of ADS-B as a sole surveillance source shall be subject to the operational and safety requirements defined in Chapter 6.
b) Controllers shall ensure continuous monitoring of surveillance performance and system status during sole-surveillance operations.
c) Where surveillance performance or system integrity cannot be assured, operations shall be conducted in accordance with the degraded and reversion provisions defined in Chapter 6.

7 Mixed-Equipage Operational Principles

7.1 ADS-B applications in mixed-equipage environments shall be conducted in accordance with Chapter 6.

7.2 Controllers shall:

a) Continuously assess aircraft surveillance capability and performance;
b) Apply separation based on the most limiting surveillance capability or performance available; and
c) Apply approved contingency and reversion procedures where required.

7.3 Application of ADS-B in mixed-equipage environments shall be subject to the following:

a) ADS-B may be used to support situational awareness and ATS surveillance services where operational conditions permit;
b) ADS-B surveillance-based separation shall be applied only in accordance with Chapter 6 and where aircraft are confirmed as ADS-B Eligible;
c) Where aircraft are not eligible, degraded, or where surveillance performance is uncertain, controllers shall apply alternative ATS surveillance (e.g., SSR) or procedural separation; and

8 Continuous Review and Evolution

8.1 Mixed-equipage operations shall be subject to continuous review based on:

d) Equipage trends;
e) Surveillance performance monitoring;
f) Safety indicators and occurrences; and
g) GNSS operational environment.

8.2 Transition toward ADS-B-dominant or ADS-B-exclusive operations shall require:

a) Regulatory action
b) Updated Safety Assessment; and
c) Authority approval.

Chapter 8 - Documentation, Approval, and Regulatory Requirements

1. General

1.1 Operational use of ADS-B for ATS surveillance services or ATS surveillance-based separation shall require formal Authority approval.

1.2 Approval shall be based on demonstrated compliance with the following elements:

a) An approved Concept of Operations (CONOPS);
b) An accepted Safety Assessment;
c) Validated surveillance performance;
d) An established operational framework, including mixed-equipage management and operational procedures; and
e) Approved training, competency, and operational readiness.

1.3 . The availability of ADS-B infrastructure shall not, in itself, constitute authorization for operational use.

2. Regulated ATS Operational Change

2.1 ADS-B implementation shall be treated as a regulated ATS operational change in accordance with CAR-172 and CAR-100.

2.2 The ATS Provider shall:

a) Submit required documentation to the Authority;
b) Demonstrate traceability between CONOPS, performance, procedures; training and Safety Assessment.
c) Obtain approval prior to operational implementation.

2.3 No operational use shall commence until formal approval has been granted by the Authority.

3. Required Submission Package

3.1 The ATS Provider shall submit a complete documentation package, appropriate to the intended ADS-B operational use and implementation phase, including, as a minimum:

a) Concept of Operations (CONOPS);
b) Surveillance Performance Specification;
c) Safety Assessment (in accordance with Chapter 5);
d) Operational procedures and manuals;
e) Training and competency programme; and
f) Performance monitoring plan (in accordance with Appendix C).

3.2 The documentation package shall:

a) Be complete and internally consistent;
b) Ensure traceability across all elements, including CONOPS, performance, procedures, training, and safety assessment;
c) Be validated by the ATS Provider; and
d) Be sufficient to support operational approval for the intended ATS surveillance application.

3.3 Phase-Based Submission Requirements

3.3.1 Approval for each implementation phase defined in Chapter 2 shall be based on the submission of documented evidence, as a minimum, appropriate to the intended ATS surveillance application and level of operational use.

a) Phase 1 — Facility Operational Approval (ATM Integration)

The ATS Provider shall submit evidence, as a minimum, demonstrating:

- System integration and end-to-end validation within the CNS/ATM environment;
- Initial CONOPS defining the intended use;
- Initial Safety Assessment;
- Operational procedures for the intended use;
- Initial training and familiarization arrangements; and
- Results of operational trials and validation commensurate with the intended operation use.

Note: *ATS surveillance-based separation shall not be applied at this phase*

b) Phase 2 — Limited Operational Use

The ATS Provider shall submit evidence, as a minimum, demonstrating:

- Updated CONOPS defining the use of ADS-B for situational awareness and, where applicable, ATS surveillance services;
- Validated surveillance performance for the intended use;
- Validated operational procedures, including degraded and reversion procedures;
- Training and competency evidence;
- Updated Safety Assessment;
- Initial performance monitoring arrangements; and
- Results of operational trials and validation commensurate with the intended operation use.

Note: *ATS surveillance-based separation shall not be applied at this phase.*

c) Phase 3 — ATS Surveillance-Based Separation (Subject to Approval)

The ATS Provider shall submit evidence, as a minimum, demonstrating:

- Validated surveillance performance supporting the proposed separation minima;
- Final CONOPS and approved operational procedures;
- Safety Assessment including validation results and residual risk acceptance;
- Training and competency completion;

- Implementation of the performance monitoring framework; and
- Results of operational trials and validation commensurate with the intended operational use.

Note: *Application of ATS surveillance-based separation shall require explicit Authority approval*

3.3.2 The ATS Provider shall establish post-implementation monitoring and assurance arrangements and define measurable trial exit criteria for each implementation phase to ensure continued compliance with surveillance performance requirements, achievement of safety objectives, and acceptance by the Authority.

4. . Operational Trial and Validation

4.1 A structured operational trial and validation programme shall be conducted for each implementation phase of ATS surveillance applications (situational awareness, ATS surveillance services, and ATS surveillance-based separation), prior to operational use.

4.2 The trial shall:

a) Validate surveillance performance against defined requirements;
b) Validate operational procedures under normal and degraded conditions
c) Assess controller workload and operational complexity; and
d) Demonstrate safe application of the intended surveillance function.

