INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA/PACIFIC REGIONAL GUIDANCE MATERIAL FOR GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) RADIO FREQUENCY INTERFERENCE (RFI) AND ASSOCIATED DATA LINK DISRUPTION COORDINATION AND REPORTING PROCEDURES

Version 1.0, August 2026

This guidance was developed by the Procedures for GNSS and Data Link Disruption Ad Hoc Group

Approved by ATM/SG/14 and published by the
ICAO Asia and Pacific Office, Bangkok

CONTENTS

1. SCOPE OF THE DOCUMENT

Guidance for GNSS RFI and its Associated Data Link Disruption Coordination and Reporting Procedures

1.1 This document, *Asia/Pacific Regional Guidance Material for GNSS RFI and Associated Data Link Disruption Coordination and Reporting Procedures*, provides non-binding guidance material for Asia and Pacific (APAC) States/Administrations on Radio Frequency Interference (RFI) affecting Global Navigation Satellite System (GNSS) and its associated Air Traffic Services (ATS) data link operations.

1.2 This document is intended to support a harmonized regional approach through the establishment of common reporting processes, coordination mechanisms, and operational considerations intended to mitigate the safety and operational impacts of GNSS RFI and its associated data link disruption.

1.3 This document does not supersede ICAO Standards and Recommended Practices (SARPs) and should be applied in conjunction with relevant provisions contained in ICAO Annexes, Procedures for Air Navigation Services (PANS) and associated guidance material.

Document Review

1.4 This document will be subject to ad hoc review as needed, in response to relevant global or regional developments.

1.5 Reviews should include examination of relevant new or amended ICAO Annexes, PANS and guidance material to ensure the minimization of duplication, and alignment with global direction.

2. INTRODUCTION

Background

2.1 The Twelfth Meeting of the Air Traffic Management Sub-Group (ATM/SG/12, Bangkok, Thailand, 23 – 27 September 2024), which reports to the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG), adopted *Decision ATM/SG/12-8: Establish Procedures for GNSS and Data Link Disruption Ad Hoc Group*.

2.2 The Ad Hoc Group was tasked to:

a) collect data on GNSS and data link disruption in APAC region; and

b) develop the procedures for GNSS and data link disruption that include (but not limited to) the need for:

   i. reporting process by airspace users to ATS units; and

   ii. sharing of information between stakeholders.

2.3 The work of the Ad Hoc Group resulted in the development of operational reporting procedures and coordination mechanisms intended to enhance regional situational awareness and resilience.

Background on GNSS in Aviation

2.4 The United States' Global Positioning System (GPS), the first operational GNSS, became fully operational in 1995. Since then, additional satellite constellations have become operational, including:

a) Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS);

b) Galileo; and

c) BeiDou Navigation Satellite System.

2.5 Collectively, these systems form the foundation of modern GNSS capability.

2.6 GNSS has enabled significant safety and efficiency improvements in civil aviation. Applications include:

a) Performance-based Navigation (PBN) operations across all phases of flight;

b) area navigation;

c) Automatic Dependent Surveillance – Broadcast (ADS-B);

d) Automatic Dependent Surveillance – Contract (ADS-C);

e) Multilateration (MLAT) when integrated with GNSS-derived timing;

f) moving map displays and synthetic vision systems;

g) Search and Rescue (SAR) emergency locator transmitters (ELTs); and

h) precision timing application supporting Communications, Navigation and Surveillance (CNS) systems.

2.7 The increasing integration of GNSS into airborne and ground-based systems has resulted in substantial operational dependence on satellite-based Positioning, Navigation and Timing (PNT).

2.8 The need for resilient terrestrial backup capabilities was recognized under the Global Air Navigation Plan's (GANP) Aviation System Block Upgrade (ASBU) framework through the Minimum Operational Network (MON) concept. While MON provides a terrestrial navigation safety net, it represents only one component of a comprehensive resilience strategy required to address widespread GNSS disruption.

GNSS RFI

2.9 GNSS signals are inherently low power at the receiver antenna and therefore vulnerable to both intentional and unintentional sources of RFI. In addition, certain ionospheric disturbances from space weather events may degrade signal quality.

2.10 RFI affecting GNSS may result in:

a) loss of position accuracy:

b) loss of navigation capability;

c) loss of timing synchronisation; or

d) hazardously misleading information.

2.11 In recent years, the aviation community has observed a rising number of GNSS RFI occurrences in the form of jamming and spoofing, reported on a recurring basis in several regions of the world especially in proximity to certain conflict areas, with associated operational impacts reported by operators and service providers.

2.12 The United Nations Terminology Database (UNTERM; https://unterm.un.org) defines:

a) **jamming**, as intentional RFI that prevents GNSS receiver from locking onto satellite signals, effectively rendering the GNSS system unusable or degraded for users in the jammed area; and

b) **spoofing**, as the broadcast of GNSS-like signals that cause avionics to calculate erroneous positions and provide false guidance.

2.13 GNSS RFI affecting civil aviation arises under a range of circumstances:

a) **unintentional interference**, often associated with equipment malfunction or unintended emissions from aviation or non-aviation systems. Such occurrences have historically been limited and typically resolved once identified;

b) **intentional interference not directed at aviation**, where any impact on aviation is generally incidental rather than deliberate and civil aircraft becomes a collateral consequence; and

c) **intentional interference directed at aviation**, where the severity can range from relatively benign cases such as the misuse of low-power devices in or near aircraft or aerodromes to more serious scenarios involving targeted jamming of approach or terminal airspace.

2.14 Such interference is typically localized and intermittent. However, when combined with multipath effects or ionospheric disturbances, it may degrade GNSS receiver performance.

2.15 Multipath occurs when a radio signal reaches the receiver via both direct and reflected paths, creating time-delayed and phase-shifted signal components. Although GNSS receivers are designed to mitigate predictable multipath and ionospheric effects, unpredictable RFI may compound these errors and reduce positioning integrity.

2.16 There are no specific flight crew alerts for GNSS RFI. When GNSS RFI occurs, flight crew may see multiple system warnings but cannot easily tell which ones are caused by the interference. For example, some aircraft Flight Management Systems (FMS) rely on GNSS for time measurement and even Inertial Navigation Systems (INS) may use GNSS inputs. Thus, GNSS RFI can affect multiple systems simultaneously, making it difficult for flight crew to identify the source of the problem.

Operational Considerations

2.17 As GNSS RFI may occur during any phase of flight, contingency procedures should consider:

a) phase-of-flight criticality;

b) available response time;

c) airspace complexity; and

d) availability of conventional navigation infrastructure.

2.18 Mitigation measures should prioritize:

a) prevention of interference sources where practicable;

b) system resilience through redundancy and alternative navigation capability; and

c) reactive operational measures to ensure continued safety of flight.

Policy and Strategic Considerations

2.19 The ICAO Fourteenth Air Navigation Conference (AN-Conf/14, Montreal, Canada, 26 August – 06 September 2024) *Recommendation 2.2/2*, urged States/Administrations to address GNSS RFI and contingency planning by maintaining sufficient conventional navigation infrastructure to ensure operational safety and airspace capacity during periods of satellite navigation disruption.

2.20 The ICAO APAC Radio Navigation Symposium (New Delhi, India, 7 – 9 April 2025) identified several recommendations relevant to RFI management. Key focus areas include:

a) improve coordination with the military;

b) monitor and geolocate the source of the GNSS RFI [consider using ADS-B Out (ground-based or space-based) or Wide Area Multilateration (WAM)];

c) prohibit the sale of GNSS jamming transmitters;

d) use standard radiotelephony phraseologies for specific RFI scenarios;

e) integrate GNSS RFI factors into contingency fuel and alternate planning;

f) maintain a Resilient Navigation Operational Network (RON) in the event of RFI;

g) consider space-based surveillance and evolution into Satellite Time Difference of Arrival (TDA) to mitigate GNSS RFI;

h) ensure flight crew maintain proficiency in conventional navigation methods;

i) ensure a full Inertial Reference System (IRS) alignment before departure;

j) provide comprehensive training and awareness programmes for controller and Air Traffic Safety Electronic Personnel (ATSEP);

k) consider GNSS RFI information exchange using NOTAM, Aeronautical Information Publication (AIP), and/or Automatic Terminal Information Service (ATIS), Electronic Flight Bags (EFB) and the International Air Transport Association's (IATA) Turbulence Aware platform;

l) enhance GNSS robustness with rapidly deployable Multi-Mode Receivers (MMR) and strategic system upgrades; and

m) achieve robust PNT with a comprehensive assessment of:

   i. cyber risk for all CNS and ATM systems; and

   ii. GNSS vulnerabilities, their impact on air, ground and space systems, and the maintenance of operational independence.

3. REFERENCES

3.1 ICAO Annexes and Documents:

a) ICAO Annex 6 – *Operation of Aircraft*;

b) ICAO Annex 10 – *Aeronautical Telecommunication*;

c) ICAO Annex 19 – *Safety Management*;

d) ICAO Doc 4444 – *Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM)*;

e) ICAO Doc 9849 – *Global Navigation Satellite System (GNSS) Manual*;

f) ICAO Doc 10037 – *Global Operational Data Link Manual*;

g) ICAO Doc 10066 – *Procedures for Air Navigation Services – Aeronautical Information Management (PANS-AIM)*; and

h) ICAO Doc 10088 – *Manual on Civil-Military Cooperation in Air Traffic Management*.

3.2 ICAO Assembly Resolutions:

a) *Assembly Resolution A41-8, Appendix C: Ensuring the resilience of ICAO CNS/ATM systems and* services; and

b) *Assembly Resolution A42-4: Addressing risks to civil aviation arising from conflict zones*.

3.3 APANPIRG Conclusions/Decisions:

a) *APANPIRG Conclusion 27/36: Protection of GNSS Signal Against Jamming*.

3.4 Others:

a) ICAO State Letter AN 7/5-20/89 – *Strengthening of communications, navigation, and surveillance (CNS) systems resilience and mitigation of interference to global navigation satellite system (GNSS)*; and

b) ICAO Electronic Bulletin 2011/56 – *Interference to Global Navigation Satellite System (GNSS) Signals*.

3.5 Abbreviations:

ACI	Airports Council International
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance – Contract
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
ANSP	Air Navigation Services Provider
APAC	Asia/Pacific
APNT	Alternative Position, Navigation and Timing
ASBU	Aviation Safety Block Upgrade
ATIS	Automatic Terminal Information Service

ATS	Air Traffic Services
ATSEP	Air Traffic Safety Electronic Personnel
CAA	Civil Aviation Authority
CFIT	Controlled Flight into Terrain
CNS	Communications, Navigation and Surveillance
CPDLC	Controller-Pilot Data Link Communications
DFMC	Dual-Frequency/Multi-Constellation
DME	Distance Measuring Equipment
ECAM	Electronic Centralized Aircraft Monitor
EFB	Electronic Flight Bag
EICAS	Engine Indicating and Crew Alerting System
ELT	Emergency Locator Transmitter
FCOM	Flight Crew Operating Manual
FIR	Flight Information Region
FMS	Flight Management System
GANP	Global Air Navigation Plan
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HF	High Frequency
IATA	International Air Transport Association
IFALPA	International Federation of Airline Pilots' Associations
IFATCA	International Federation of Air Traffic Control Associations
ILS	Instrument Landing System
INS	Inertial Navigation System
IRS	Inertial Reference System
ITU	International Telecommunication Union
MEL	Minimum Equipment List
MFMC	Multi-Frequency Multi-Constellation
MLAT	Multilateration
MMR	Multi-Mode Receivers
MON	Minimum Operational Network
MOPS	Minimum Operational Performance Standards
OEM	Original Equipment Manufacturer
PANS	Procedures for Air Navigation Services
PBN	Performance-based Navigation

PNT	Positioning, Navigation and Timing
POC	Point of Contact
RAIM	Receiver Autonomous Integrity Monitoring
RFI	Radio Frequency Interference
RON	Resilient Navigation Operational Network
SAR	Search and Rescue
SARPs	Standards and Recommended Practices
SATCOM	Satellite Communication
SBAS	Satellite-Based Augmentation System
SIRRS	Satellite Interference Reporting and Resolution System
SMS	Safety Management System
TAWS	Terrain Awareness Warning System
TCAS	Traffic Alert and Collision Avoidance System
TDA	Time Difference of Arrival
UAS	Unmanned Aerial System
UTC	Coordinated Universal Time
VOR	VHF Omnidirectional Radio Range
WAM	Wide Area Multilateration

4. OVERVIEW

4.1 This document establishes a harmonized framework for the detection, reporting and management of GNSS RFI and its associated data link disruptions in the APAC region. It integrates operational, technical and regulatory perspectives to support timely mitigation of safety and operational impacts while maintaining consistency across States/Administrations and Air Navigation Service Providers (ANSPs).