4.3 The ATS Provider shall produce a formal evaluation report for each trial phase, including:

a) Evidence of performance compliance;
b) Identification of deviations and limitations;
c) Residual risk evaluation; and
d) Recommendations for progression or restriction.

4.4 Operational expansion or progression between phases shall:

a) Be supported by documented validation results;
b) Be subject to an updated Safety Assessment; and
c) Require Authority approval.

4.5 Completion of an operational trial shall not, in itself, constitute authorization for operational use.

5. Publication and Promulgation

5.1 ADS-B operational use shall be promulgated through the AIP and associated publications.

5.2 Promulgation shall include:

a) Airspace designation;
b) Operational limitations;
c) Eligibility requirements;

d) Degraded mode and contingency procedures; and
e) Non-compliance handling.

5.3 Changes to operations shall be promulgated through:
a) AIP amendment;
b) AIP supplement; or
c) NOTAM, as appropriate

6. Recording and Data Retention

6.1 Surveillance data and operational records shall be retained to support:
a) Safety investigations;
b) Performance monitoring;
c) Operational analysis; and
d) Regulatory oversight.

6.2 Records shall be maintained in accordance with applicable regulatory requirements and made available to the Authority upon request.

7. Continued Compliance and Oversight

7.1 Operational approval shall remain conditional upon:
a) Sustained compliance with surveillance performance requirements;
b) Continued safety assurance;
c) Effective monitoring and reporting; and
d) Maintenance of approved procedures and training.

7.2 The ATS Provider shall:
a) Monitor performance continuously;
b) Report degradation and anomalies; and
c) Implement corrective actions where required;
d) Address other operational or system issues identified through monitoring or safety assessment.

8. National ADS-B Mandate Framework

8.1 Aircraft equipage requirements shall be established through Civil Aviation Regulations and promulgated via the AIP.

8.2 This Guidance Material shall not constitute equipage mandate authority.

9. Operational Restrictions, Suspension, or Withdrawal

9.1 The Authority may impose operational limitations, restrictions, or conditions as necessary to ensure safety.

9.2 The Authority shall suspend or withdraw approval where:
a) Surveillance performance requirements are not met;
b) GNSS reliability is compromised;
c) Reversion capability is not assured; or
d) Safety is not maintained.

9.3 Immediate suspension of ADS-B surveillance-based separation shall occur where:
a) Integrity cannot be assured; or

b) Surveillance data is no longer reliable for separation.

10. Amendment and Future Evolution

10.1 Any change to ADS-B operations, performance, or airspace application shall require:

a) Updated CONOPS;
b) Revised Safety Assessment;
c) Updated training, competency, and operational readiness requirements;
d) Authority approval; and
e) AIP update.

10.2 Future enhancements, including expansion to new airspace or applications, shall follow the same regulatory approval and validation process.

A1. ADS-B Implementation and Operational Approval Checklist

Item	Verification Required	Status	Remarks
- **ADS-B implementation formally notified to the Authority**	- Official notification letter with reference number and scope of implementation	☐	
- **Classified as regulated ATS operational change**	- Formal change classification in accordance with CAR-172 (including safety significance determination)	☐	
- **Change management process applied**	- Documented application of SMS change management process (CAR-100), including change description, impact assessment, and approval workflow	☐	
- **Safety Risk Management (SRM) conducted**	- Complete safety assessment package including hazard log, risk analysis, mitigation measures, and residual risk evaluation (CAR-100 compliant)	☐	
- **Safety Assessment formally accepted by Authority**	- Official acceptance/approval letter issued by the Authority	☐	
- **Operational Concept (CONOPS) approved**	- Approved CONOPS document demonstrating alignment with Chapter 2 & 3 requirements	☐	
- **Training and competency requirements established and implemented**	- Approved training programme, competency assessment records, and evidence of operational readiness of personnel.	☐	
- **Operational trials conducted**	- Structured trial programme completed for the applicable implementation phase	☐	
- **Trial exit criteria defined and met**	- Documented and measurable criteria demonstrating: • Performance compliance • Procedure validation • Acceptable workload • No unresolved safety-critical issues	☐	
- **Trial evaluation report completed**	- Formal report including performance results, deviations, residual risk, and recommendations	☐	
- **Trial results accepted by the Authority**	- Evidence of Authority review and acceptance prior to progression		

A2. Airspace Concept and Operational Use Verification

Item	Verification Required	Status	Remarks
- **Airspace scope clearly defined**	- Defined lateral and vertical limits, supported by charts and formal airspace description in the CONOPS and draft AIP	☐	
- **Intended ATS surveillance applications specified**	- CONOPS clearly defines the intended ATS surveillance applications (e.g. situational awareness, ATS surveillance service, ATS surveillance separation)	☐	
- **Separation minima defined and justified**	- Applicable separation minima defined with reference to ICAO Doc 4444, including conditions for application	☐	
- **Coordination arrangements established**	- Documented coordination procedures with adjacent ATS units/FIRs, including transfer of control and surveillance applicability conditions.		
- **Mixed-equipage procedures documented**	- Operational procedures defining aircraft classification, application of separation based on the aircraft with the lower capability, and separation application logic	☐	
- **Degraded mode and reversion procedures established**	- Documented procedures for surveillance degradation (including GNSS and ADS-B) and transition to alternative separation minima (surveillance/procedural), as applicable	☐	

- **Operational limitations and conditions identified**	- Defined operational constraints, including coverage limits, surveillance performance conditions, and applicable restrictions, reflected in draft AIP text	☐	