4.2 This document promotes a structured and consistent approach to:

a) timely reporting of suspected GNSS RFI and its associated data link disruption events;

b) coordinated operational response to mitigate safety impacts;

c) systematic information sharing among civil aviation stakeholders; and

d) enhancement of regional situational awareness and resilience.

4.3 The framework operates across three layers:

a) operational layer, covering real-time flight crew reporting, controller response, and tactical mitigation;

b) national layer, encompassing technical validation, post-flight reporting, and coordination among ANSPs, Civil Aviation Authorities (CAAs), and aircraft operators; and

c) regional layer, which addresses cross-Flight Information Region (FIR) coordination, harmonized reporting, and engagement with the ICAO APAC Regional Office for interference events with impact to multiple States/Administrations.

4.4 Both tactical and pre-tactical reporting, along with standardized phraseology and structured workflows, ensure consistent situational awareness and risk mitigation.

4.5 By providing an integrated approach to detection, operational response, investigation, regional coordination, and trend monitoring, this framework strengthens resilience to GNSS and data link disruptions. It promotes transparency, enables rapid mitigation measures, and supports long-term planning to preserve the safety, continuity, and efficiency of civil aviation operations across the APAC region.

5. ROLES AND RESPONSIBILITIES

Overview

5.1 Effective management of GNSS RFI requires coordinated action at international, regional, national and operational levels. The following roles and responsibilities support a harmonized APAC region framework.

International Civil Aviation Organization (ICAO)

5.2 ICAO plays a central role in the global coordination of GNSS RFI resilience and mitigation.

5.3 ICAO should:

a) develop and promulgate international SARPs, PANS and guidance material addressing GNSS RFI, including updates to relevant documents such as ICAO Annex 10 and ICAO Doc 9849, to support States/Administrations in mitigating its safety and operational impacts;

b) coordinate expert groups dedicated to the development of standards and long-term resilience measures, including work on Alternative Position, Navigation and Timing (APNT), spectrum protection, and system robustness;

c) promote global awareness of GNSS RFI risks and highlight that such interference is expected to persist, thereby encouraging States/Administrations to strengthen monitoring and resilience measures;

d) facilitate coordination where GNSS RFI events have cross-FIR implications and cannot be resolved by individual States/Administrations, including engagement under International Telecommunication Union (ITU) radio regulations procedures; and

e) review the standardized radiotelephony phraseologies in ICAO Doc 4444 to ensure relevancy for GNSS RFI scenarios, and propose new phraseologies for inclusion where gaps, which may require additional phraseologies to be added, are identified.

States/Administrations and CAAs

5.4 States/Administrations retain overall responsibility for ensuring the safety of civil aviation within their airspace.

5.5 States/Administrations, through their CAAs, should:

a) establish regulatory frameworks to address GNSS RFI mitigation and resilience;

b) monitor, assess, and report GNSS RFI events within their airspace, and collaborate with ANSPs and international counterparts to mitigate operational impacts;

c) issue operational advisories and contingency instructions to airspace users when GNSS RFI affects navigation performance or system integrity;

d) report to and coordinate with national spectrum and telecommunications regulators to investigate interference sources and provide relevant information to ICAO for regional and global situational awareness;

e) coordinate with military authorities regarding activities potentially hazardous to civil aviation, including the use of GNSS jammers during exercise or operations; and

f) include appropriate reporting provisions in the AIP, including procedures related to GNSS loss of capability.

5.6 Based on the State's/Administration's arrangement, these responsibilities may also be handled by the ANSP.

ANSPs

5.7 ANSPs are responsible for maintaining safe and orderly air traffic services during GNSS RFI and its associated data link disruptions.

5.8 ANSPs should:

a) strengthen navigation aid resilience, particularly when implementing rationalization under the MON concept;

b) conduct risk assessments addressing potential impacts of GNSS RFI on navigation, surveillance and timing systems, including ADS-B and other GNSS-dependent services;

c) establish procedures to identify, assess and minimize GNSS RFI sources in coordination with regulators and law enforcement authorities;

d) coordinate with adjacent FIRs to ensure consistent handling of interference events across boundaries;

e) disseminate GNSS RFI events and information via appropriate notification channels as described in Chapter 10 of this document;

f) develop contingency procedures to mitigate the effects of GNSS RFI, including fallback surveillance and communication measures; and

g) implement GNSS RFI awareness training for operational and technical personnel.

ATS Units

5.9 ATS units should:

a) monitor flight crew reports and correlate them with other situational data to validate potential GNSS RFI and its associated data link disruptions;

b) provide immediate operational instructions to affected aircraft, including radar vectors, position verification, altitude confirmation, and fallback communications procedures;

c) coordinate with adjacent ATS units to ensure continuity of service and consistent handling of anomalies across FIR boundaries;

d) submit notifications or reports through existing national and ICAO-compliant mechanisms, ensuring no duplication of reporting pathways; and

e) support information flow to relevant ANSP CNS units for technical investigation and analysis.

CNS Units

5.10 CNS units should:

a) coordinate with ATS units and/or relevant monitoring units, where applicable to assess operational impacts, investigate potential root causes, and ensure accurate documentation of the event;

b) report significant disruptions to the national level ATM POC in a timely and standardized manner; and

c) if applicable, report GNSS RFI events to national spectrum and telecommunications regulators to investigate interference sources.

AIS/Aeronautical Information Management (AIM) Unit

5.11 AIS/AIM units should:

a) publish aeronautical information appropriately and in a timely manner upon receiving a request from originator, concerning GNSS RFI and associated data link failure;

b) ensure that publications are timely, accurate and operationally relevant; and

c) coordinate with ATS, CNS and regulatory authorities prior to publication, as required by national procedures.

Aircraft Operators

5.12 Aircraft operators are responsible for assessing operational risks associated with GNSS RFI and ensuring appropriate mitigation measures are implemented.