A3. Operational Readiness Verification

Item	Verification Required	Status	Remarks
- **ATCO training and competency completed**	- Training programme, attendance records, and competency assessment demonstrating readiness for ADS-B operations (including degraded and reversion scenarios)	☐	
- **Operational procedures validated**	- Evidence of procedure validation through simulation, trials, or shadow operations (normal, degraded, contingency)	☐	
- **HMI and system functionality validated**	- Evidence from simulation and/or operational testing confirming correct display, symbology, data integrity indication, and usability	☐	
- **Reversion capability tested and validated**	- Documented exercises demonstrating transition to radar and/or procedural separation under degraded conditions	☐	
- **Surveillance performance monitoring tools operational**	- Operational monitoring capability (dashboard/reports) demonstrating tracking of accuracy, integrity, continuity, availability, and timeliness	☐	
- **Operational roles and responsibilities defined**	- Clear definition of responsibilities for ATCOs, supervisors, and technical staff in normal and degraded operations	☐	
- **Post-implementation monitoring and review plan established**	- Documented plan for performance monitoring, safety review, reporting, and corrective actions following implementation	☐	

A4. Publication and Promulgation of ADS-B Operations

Item	Verification Required	Status	Remarks
- **AIP / AIP SUP prepared**	- Draft AIP/AIP SUP text covering ADS-B operations, airspace, procedures, limitations, and conditions of use	☐	
- **Airspace designation and scope published**	- Defined lateral/vertical limits and applicability of ADS-B surveillance (per phase, if applicable) reflected in AIP	☐	
- **ATS surveillance applications promulgated**	- Published description of services (Situational Awareness / ATS Surveillance Service / ATS Surveillance Separation) and conditions of use	☐	
- **Separation minima and conditions published**	- Applicable minima and operational conditions aligned with ICAO Doc 4444 and Authority approval	☐	
- **Equipage and eligibility requirements promulgated**	- Aircraft equipage/performance requirements and eligibility criteria clearly defined in AIP	☐	
- **Degraded mode and contingency procedures referenced**	- AIP references to reversion procedures, GNSS degradation handling, and service limitations	☐	
- **Operational limitations and restrictions published**	- Coverage limits, performance constraints, and any operational restrictions clearly stated	☐	
- **NOTAM template prepared and validated**	- Standard NOTAM format for activation, restriction, degradation, or suspension of ADS-B operations	☐	
- **Consistency between AIP and approved CONOPS verified**	- Cross-check ensuring AIP content matches approved CONOPS, safety assessment, and operational approval conditions	☐	

A5. Authority Decision and Approval

☐ Full Approval
☐ Conditional Approval
☐ Restricted Approval
☐ Approval Withheld

Conditions (if applicable): _____

A6. Conditions and Limitations (as applicable)

Appendix B - Minimum Content Requirements for the Safety Assessment

B1. Change Description

1. The safety assessment shall clearly describe:
   a) Operational scope and boundaries;
   b) Airspace designation (lateral and vertical limits);
   c) Intended ATS surveillance applications (per implementation phase);
   d) Proposed separation minima and conditions of application; and
   e) Implementation, transition, and phased deployment strategy.

B2. System Description

2. The Safety Assessment shall describe the end-to-end ADS-B system, including:
   a) Aircraft equipage assumptions and capability (ADS-B OUT compliance);
   b) GNSS dependency and external system reliance;
   c) Ground-based and/or space-based surveillance infrastructure;
   d) Communication and data network architecture;
   e) ATM processing systems and automation logic;
   f) Human-Machine Interface (HMI) configuration; and
   g) Monitoring, alerting, recording and data retention capabilities.

B3. Hazard Identification

1. A comprehensive hazard log shall be developed and maintained.
2. Hazards shall include, as a minimum:
   a) Technical hazards (e.g. GNSS degradation, latency exceedance, integrity failure);
   b) Operational hazards (e.g. misidentification, incorrect separation application, mixed-equipage complexity);
   c) Systemic hazards (e.g. common-mode GNSS failure, cybersecurity risks, system interdependency); and
   d) Human factors hazard (e.g. workload, over-reliance, delayed reversion).
3. Each hazard entry shall include:
   a) Cause;
   b) Consequence;
   c) Initial risk level;
   d) Mitigation measures;
   e) Residual risk level; and
   f) Assigned responsible owner.

B4. Performance Assumptions and Safety Linkage

1. The Safety Assessment shall define the surveillance performance assumptions supporting the intended ATS application, including:
   a) Data timeliness (update rate and latency);

b) Overdue Time (OT);
c) Integrity thresholds;
d) Availability targets;
e) Accuracy assumptions; and
f) Reversion timing and response requirements.

2. Performance assumptions shall be:
   a) Be justified by system capability, validation evidence, and operational trials; and
   b) Be fully traceable to operational procedures, separation minima, and reversion criteria.

B5. Risk Assessment and Acceptance

1. Risk assessment shall be conducted using an approved risk matrix in accordance with CAR-100.
2. The Safety Assessment shall include:
   a) Defined severity and likelihood classifications;
   b) Risk evaluation and mitigation strategy;
   c) Residual risk justification; and
   d) Formal acceptance by the accountable manager prior to submission to the Authority.

B6. Operational Validation and Trials

1. Where ATS surveillance separation is proposed, the Safety Assessment shall include evidence of operational validation and trials.
2. This shall include, as applicable:
   a) Approved trial plan defining scope, limitations, and objectives;
   b) Defined monitoring and performance criteria;
   c) Entry and exit criteria for each implementation phase;
   d) Summary of trial results and observed system and operational performance; and
   e) Comparison of actual performance against defined safety and performance assumptions.

B7. Post-Implementation Monitoring and Continued Assurance

1. The Safety Assessment shall include a post-implementation monitoring plan.
2. The plan shall define:
   a) Key Performance Indicators (KPIs)
   b) Safety Performance Indicators (SPIs);
   c) Monitoring methods, tools, and frequency;
   d) Defined thresholds for acceptable performance;
   e) Escalation and corrective action triggers; and
   f) Authority notification and reporting requirements.