5.13 Aircraft operators should:

a) establish mechanisms to receive current GNSS RFI information, including regulatory advisories, ICAO guidance, industry briefings and NOTAMs;

b) conduct safety assessments addressing risks associated with degradation or loss of GNSS-dependent systems;

c) coordinate with Original Equipment Manufacturers (OEMs) to understand aircraft-specific impacts of GNSS RFI events;

d) develop and maintain contingency procedures addressing GNSS RFI and associated data link disruptions;

e) ensure flight planning considers availability of conventional navigation aids and suitable alternate procedures;

f) brief flight crews and operational control personnel on ongoing GNSS RFI events and associated operational considerations;

g) conduct GNSS RFI awareness training for flight operations, dispatch and maintenance personnel; and

h) analyze reported GNSS RFI events to support internal safety management and State/Administration-level reporting.

Flight Crew

5.14 Flight crew should:

a) timely recognise and verify potential GNSS degradation, navigation anomalies, or ADS-C/Controller-Pilot Data Link Communications (CPDLC) performance issues;

b) report anomalies to ATS units using established procedures, including voice communication where data link performance is degraded;

c) execute operational contingency procedures, such as reverting to conventional navigation or surveillance methods as required; and

d) document post-flight reports in accordance with operator procedures to support trend analysis and State/Administration-level safety assessments.

Aerodrome Operators

5.15 Aerodrome operators should:

a) submit requests to the AIS/AIM unit for the publication of aeronautical information related to aerodrome facilities affected by GNSS RFI;

b) maintain reliable communication and coordination with ATS units, CNS units, aircraft operators, and relevant authorities;

c) as applicable, implement or otherwise support aerodrome radio frequency management measures to mitigate the risk of local radio frequency interference, including the identification, control, or elimination of potential radio frequency emitters located within aerodrome boundaries;

d) in the event of persistent interference, facilitate or otherwise support (as applicable) radio frequency spectrum surveys, site inspections, or technical investigations in coordination with the CAA and/or the ANSP, in accordance with applicable national regulatory requirements;

e) participate in post-event reviews by providing relevant ground-based system logs, maintenance data, and local observations to support safety investigation, analysis, and root-cause identification; and

f) monitor trends in GNSS RFI-related occurrences, incorporating relevant findings into airport safety committee deliberations, Safety Management System (SMS) reporting processes, and corrective action tracking mechanisms to support continuous safety improvement in close coordination with the CAA.

6. DETECTION OF GNSS RFI EVENTS

Overview

6.1 Detection of GNSS RFI events relies on a combination of technical monitoring systems, operational observations, and aircraft reports. Timely detection is critical given the density of international operations and the extensive reliance on GNSS for navigation, surveillance, and data link enabled ATM services.

6.2 GNSS RFI events may be detected through the following sources:

a) ground-based GNSS monitoring networks and reference stations;

b) ATM system alerts indicating degradation of dependent services (e.g. ADS-B, ADS-C, CPDLC). Depending on the ATM system in use, controllers may be alerted by, but not limited to, the following:

i. degradations in RNP due to overdue position reports or low figure of merit values;

ii. discarded downlinks with time stamps indicating that they were sent after they were received;

iii. aircraft inability to remain connected to CPDLC; and

iv. ADS-B position gaps, inconsistencies or jumps.

c) flight crew reports of navigation or data link abnormalities. Reports may include, but are not limited to:

i. GNSS failure message;

ii. ADS-B failure/warning;

iii. Ground Proximity Warning System (GPWS) caution or failure message;

iv. loss of Satellite Communication (SATCOM);

v. loss of synthetic vision system;

vi. rapid actual navigation performance value increase;

vii. GNSS position and IRS or FMS “Position Disagree” caution message; and

viii. unexpected change in aircraft clock time.

d) ANSP operational observations, including loss of surveillance fidelity or unexpected system behaviour.

6.3 Early detection enables rapid coordination, mitigation, and accurate reporting to regional and global stakeholders.

Recognition of GNSS RFI

6.4 GNSS RFI should be recognized when abnormal GNSS performance is observed that is inconsistent with known system outages or expected propagation effects. GNSS RFI may be intentional or unintentional and may manifest as jamming or spoofing.

6.5 Common indicators of GNSS RFI include:

a) sudden or intermittent loss of GNSS position, velocity, or time information;

b) degradation of navigation accuracy, integrity, or availability without prior notice;

c) simultaneous GNSS performance issues reported by multiple aircraft or ground systems within a defined geographic area;

d) GNSS receiver alerts indicating signal interference, loss of lock, or integrity warnings; and

e) correlated degradation across multiple GNSS-dependent services (e.g. PBN operations, ADS-B).

Note: recognition should be based on pattern analysis rather than single-source observations.

Recognition of Data Link Disruption due to GNSS RFI

6.6 Data link disruptions attributable to GNSS RFI should be recognized when CPDLC, ADS-C, or related services are disrupted in a manner that correlates temporally and geographically with GNSS performance issues.

6.7 Common indicators include:

a) loss or degradation of ADS-C position reporting coincident with GNSS anomalies, such as:

i. position reports overdue

ii. degraded figure of merit values;

b) CPDLC message failures, delays, or abnormal session terminations linked to GNSS-derived position or time dependencies;

c) inconsistencies between primary and backup communication or surveillance systems; and

d) concurrent reports from aircraft indicating both navigation performance degradation and data link disruption.

6.8 It is essential to distinguish GNSS associated data link disruptions from network or service provider outages, aircraft avionics failures, or procedural and human factors issues.

Classification of GNSS RFI Events

6.9 Once detected and recognized, GNSS RFI and its associated data link anomalies should be classified to support appropriate coordination, reporting, and mitigation actions. Initial classification should be operationally focused and may be refined as additional information becomes available.

6.10 Recommended classification dimensions include:

a) type of GNSS RFI events:

i. GNSS interference (jamming);

ii. GNSS signal manipulation (suspected spoofing);

iii. GNSS signal degradation or loss (cause undetermined);

iv. GNSS associated data link disruption; and

v. combined GNSS and data link impact.

b) scope and impact:

i. single aircraft;

ii. multiple aircraft;

iii. sector-wide;

iv. airport-wide;

v. FIR-wide or cross-FIR; and

vi. regional or cross-regional.

c) severity (operational impact):

i. Minor: no impact to safety or service continuity;

ii. Moderate: degraded operations requiring procedural mitigation;

iii. Significant: loss of services requiring contingency procedures; and

iv. Severe: safety-critical impact or widespread disruption.

d) confidence level:

i. confirmed;

ii. suspected; or

iii. under investigation.

6.11 Initial classification should prioritize operational decision-making and information sharing rather than definitive technical attribution.

7. STANDARDIZED OPERATIONAL REPORTING MECHANISMS

Overview

7.1 Effective management of GNSS RFI and its associated data link disruptions requires timely operational reporting, structured controller response, and coordinated information dissemination. Procedures related to GNSS RFI should be published in the AIP as follows:

a) where procedures describe actions to be taken by flight crew during GNSS or data link disruption that directly affect the conduct of flight, the most appropriate location is section ENR 1.1; and

b) where additional detail is required regarding formal reporting mechanisms, post-event notification process, or coordination channel with ATS unit or relevant authorities, a reference may be included in section ENR 1.14.

Reporting Procedures by Flight Crew to Controller

7.2 Flight crew encountering GNSS RFI and its associated data link disruptions should, as soon as practicable, report the occurrence to the appropriate ATS unit using the applicable air-ground communication frequency. This reporting is vital if it is a previously unidentified area of RFI, to facilitate the rapid dissemination of safety-critical information to other aircraft operating within the affected area.

7.3 Flight crew should, as soon as practicable, report to the appropriate ATS unit upon the occurrence of any operational anomaly or system degradation consistent with the indicators described in Chapter 6 of this document. Reporting should be conducted in accordance with the provisions in ICAO Doc 4444 Chapter 12 and ICAO Annex 10 Volumes I and II.

GNSS RFI

7.4 Flight crews should report any suspected or confirmed GNSS degradation, denial, or interference, including but not limited to:

a) total or partial loss of GNSS signals reception impacting navigation accuracy;

b) anomalies impacting navigation precision or surveillance integrity (e.g. ADS-B positional integrity); or

c) disruption of time synchronisation services critical to flight operations.

GNSS RFI Associated Impacts

7.5 For GNSS RFI associated data link disruption, flight crew should notify controller of the occurrence in accordance with the ICAO Doc 10037.

7.6 For GNSS RFI associated navigation performance degradation, flight crew shall notify controller of any loss of RNP or inability to comply with the navigation specification in accordance with ICAO Doc 9613.

Safety-Significant Operational Impact

7.7 Flight crew should report any GNSS RFI event where system degradation directly necessitates a change in flight profile or tactical execution, specifically, but not limited to:

a) any event resulting in the inability to execute published instrument flight procedures;

b) execution of a missed approach or go-around due to navigation guidance loss; or

c) requiring reversion from PBN to conventional navigation methods [e.g. VHF Omnidirectional Radio Range (VOR), Distance Measuring Equipment (DME) and Instrument Landing System (ILS)].

7.8 Radiotelephony phraseology examples are as follows:

Event	**Phraseology**
GNSS RFI experienced	BASIC GNSS UNAVAILABLE [DUE TO (*reason, e.g.* LOSS OF RAIM *or* RAIM ALERT)] e.g. BASIC GNSS UNAVAILABLE DUE TO GNSS JAMMING BASIC GNSS UNAVAILABLE DUE TO GNSS SPOOFING BASIC GNSS UNAVAILABLE DUE TO INTERFERENCE

Note: As there is currently no standard phraseology for flight crew to advise controller that GNSS RFI is no longer present, flight crew may convey this using one of the following:

a) GNSS JAMMING NO LONGER EXPERIENCED; or

b) GNSS SPOOFING NO LONGER EXPERIENCED; or

c) GNSS INTERFERENCE NO LONGER EXPERIENCED.

7.9 Flight crew should, as soon as practicable, relay the following minimum information to controller at the time the anomaly is observed:

a) aircraft callsign;

b) time of occurrence in Coordinated Universal Time (UTC); and

c) approximate position (latitude/longitude, fix, radial/distance, or segment of ATS route).

7.10 Flight crew is required to communicate the following supplemental information to controller when it is practicable to do so:

a) nature of anomaly (GNSS, CPDLC, ADS-C, ADS-B);

b) operational impact (unable RNAV/RNP, rerouting needed, reverting to voice, surveillance affected);

c) any assistance required; and/or

d) any attempted mitigation (switch to DME/VOR, inertial navigation, reversionary procedures).

Sequence of Actions to be Taken by ATS Unit

7.11 Upon receipt of a GNSS RFI report from flight crew, the ATS unit should first acknowledge the report and initiate tactical operational mitigation.

7.12 The ATS unit should concurrently forward the report to the appropriate ANSP CNS unit for investigation and analysis of the situation. This phase ensures that immediate safety measures are applied while investigation and analysis are being conducted.

7.13 Following the initial assessment and controller acknowledgement, the ATS unit should monitor the affected airspace for further reports. If no further instances are reported, the process moves directly to recording the information. In the event of repeated occurrences, the ATS unit should notify all related stakeholders, including adjacent ATS units/ANSPs and aircraft operators. This notification is a precursor to the formal issuance of a NOTAM to alert all affected airspace users.

7.14 If the GNSS RFI is determined to be persistent, the ATS unit should coordinate the issuance of a NOTAM to officially promulgate the hazard information to all airspace users. Once a NOTAM has been issued, the ATS unit should continue to monitor for further recurrence to assess whether there is a need to extend the NOTAM validity should the occurrence prolong or cancel the NOTAM and resume normal operation should there be no recurrence reported.

7.15 The ATS unit should record all pertinent information received and file a formal report in accordance with applicable national regulatory requirements, to document the event and its resolution.

7.16 A comprehensive workflow chart for the ATS unit action in handling GNSS RFI real-time reporting can be found in **Appendix 1**.

Post-Flight Reporting

7.17 Aircraft operators should submit a Post-Flight Reporting Form (see sample template in **Appendix 2**) following any GNSS RFI event, as follows:

Item / Elements	**Details**
Submission Timeline	Within 48 hours of the event, or as soon as practicable in the case of a safety-significant occurrence.
Reporting Channels	CAA occurrence reporting system, or any applicable reporting medium, is available for use.
Purpose	To support occurrence investigation, trend analysis, and coordination of operational, technical, and regulatory mitigation measures.