Appendix C - ADS-B Performance Monitoring Framework

Note 1: *The ATS Provider may establish and monitor additional technical performance indicators, as appropriate, based on operational needs, system characteristics, or identified risks.*

Note 2: *These indicators are indicative and not mandatory, provided that they are defined, documented, and accepted by the Authority.*

C1. Monitoring Categories

1. The ATS Provider shall implement a continuous monitoring framework covering:
   a) Technical Performance
   b) Operational Performance
   c) Safety Performance
   d) GNSS Environment Monitoring
   e) Data quality, including accuracy, integrity, and timeliness; and
   f) System availability and continuity

C2. Technical KPIs

2. The ATS Provider shall monitor, record, and report the following technical performance indicators:
   a) Surveillance data timeliness compliance
      - Percentage of data updates meeting defined latency thresholds
   b) Surveillance data validity compliance
      - Percentage of data within defined validity limits (data age thresholds)
   c) Integrity alert frequency
      - Number and rate of integrity or quality alerts per reporting period
   d) Track continuity / drop rate
      - Rate of track loss, update interruption, or discontinuity
   e) Infrastructure availability
      - Ground-based and/or space-based station uptime and availability
   f) Automation and data feed reliability
      - Availability and continuity of surveillance data processing and system feeds

C3. Operational KPIs

1. The ATS Provider shall monitor operational impact indicators, including:
   a) Number and frequency of reversion events (to radar or procedural separation);
   b) Number of suspensions of reduced or surveillance-based separation;
   c) Mixed-equipage transitions and reclassifications during operations;
   d) Impact on sector capacity, workload, and traffic complexity; and
   e) Controller-reported anomalies or operational limitations related to ADS-B use.

C4. Safety Performance Indicators (SPIs)

1. Safety performance indicators shall include, as a minimum:

a) ADS-B-related occurrences and incident reports;
b) GNSS interference, jamming, or spoofing events;
c) Separation events or losses of separation in ADS-B airspace;
d) Frequency of degraded mode activation; and
e) Trends indicating increased operational risk or system instability.

C5. Escalation and Corrective Action

1. The ATS Provider shall define and implement:
   a) Quantitative alert thresholds for each KPI and SPI;
   b) Immediate mitigation actions when thresholds are exceeded;
   c) Supervisor intervention criteria and escalation procedures; and
   d) Authority notification triggers where safety or operational performance is affected.
2. Exceedance of defined thresholds shall result in**:**
   a) Operational review;
   b) Implementation of corrective and preventive actions; and
   c) Assessment of continued suitability for surveillance-based separation.C6. Authority

C6. Oversight

1. The Authority shall:
   a) Audit performance monitoring data and supporting records;
   b) Conduct independent sampling and validation of surveillance performance;
   c) Require corrective actions or impose operational limitations; and
   d) Suspend or withdraw operational approval where performance does not support safe operations.

Appendix D - Space-Based ADS-B Surveillance Operations

D1. Scope

1) This Appendix supports the progressive integration of space-based ADS-B, as outlined in the Foreword, by defining operational, performance, and safety considerations specific to its use.
2) It provides guidance on the operational use of space-based ADS-B in support of ATS surveillance services within the Muscat FIR, where such surveillance is used to supplement or extend existing surveillance coverage.
3) The use of space-based ADS-B shall be subject to the approval process defined in Chapter 8. The ATS Provider shall ensure that all elements relevant to space-based ADS-B operations are included in the implementation package submitted to the Authority.
4) Space-based ADS-B may support situational awareness, ATS surveillance services, and, where specifically approved, ATS surveillance-based separation, subject to validated performance for the intended operational context and in accordance with ICAO Doc 4444 PANS - ATM.
5) This Appendix shall be applied in conjunction with Chapter 4 (Surveillance Performance Requirements); Chapter 5 (Safety Assessment); Chapter 6 (ATS Procedures); and Appendix C (Performance Monitoring Framework).
6) This Appendix is limited to space-based ADS-B specific considerations and does not repeat requirements contained in those provisions.

D2. Operational Application

1) Space-based ADS-B may be used to support ATS surveillance applications in accordance with the approved operational framework.
2) The application of ATS surveillance services and separation shall be in accordance with ICAO Doc 4444 (Chapter 8) and subject to:
   a) Validated surveillance performance;
   b) Defined operational limitations; and
   c) Explicit Authority approval for the intended operational use.

D3. Space-Based Specific Considerations

1) The use of space-based ADS-B shall take into account characteristics that differ from terrestrial surveillance, including:
   a) Latency and update interval characteristics;
   b) End-to-end data delivery time;
   c) Variability in surveillance update performance;
   d) Geographic variation in performance; and
   e) Service provider/interface performance, including data delivery, system availability, and continuity.

2) These characteristics shall be considered, as applicable, in:
   a) Operational approval;
   b) Surveillance performance specification;
   c) Determination and application of separation minima;
   d) Degraded-mode and reversion procedures; and
   e) Ongoing performance monitoring.

D4. Operational Limitations

1) Operational use shall consider limitations specific to space-based ADS-B, including:
   a) Increased or variable latency;
   b) Variable update interval;
   c) GNSS dependency and associated risks;
   d) Satellite and data relay effects;
   e) Coverage variability, including altitude-dependent performance; and
   f) Other factors affecting surveillance performance or operational use, as applicable.
2) Where such limitations affect performance, the application of ATS surveillance-based separation shall be restricted or not applied.

D5. Degraded Performance

1) Where space-based ADS-B performance is degraded or uncertain, including due to:
   a) Latency or update interval effects;
   b) GNSS-related degradation;
   c) Data relay, processing, or interface failure; or
   d) Other factors affecting surveillance performance.

ADS-B surveillance-based separation shall not be applied or shall be suspended without delay, and alternative ATS surveillance or procedural separation shall be used.

D6. Monitoring and Oversight

1) Space-based ADS-B performance shall be monitored in accordance with Appendix C.
2) Monitoring should ensure visibility of:
   a) Latency and update performance;
   b) Data continuity and stability;
   c) Availability of space-based ADS-B data feeds;
   d) GNSS-related effects;
   e) Geographic or altitude-related performance variation; and
   f) Other relevant factors affecting surveillance performance.
3) Where performance degradation or adverse trends are observed, appropriate operational and safety actions shall be taken, including Authority notification where required.

Appendix E - Operational Training and Competency Requirements for ADS-B

E1. Purpose

1) This Appendix defines the training and competency requirements necessary to support the safe operational use of ADS-B surveillance, including both ground-based and space-based systems, within the Muscat FIR.

2) Training shall ensure that operational personnel possess the knowledge and skills required to apply ATS surveillance services and ATS surveillance-based separation using ADS-B in accordance with the applicable provisions of ICAO Doc 4444 (PANS-ATM) and CAR-172.

3) The provisions of this chapter apply to both ground-based and space-based ADS-B surveillance systems, unless otherwise specified."

E2. Scope

1) This appendix applies to:
   a) Air Traffic Controllers (ATCOs)
   b) Supervisors
   c) Operational Safety Specialists
   d) ATS operational support personnel involved in surveillance operations
   e) other ATS functions, as appropriate.
2) Training shall address both:
   a) initial implementation and
   b) continued operational competency.

E3. Training Objectives

1) Training shall ensure that operational personnel understand:
   a) ADS-B surveillance principles and limitations
   b) ATS surveillance service provision
   c) Application of surveillance-based separation
   d) Mixed-equipage operations
   e) Degraded mode operations and reversion procedures;
   f) GNSS interference, jamming, and spoofing risks
   g) Surveillance anomalies and system limitations; and
   h) Operational limitations associated with ADS-B surveillance.

E4. Training Program Content

1) The training syllabus shall include, as a minimum, the following topics related to ground-based and space-based ADS-B operations, and the ATS provider may include other relevant training topics, as appropriate.

2) The topics shall include:

a) Surveillance Fundamentals

- Principles of ADS-B surveillance;
- Differences between radar and ADS-B surveillance;
- ADS-B Surveillance performance parameters (accuracy, integrity, continuity, availability, timeliness);
- GNSS dependency and associated risks;
- End-to-end surveillance chain (aircraft → satellite/ground → network → ATM system).

b) Operational Procedures

- ADS-B Identification procedures;
- Application of ADS-B ATS surveillance services;
- ADS-B ATS Surveillance-based separation procedures;
- Mixed-equipage operational management and classification;
- Use of system indications and alerts for surveillance validation;
- Conditions for application, suspension, and reversion of ADS-B separation.

c) Degraded Mode and Contingency

- ADS-B integrity and system alerts;
- Loss of ADS-B capability (aircraft or system);
- GNSS degradation, interference, and anomaly scenarios;
- Data latency, validity, and continuity degradation;
- Reversion to alternative ATS surveillance (e.g., SSR) or procedural separation;
- Application of degraded-mode procedures and operational limitations.

d) Operational Limitations

- ADS-B Surveillance data validity limits;
- Operational coverage limitations;
- ADS-B Separation minima restrictions;
- System limitations (latency, update interval, processing delays);
- Situations where ADS-B separation shall not be applied.

e) Human Factors

- Automation bias and over-reliance;

- Capability misclassification risks;
- Controller workload management and situational awareness management;
- Decision-making under degraded or uncertain surveillance conditions;
- Trust vs verification (use of system indications vs assumptions).

3) Simulation and Practical Training
   a) Training shall include simulation-based exercises, including scenarios such as:
      - Mixed-equipage traffic scenarios;
      - ADS-B performance degradation;
      - GNSS interference and anomaly events;
      - Surveillance reversion procedures;
      - Loss of ADS-B surveillance capability (aircraft/system);
      - Transition between surveillance applications (SA → service → separation);
      - Other operational scenarios, as appropriate.
   b) Simulation exercises shall demonstrate the controller's ability to:
      - Apply the appropriate separation standards in accordance with procedures;
      - Recognize degraded or unreliable surveillance conditions;
      - Verify surveillance performance using system indications and alerts;
      - Identify when ADS-B separation shall not be applied;
      - Transition safely and promptly to alternative separation methods;
      - Maintain situational awareness and safe traffic management under degraded conditions.

E5. Competency Assessment

1) Operational personnel shall undergo competency assessment prior to operational authorization.
2) Competency validation shall include:
   a) theoretical knowledge assessment
   b) simulator or operational scenario evaluation
   c) Supervisor or designated assessor endorsement.
3) Operational authorization shall only be granted following successful competency validation.

E6. Assessment Criteria

E6.1 Operational personnel shall demonstrate the ability to:

1) Surveillance Application:
   a) Correctly apply ATS surveillance services and separation in accordance with ICAO Doc 4444
   b) Maintain continuous aircraft identification;
2) Performance Awareness

a) Interpret surveillance data quality (integrity, timeliness, validity);
b) Recognize when data is unsuitable for separation;

3) Decision-Making
   a) Apply correct separation minima under normal conditions;
   b) Select and apply appropriate alternate separation without delay;
4) Degraded Mode Handling
   a) Recognize surveillance degradation (e.g. latency, integrity alerts, GNSS interference);
   b) Execute reversion procedures safely and promptly;
5) Mixed-Equipage Management
   a) Correctly classify aircraft capability;
   b) Apply the applicable ATS Surveillance separation minima based on the aircraft with the lower capability.
6) Situational Awareness
   a) Maintain accurate traffic awareness in mixed and degraded environments;
   b) Avoid over-reliance on automation;
7) Communication and Coordination
   a) Use correct ICAO phraseology;
   b) Coordinate effectively with adjacent units during degraded or contingency operations.