7.18 The following data elements should be collected consistently by the State/Administration to enable effective investigation, analysis, and trend monitoring:

Elements	**Details**
Aircraft Identification	Callsign, aircraft registration, aircraft type and operator.
Flight Details	Flight number, origin and destination aerodromes, ATS route or segment, cleared level and speed
Time and Position	time (in UTC) of onset and cessation; aircraft position (latitude/longitude or fix), altitude/flight level, and phase of flight.
Symptoms / Operational Impacts	Examples: loss or degradation of navigation guidance; RAIM alerts; “GPS PRIMARY LOST” indications; inability to conduct RNAV/RNP operations; CPDLC uplink/downlink failures; ADS-C contract drops; ADS-B degradation; timing or synchronization anomalies.
Duration / Intermittency	Event characterization (single, intermittent, or continuous), including start and end times.

Elements	Details
Mitigations Applied	Reversion to conventional navigation aids; radar vectoring; speed and/or altitude changes; procedural or route amendments.
Operational Consequences	Route deviations, delays, go-around events, activation of contingency procedures, or any loss of separation risk (if applicable).
Unit and Contacts	ATS unit, controller identifier (where permitted), and FIR contact point.
Weather / Environmental Context	Relevant meteorological or environmental conditions, including known solar activity, thunderstorms, military activity, or observed RF sources.
Equipment Details (if available)	FMS make and model; GNSS receiver type; software/Software Control Number version; data link media (SATCOM, VHF, HF) and service provider; antenna configuration where relevant.
Attachments / Logs (if available)	Supporting evidence such as FMS screenshots, maintenance log references, ACARS or CPDLC log extracts, and recorded alerts or messages.

7.19 States/Administrations shall apply applicable national and operator data-protection policies in accordance with ICAO Annex 19, ensuring a non-punitive safety reporting environment and the appropriate protection of personal identifiers.

7.20 GNSS RFI event reports should be processed in accordance with the reporting workflow outlined in **Appendix 3**.

Aerodrome Operator Engagement

7.21 To enhance aerodrome-level situational awareness, timely dissemination of operational advisories to airspace users is needed to support effective management of the local radio frequency environment, particularly where GNSS RFI may impact aerodrome safety or efficiency.

7.22 Aircraft operators should submit a report of any GNSS RFI incidents occurring within the vicinity of an aerodrome to the relevant aerodrome operator via an established reporting platform or any applicable reporting procedures.

7.23 The aerodrome operator should establish procedures to promulgate airside advisories internally, ensuring operational awareness among key aerodrome stakeholders.

Original Equipment Manufacturer (OEM) Engagement

7.24 Close coordination and strategic engagement with aircraft and equipment OEMs are crucial to enable targeted technical diagnostics and effective corrective actions. This coordination ensures alignment with applicable manufacturer notifications, such as Service Bulletins and Service Letters regarding effects of GNSS RFI events.

7.25 Engagement with OEMs should be initiated upon the identification of any of the following conditions:

a) recurrent anomalies affecting specific aircraft fleets, avionics types, or equipment configurations;

b) suspected defects in avionics software, firmware, or system configuration impacting GNSS, data link, or surveillance performance; or

c) complex or safety significant events requiring specialist engineering analysis or manufacturer-level support.

8. INVESTIGATION AND ANALYSIS PROCEDURES

Overview

8.1 Once immediate safety is assured and initial reports are received, the investigation and analysis will need to be carried out to establish the source and scope, assess the safety impact, and apply applicable mitigations. The following provisions describe some of the investigation and analysis procedures.

ANSP CNS Unit Actions

8.2 There are different levels of investigation and analysis that may be carried out by ANSP CNS units. These range from use of existing information already available to the ANSP to do basic investigation and analysis to advanced detection capabilities. States/Administrations can determine the appropriate level of investigation and analysis capabilities of the ANSP CNS unit to ensure safe operations.

8.3 Basic investigation and analysis of GNSS RFI events may be conducted through monitoring of systems dependent on GNSS (e.g. ADS-B). ADS-B messages contain multiple data fields [e.g. Navigation Uncertainty Category – Position (NUCp), Navigation Integrity Category (NIC), Navigation Accuracy Category for Position (NACp), Source Integrity Level (SIL), Figure of Merit (FOM)], which indicates the integrity and accuracy of the position message. When the ADS-B messages from multiple aircraft demonstrate low values for these data fields, it will indicate a possible GNSS RFI event and the area affected can be derived from when the ADS-B messages first show signs of degradation. A rough location of the source of interference may then be determined.

8.4 ANSP CNS units may also, if applicable, coordinate with the national spectrum and telecommunications regulators to explore deploying direction finders to detect and locate GNSS RFI sources. These employ various techniques like using time difference of arrival from multiple signals to then triangulate the location of the source with greater precision.

Operational Risk Assessment

8.5 Based on the investigation and analysis results of the GNSS RFI event, ANSPs should conduct an operational risk assessment to determine the effects and necessary mitigations based on the likelihood and severity of the identified scenario.

8.6 Once the appropriate required mitigations have been identified, ANSPs should begin coordination and notification processes to raise awareness of all stakeholders on the ongoing event as well as monitoring for trends and incorporating lessons learnt into training syllabus which will be covered in the later chapters.

8.7 IATA has published *Global Navigation Satellite System (GNSS) Radio Frequency Interference Safety Risk Assessment* for use by airlines and included in-part in Chapter 11 of this document.

9. REGIONAL COORDINATION FRAMEWORK

Overview

9.1 Addressing GNSS RFI that transcends national borders requires a multi-lateral approach involving diplomacy, data synchronization, and cross-border regulatory enforcement. Given the proliferation of interference, States/Administrations must recognize that GNSS RFI may impact neighbouring regions across national borders. In such instances, the regional coordination framework detailed in this Chapter can be used as a guidance on the communication channels and POCs for the coordination.

Establishment of Formal Communication Channels

9.2 Effective mitigation relies on pre-emptive coordination rather than reactive measures. States/Administrations should establish formal communication protocols to ensure any RFI events are promptly coordinated and communicated.

9.3 Each State/Administration should designate operational and technical POCs for GNSS-related matters at both:

a) ATS unit level; and

b) national level (ATM POC).