E6.2 Performance Standard

1) Competency shall be demonstrated by:
   a) Safe and correct application of procedures;
   b) Timely recognition and response to abnormal conditions;
   c) Absence of critical errors affecting separation;
   d) Consistent performance across assessed scenario

E7. Recurrent Training

E7.1 Recurrent training shall be conducted periodically and shall include:

a) review of surveillance procedures
b) lessons learned from operational events
c) updated surveillance system capabilities
d) GNSS anomaly awareness and mitigation.

E7.2 Recurrent training frequency shall be defined within the ATS provider's training management system.

E8. Training Records

1) The ATS provider shall maintain training and competency records demonstrating that operational personnel are qualified to apply ADS-B surveillance procedures.

2) Training records shall be available for regulatory oversight and audit by the Authority

Appendix F - MIXED-EQUIPAGE SCENARIOS

1) All proposed ATC actions are indicative and not exhaustive; the ATS provider may apply other approved measures, including locally agreed procedures or contingency procedures, as appropriate, in accordance with applicable regulations.
2) Controllers shall proactively adjust separation application and workload management measures where mixed-equipage risk increases.

F0. General

ATS Application	Use in Mixed-Equipage	Condition
Situational Awareness	Permitted	- Subject to validated coverage and surveillance performance; ADS-B data may be used to support controller awareness
ATS Surveillance Service	Permitted	- Subject to validated surveillance performance and approved operational procedures
ADS-B Surveillance-Based Separation	Restricted	- Only between ADS-B Eligible aircraft where surveillance data is reliable and suitable for the intended application

- Where the above conditions are not met, ADS-B surveillance-based separation shall not be applied and alternative ATS surveillance (SSR) or procedural separation shall be used, as appropriate.

F1. Scenario 1

Scenario	Aspect	ATC Action
1.1	Mixed-Equipage Operations	The applicable ATS separation shall be based on the most limiting surveillance capability or performance.
1.2	Uncertainty Handling	Where there is any uncertainty regarding aircraft capability or surveillance performance, controllers shall not apply ADS-B surveillance-based separation and shall immediately apply alternative ATS surveillance (SSR) or procedural separation.
1.3	ADS-B Separation Condition	ADS-B surveillance-based separation shall be applied only when both aircraft are ADS-B Eligible and surveillance data is reliable and suitable for the intended application.

F2. Scenario 2 – Crossing Traffic

Scenario	Condition	ATC Action
2	Mixed-equipage crossing traffic (Aircraft A: ADS-B Eligible; Aircraft B: Not eligible for ADS-B surveillance-based separation)	**1**. Do not apply ADS-B surveillance-based separation; **2.** Apply alternative ATS surveillance (SSR) or procedural separation, as appropriate; **3.** Maintain continuous monitoring; and **4**. Be prepared to apply additional approved separation or contingency measures, as required.

F3. Scenario 3 – Climb/Descent Conflict

Scenario	Condition	ATC Action
3	ADS-B performance degradation during climb/descent	1. Consider ADS-B data unreliable for the purpose of separation; 2. Suspend ADS-B surveillance-based separation immediately; 3. Apply alternative ATS surveillance (SSR) or procedural separation without delay, in accordance with ICAO Doc 4444 PANS ATM; and 4. Maintain continuous monitoring and apply additional approved measures, as required.

F4. Scenario 4 – Vectoring in Terminal Airspace (TMA)

Scenario	Condition	ATC Action
4	Mixed-equipage during vectoring in TMA	1. Apply separation based on the most limiting surveillance capability or performance; 2. Do not apply ADS-B surveillance-based separation unless both aircraft are ADS-B Eligible and data is reliable and suitable; 3. Do not rely on surveillance capability beyond approved limits; and 4. Actively manage sector workload and traffic complexity, including the application of additional approved measures, as required.

F5. Scenario 5 – Loss of ADS-B Capability (Single Aircraft)

Scenario	Condition	ATC Action
5	Loss of ADS-B capability (one aircraft)	1. Consider the aircraft not eligible for ADS-B surveillance-based separation; 2. Suspend ADS-B surveillance-based separation without delay; 3. Apply alternative ATS surveillance (SSR) or procedural separation in accordance with ICAO Doc 4444; and 4. Initiate reversion procedures and maintain continuous monitoring.

F6. Scenario 6 – GNSS interference or systemic degradation

Scenario	Condition	ATC Action
6	GNSS interference or systemic degradation (suspected/confirmed)	1. Increase monitoring and assess the reliability and suitability of surveillance data; 2. Consider the surveillance environment degraded where data is not reliable; 3. Suspend ADS-B surveillance-based separation without delay; 4. Apply alternative ATS surveillance (SSR) or procedural separation, as appropriate, in accordance with ICAO Doc 4444; and 5. apply additional approved operational measures, as appropriate, and record the event in accordance with local procedures.

F7. Scenario 7 – Monitoring Mixed-Equipage Risk

Scenario	Aspect	ATC Action
7	**Operational Awareness**	Maintain awareness of mixed-equipage conditions, including capability mismatches, recent reversion events, and traffic complexity/workload indicators.
	Application of Separation	Apply separation based on the most limiting surveillance capability or performance.
	Use of ADS-B Separation	Apply ADS-B surveillance-based separation only when both aircraft are ADS-B Eligible and data is considered reliable and suitable.
	Degraded or Uncertain Performance	Where surveillance performance is degraded or uncertain, do not apply ADS-B surveillance-based separation and apply alternative ATS surveillance (SSR) or procedural separation.
	Reversion / Control Measures	Suspend ADS-B surveillance-based separation without delay when required and apply approved fallback or contingency measures, as appropriate.
	System-wide Degradation (e.g. GNSS interference)	ADS-B surveillance-based separation shall be suspended and alternative separation shall be applied for all affected traffic.