9.4 These POCs should be:

a) codified in bilateral or multilateral Letters of Agreement (LoA);

b) maintained in an up-to-date regional contact directory; and

c) reviewed and updated annually through ATM/SG meetings to ensure effective coordination and information exchange.

9.5 ATS unit level POCs are designated to coordinate and implement operational measures arising from unforeseen events. Having direct communication links or “hotlines” can facilitate immediate tactical responses, such as traffic rerouting or increasing separation minima.

9.6 National level ATM POCs are responsible for coordinating planned RFI activities to ensure that aviation risks are minimized through prior notification. For ease of having an up-to-date regional contact directory, these national level ATM POCs will be based on the list of ATM POCs (i.e. ATC = Air Traffic Control), as reviewed and updated annually through ATM/SG by ICAO APAC Regional Office.

9.7 In the event that coordination with the designated national level ATM POC cannot be established, the ICAO APAC Regional Office should be notified to facilitate the resolution of GNSS RFI and to mitigate potential safety risks.

Harmonized Regional Coordination

9.8 To support development of a comprehensive regional database of GNSS RFI hot spots, there will be a need for information to be shared and coordinated within the region and should be structured at two distinct levels: pre-tactical and tactical.

9.9 Pre-tactical coordination:

a) pre-tactical coordination supports trend analysis, risk assessment and flight planning considerations;

b) utilizing the standardized reporting mechanisms in Chapter 7, the collation of historical RFI data aids in trend analysis (as detailed in Chapter 8) and supports the identification of geographical areas of concern and commonly reported operational effects to inform the development of mitigation priorities;

c) the resulting regional information may assist aircraft operators in incorporating GNSS RFI awareness into flight planning, navigation contingency and backup considerations, alternate routing where practicable, and flight crew briefings regarding the potential operational effects of GNSS RFI; and

d) in addition, the resulting regional information may enhance ATS unit situational awareness of areas where aircraft may experience loss, degradation, or failure of surveillance or navigation signal transmission, such as ADS-B which could result in incorrect information being displayed to them. Improved awareness supports timely operational responses and reduces the risk of airspace infringements and/or unintended route deviations.

9.10 Tactical coordination:

a) for known or scheduled military electronic warfare training or security operations RFI events, NOTAMs must be disseminated using the harmonized format specified in Chapter 10. Clear, standardized NOTAMs reduce flight crew workload and mitigate the stress associated with sudden system degradations.

9.11 Cross-border notification and procedures:

a) a structured three-phase approach is recommended for managing inter-State RFI events with the flow diagram in **Appendix 4**:

Coordination with ICAO APAC

9.12 States/Administrations should provide consolidated GNSS RFI occurrence reports to the ICAO APAC Regional Office on a semi-annual basis. The regional data collection and analysis process is outlined below:

Phase	**Step**	**Responsible Party**	**Action / Deliverable**	**Timeline**
1. Data Collection and Processing	1.1 Occurrence Reporting	Operators and ANSPs	Operational occurrences reported to the State authority	Real-time / per occurrence
	1.2 State Data Consolidation	National level ATM POC	Consolidation and submission of occurrence data to the ICAO APAC Regional Office	Semi-annually, prior to APRAST meetings
	1.3 Regional Data Consolidation	ICAO Secretariat	Consolidation of regional data and dissemination to relevant working groups	Within 30 days following data submission

Phase	Step	Responsible Party	Action / Deliverable	Timeline
2. Data Analysis and Prioritization	2.1 Safety Risk Assessment	OPS WG and CNS SG	Assessment of operational safety impacts, identification of areas of concern, and prioritization of associated regional safety risks	Conducted through intersessional coordination activities and APRAST meetings
3. Consultation and Regional Action	3.1 Joint Review and Action Planning	OPS WG and CNS SG	Joint review of findings and agreement on appropriate regional actions	Following APRAST meetings
	3.2 Mitigation Measures	OPS WG and CNS SG	Development of operational guidance material, including Regional Aviation Safety Group – Asia Pacific (RASG-APAC) Safety Advisories (RSAs), as appropriate	Prior to RASG-APAC meetings
		OPS WG and CNS SG	Consideration of immediate mitigation measures, including State Letters or other urgent coordination actions, where necessary	As required
4. Progress Reporting	4.1 Outcome Reporting	OPS WG and CNS SG	Reporting of progress, analysis outcomes, and mitigation activities to APANPIRG and RASG-APAC	Through appropriate APANPIRG/RASG-APAC meetings

10. NOTIFICATION OF GNSS RFI EVENTS

GNSS RFI Notifications Mechanism

10.1 This Chapter documents the various notification mechanisms for dissemination of GNSS RFI events. ATS units should select the most efficient means to ensure rapid dissemination of information to all stakeholders as appropriate. These include:

a) **broadcast over VHF**, direct broadcast over the current means of communication established with aircraft in the affected area. This means is for fast and efficient outreach to aircraft already in the affected area but less sustainable for prolonged events;

b) **publication of NOTAM**, coordinate with AIS unit to publish a NOTAM for GNSS RFI event (both planned and unplanned) with short notice. This means will provide advance notice to aircraft about to enter affected areas and allow for mitigating actions such as rerouting or configuration of aircraft to exclude GNSS inputs, if applicable, to be taken; and/or

c) **broadcast on ATIS**, inclusion of information of GNSS RFI events in ATIS broadcast and D-ATIS, where applicable. This means is particularly effective for events occurring in the vicinity of aerodromes as it would ensure aircraft departing and arriving would receive updated information to apply mitigating measures prior to entering the affected area.

10.2 While there are many means of notification available, it is important to determine the appropriate notification mechanism to ensure that information is promptly conveyed to the relevant stakeholders without unnecessary workload. States/Administrations may consider referencing the following decision matrix framework to develop the appropriate notification framework that best suits their environment.

Area Affected	**Notification Mechanism**
Enroute	NOTAM and through ATS unit over VHF
Terminal Control Area	NOTAM and ATIS
Approach	NOTAM and ATIS
Aerodrome	NOTAM and ATIS

10.3 ATS units should also develop their own criteria for the trigger of notification to airspace users considering the following:

a) impact to provision of ATS (i.e. results in changes to the level of service provided);

b) impact to safety of airspace users (i.e. close proximity to airports and approach paths);

c) severity of the occurrence (i.e. large volume of airspace that crosses FIR); and

d) number of airspace users impacted (i.e. small number or all aircraft affected).