APPENDIX G – ADS-B Sole-Surveillance Operational Safeguards

G1. Purpose

1) This Appendix provides guidance on additional safeguards applicable where ADS-B is used as the **sole source of surveillance** for ATS surveillance services.
2) It complements, and shall be applied in conjunction with:
   a) Appendix B (Safety Assessment);
   b) Appendix C (Performance Monitoring); and
   c) Appendix F (Mixed-Equipage Operations).
3) This Appendix does not repeat requirements contained in the above and is limited to specific considerations unique to sole-surveillance operations.

G2. Applicability

1) This guidance applies where no independent surveillance source is available to support ATS surveillance services.
2) The use of ADS-B as a sole surveillance source shall only be approved where system performance and operational conditions support its safe use and shall be subject to the approval process defined in Chapter 8 of this Guidance Material.
3) Approval shall be subject to the process defined in Chapter 8 of this Guidance Material.

G3. Sole-Surveillance Safeguards

1) The ATS Provider should ensure the following safeguards are addressed:

G3.1 Continuous Performance Awareness

1) The system shall provide timely detection of degradation or loss of surveillance performance.
2) Controllers shall have operational awareness of system status sufficient to support real-time decision-making.

G3.2 GNSS-Related Risk Exposure

1) ADS-B dependency on GNSS shall be explicitly addressed in the safety assessment.
2) Procedures shall be established for identifying and responding to GNSS degradation, interference, spoofing, or loss.

G3.3 Immediate Reversion Capability

1) Predefined actions shall be established for:
   a) Loss of ADS-B data;
   b) Degraded surveillance performance;
   c) Uncertainty in data integrity; and
   d) GNSS degradation or interference.
2) Reversion actions shall be applied without delay where required

G3.4 Operational Constraints

1) ADS-B-only operations shall account for limitations including:
   a) Coverage variability;
   b) Data latency or validity exceedance;
   c) System performance fluctuations;
   d) GNSS vulnerability; and
   e) Absence of independent surveillance verification.

G3.5 Human Performance Considerations

1) The ATS Provider shall address the impact of sole-surveillance operations on:
   a) Controller workload;
   b) Situational awareness;
   c) Decision-making under degraded conditions; and
   d) Automation bias or over-reliance on ADS-B data

G4. Operational Use

1) ADS-B sole-surveillance operations shall be conducted only where:
   a) The operational environment is assessed as suitable;
   b) Surveillance performance is validated and continuously monitored;
   c) Reversion arrangements are available and validated; and
   d) The Authority has granted explicit approval.
2) Where surveillance performance, data integrity, GNSS reliability, or system availability is degraded or uncertain, ADS-B surveillance-based separation shall not be applied or shall be suspended without delay.
3) Alternative ATS surveillance, where available, or procedural separation shall be applied in accordance with approved operational procedures.

G5. Monitoring and Feedback

1) Sole-surveillance operations shall be subject to continuous performance monitoring in accordance with Appendix C.
2) The ATS Provider shall:
   a) Monitor latency, validity, integrity, continuity, availability, and GNSS-related effects;
   b) Identify emerging operational or system issues;
   c) Review performance trends and safety occurrences; and
   d) Take corrective, operational, or safety actions in response to observed performance or safety concerns.
3) Significant degradation, adverse trends, or safety-relevant events shall be reported to the Authority in accordance with applicable reporting requirements.

G6. Approval

1) Sole-surveillance approval shall be:
   a) Explicit;
   b) Conditional;
   c) Continuously monitored;
   d) Withdrawable by the Authority.

APPENDIX H - Sample AIP Text for ADS-B Surveillance Airspace (Muscat FIR)

H1. General

1) Automatic Dependent Surveillance — Broadcast (ADS-B) is used to provide ATS surveillance services within designated portions of the Muscat FIR.
2) The provision of ATS surveillance services and the application of ATS surveillance separation using ADS-B shall be in accordance with:
    a) ICAO Doc 4444 (PANS-ATM); and
    b) Applicable national regulations.

H2. Applicability

1) ADS-B surveillance services are provided within airspace designated by the Authority and published in this AIP (ENR 1.6.3).
2) The lateral and vertical limits of ADS-B surveillance airspace shall be specified in the relevant ENR charts and descriptions.

H3. Aircraft Requirements

1) Aircraft operating within designated ADS-B surveillance airspace shall:
    a) Be equipped with ADS-B OUT compliant with ICAO Annex 10, Volume IV;
    b) Transmit ADS-B data continuously during flight, unless otherwise instructed by ATC;
    c) Indicate the appropriate surveillance capability in the ICAO flight plan; and
    d) Meet the applicable ADS-B performance requirements for the intended ATS surveillance application.
2) Aircraft not meeting these requirements may be subject to operational restrictions or denied access to the designated airspace.

H4. ATS Surveillance Services and Separation

1) ATS surveillance services may be provided using ADS-B.
2) ATS surveillance-based separation shall be applied only when:
    a) Aircraft are identified and continuously monitored; and
    b) Surveillance performance meets the requirements for the applicable separation minima.
3) Where these conditions are not met:
    a) ATS surveillance separation shall not be applied, and alternative separation minima shall be used in accordance with ICAO Doc 4444.

H5. Operational Limitations and Contingencies

1) In the event of:
    a) GNSS degradation or interference;
    b) ADS-B performance degradation; or
    c) Ground / space or system failure,

2) ATC shall take appropriate action, including:
   a) Suspension of ATS surveillance separation;
   b) Application of alternative separation minima;
   c) Reversion to alternate surveillance or procedural separation; and
   d) Application of traffic flow or level restrictions, as necessary.

H6. Promulgation and Changes

1) Airspace designation, operational limitations, and applicable conditions shall be promulgated by:
   a) AIP amendment,
   b) AIP supplement, or
   c) NOTAM, as appropriate.

Appendix I – Glossary (ADS-B Implementation Guidance – Muscat FIR)

1. Definitions

Accuracy. A measure of the difference between the reported aircraft position (e.g. ADS-B position) and the true aircraft position.

Availability. The ability of a system to perform its required function at the initiation of the intended operation. It is quantified as the proportion of time the system is available to the time the system is planned to be available. Periods of planned maintenance are discounted from the availability figures. Overall availability is composed of:

the availability of functions affecting all aircraft (e.g. external positioning function, ground /space data acquisition function); and

the availability of systems affecting only one aircraft (e.g. transponder function), expressed per flight.

- For radar and MLAT. The availability of ground / space components and data transmission equipment will affect the service for all aircraft. The availability of an individual aircraft SSR transponder function will affect the service for that aircraft.

- For ADS-B. In addition to the availability of ground / space receiving and data transmission systems, the availability, in the region, of navigation sources (including satellite constellations) of sufficient quality will affect many aircraft.

Continuity. The probability of a system performing its required function without unscheduled interruption, assuming that the system is available when the procedure is initiated. Overall, continuity is composed of the continuity of:

functions affecting all aircraft (e.g. satellite function, ground / space data acquisition function), expressed in number of disruptions per year; and

systems affecting only one aircraft (e.g. transponding functions), expressed per flight hour.

For radar and MLAT. The continuity of ground/ space radar and data transmission equipment will affect the service for all aircraft. The continuity of an individual aircraft SSR transponder function will affect the service for that aircraft.

For ADS-B. In addition to the continuity of ground / space receiving and data transmission systems, the continuity, in the region, of navigation sources (including satellite constellations) of sufficient quality will affect many aircraft.

ADS-B (Automatic Dependent Surveillance – Broadcast). A surveillance technique in which an aircraft automatically broadcasts its GNSS-derived position and other information for use by ATS and other aircraft.

ADS-B OUT. Functionality by which an aircraft periodically broadcasts position, velocity, and identification information derived from onboard systems.

ADS-B IN. Functionality enabling an aircraft to receive and process ADS-B information transmitted by other aircraft or ground / space stations.

ATS (Air Traffic Services). A generic term meaning air traffic control service, flight information service, alerting service, air traffic advisory service, or aerodrome flight information service.

ATS Surveillance Service. A service provided directly by means of an ATS surveillance system.

ATS Surveillance System. A generic term meaning variously ADS-B, PSR, SSR, MLAT, or any comparable ground-based system enabling aircraft identification and position determination.

CBTA (Competency-Based Training and Assessment); A training and assessment methodology focusing on the demonstration of operational competencies rather than completion of prescribed hours.

CONOPS (Concept of Operations). A documented description of how a system will be used operationally, including airspace, procedures, interfaces, and operational objectives.

Common-Mode Failure. A failure affecting multiple elements of a system simultaneously due to a shared dependency (e.g., GNSS outage affecting multiple ADS-B aircraft).

CNS/ATM. Communications, Navigation, and Surveillance / Air Traffic Management system framework.

Cooperative independent surveillance. Surveillance which uses the SSR transponder replies from an aircraft, but position is determined purely by the ground / space system**.**

Data Integrity. The degree of confidence that the surveillance information is correct and has not been corrupted.

Degraded Mode. Operational state in which system performance falls below nominal but remains usable in accordance with defined limitations.

GNSS (Global Navigation Satellite System). Satellite-based navigation system used as the position source for ADS-B.

HMI (Human–Machine Interface). The interface through which controllers interact with automation and surveillance systems.

Mixed-Equipage Environment. Operational environment in which aircraft with differing surveillance capabilities operate within the same airspace.

NIC (Navigation Integrity Category).A parameter indicating the containment radius of the reported position.

NAC (Navigation Accuracy Category). A parameter indicating the accuracy of the reported position.

Operational Readiness. A state in which system performance, procedures, training, safety assessment, and contingency measures have been validated and approved for operational use.

Procedural Separation. Separation provided using time, distance, or level without reliance on ATS surveillance systems.

RSP (Required Surveillance Performance). A statement of the surveillance performance required for a particular operational application.

Separation Minima. The minimum spacing applied between aircraft to ensure safe operations.

Sole-Surveillance Operation An operational configuration in which ADS-B is the only surveillance source available for ATS surveillance services within designated airspace.

Surveillance Coverage. The geographic and vertical extent within which surveillance data meets defined performance requirements.

Surveillance Performance. The combined parameters of accuracy, integrity, continuity, availability, and latency necessary to support a defined ATS application.

System-of-Systems. An integrated operational architecture in which multiple subsystems (aircraft avionics, GNSS, ground / space infrastructure, automation, procedures, human factors) function collectively.

Reversion. Operational transition from surveillance-based separation to alternative separation methods following system degradation.

2. Abbreviations /acronyms

ADS-B Automatic dependent surveillance — broadcast

ADSBP ADSB processor

ADS-C Automatic dependent surveillance — contract

CLAM Cleared level adherence monitoring

CPDLC Controller-pilot data link communications

ES Extended squitter

FDP Flight data processor

FHA Functional hazard analysis

FMS Flight management system

GBAS Ground-based augmentation system

GNSS Global navigation satellite system

GPS Global positioning system

IFR Instrument flight rules

MLAT Multilateration

MSAW Minimum safe altitude warning

MSSR Monopulse secondary surveillance radar

PSR Primary surveillance radar

PSSA Preliminary system safety assessment

RAIM Receiver autonomous integrity monitoring

RAM Route adherence monitoring

RDP Radar data processor

REC Receiver

RU Receiving unit

RVSM Reduced vertical separation minimum

SASP Separation and Airspace Safety Panel

SDP Surveillance data processor

SSA System safety assessment

SSR Secondary surveillance radar

STCA Short-term conflict alert

TDOA Time difference of arrival

UAT Universal access transceiver

WAM Wide area multilateration

End