GNSS RFI Notification through ATS Units over VHF

10.4 For unplanned GNSS RFI events, aircraft already in the affected area will need to be notified through the ATS units over VHF. Radiotelephony phraseology examples are as follows:

Event	Phraseology
GNSS RFI experienced	GNSS REPORTED UNRELIABLE (*or* GNSS MAY NOT BE AVAILABLE [DUE TO INTERFERENCE]) IN THE VICINITY OF *(location)(radius)* [BETWEEN *(levels)*] e.g. GNSS REPORTED UNRELIABLE DUE TO GNSS JAMMING IN THE VICINITY OF {WAYPOINT}
	GNSS REPORTED UNRELIABLE (*or* GNSS MAY NOT BE AVAILABLE [DUE TO INTERFERENCE]) IN THE AREA OF *(description)* (or IN *(name)* FIR) [BETWEEN *(levels)*]

Note: As there is currently no standard phraseology for flight crew to advise controller that GNSS RFI is no longer present, flight crew may convey this using one of the following:

a) GNSS NO LONGER UNRELIABLE; or

b) GNSS NOW AVAILABLE.

GNSS RFI Notification through NOTAMs

10.5 Currently, the ICAO Navigation Systems Panel has proposed standardized NOTAM codes for GNSS RFI events to differentiate between GNSS jamming or spoofing. This will allow aircraft operators to create effective filtering mechanisms to identify NOTAMs for information related to GNSS RFI events.

10.6 Key elements that should be standardized include:

a) use of Q code:
   i. QGWLF for jamming; or
   ii. a new code that is being developed for spoofing.

b) use of one of the following templates for Item E for GNSS jamming:
   i. GNSS MAY BE UNRELIABLE WITHIN THE VICINITY OF {WAYPOINT};
   ii. GNSS MAY BE UNRELIABLE WITHIN THE VICINITY OF {AERODROME}; or
   iii. GNSS MAY BE UNRELIABLE WITHIN THE AREA OF (description) (or IN (name) FIR) [BETWEEN (levels)].

c) use of one of the following templates for Item E for GNSS spoofing:
   i. GNSS MAY BE MISLEADING WITHIN THE VICINITY OF {WAYPOINT};
   ii. GNSS MAY BE MISLEADING WITHIN THE VICINITY OF {AERODROME}; or
   iii. GNSS MAY BE MISLEADING WITHIN THE AREA OF (description) (or IN (name) FIR) [BETWEEN (levels)].

d) inclusion of instruction for flight crew to report when no longer experiencing GNSS RFI within the area published in the NOTAM for ATS units to follow up with NOTAM cancellation:
   i. FLIGHT CREW TO REPORT IF GNSS INTERFERENCE NO LONGER EXPERIENCED.

e) Sample NOTAM for GNSS signal that is currently subject to jamming interference:

A1311/26 NOTAMN

Q) EACC/QGWLF/I/NBO/AE/000/999/5222N03155W250

A) EADD B) 2611131215 C) 2611132359EST

E) GNSS MAY BE UNRELIABLE WITHIN … FLIGHT CREW TO REPORT IF GNSS INTERFERENCE NO LONGER EXPERIENCED

10.7 Besides the above NOTAM template to raise awareness on the GNSS RFI event, States/Administrations should also separately assess the consequential impact and publish separate NOTAMs for the suspension of services and procedures as appropriate [e.g. suspension of ADS-B services, suspension of free-route airspace/direct routing operations, suspension of CPDLC services, unavailability of RNAV(GNSS) approaches].

GNSS RFI Notification through ATIS

10.8 For GNSS RFI events in the vicinity of aerodrome, ATS units should consider appending information of the GNSS RFI event in the ATIS broadcast and D-ATIS using the following suggested broadcast phrasing:

a) GNSS MAY BE UNRELIABLE WITHIN THE VICINITY OF {AERODROME}; or

b) GNSS MAY BE MISLEADING WITHIN THE VICINITY OF {AERODROME}.

10.9 Similarly, additional information on the suspension of affected approaches should be included as well as the expected alternative procedures.

11. TRAINING REQUIREMENTS

Flight Crew

11.1 Learning:

a) recognize the precursors/threats:

Precursors	**Description**
Jamming	Locally generated RFI is used to "drown out" satellite signals. Possible sources: personal privacy devices, television broadcast station malfunction, and military RFI.
Spoofing	Counterfeit GNSS signals are broadcast and decoded by airborne receivers, resulting in a false position displayed in the cockpit and used by avionics. (Position Manipulation)
Solar Storms	Electromagnetic interference from space weather events such as solar flares "drowns out" the GNSS satellite signals.
Signal Reflection	Reflection and/or refraction of GNSS signals due to objects such as buildings or ionospheric scintillation

b) understanding the possible consequences/impacts:

Systems Affected/Potential Accident Scenarios		**CFIT**	**Midair Collisions**	**Runway Excursion**
Navigation	Downgraded aircraft position computation. GPS (loss of GPS primary)	X		
	Loss of FMS Landing System, GBAS Landing System, SBAS Landing System deviations, and loss of RNP and RNAV capability	X		
	Abnormal differences between ground speed and true airspeed	X		
Surveillance	Loss of Terrain Awareness Warning System (TAWS) Undue TAWS Alerts false "Pull up" calls (or no calls)	X		
	Terrain display shift on Navigation Display	X		
	Loss of ADS-B Out Reporting False ADS-B Out Position Reporting		X	
	Loss of TCAS		X	
Communication	Loss of CPDLC and SATCOM		X	
Others	Loss of Runway Overrun Prevention System or Runway Situation Awareness Tools			X

11.2 Flight planning:

a) checking NOTAMs for information on known or expected GNSS RFI (potential RFI map highlighting possible areas);

b) checking the availability of non-GNSS-based routes, procedures, and approaches (ILS, VOR, and DME); and

c) consider limitations caused by inoperative radio navigation systems to operate in GNSS RFI-affected areas.

11.3 Training for in-flight:

a) communication protocol as per ICAO or other recommended radiotelephony phraseology;

b) determining the start and end of GNSS RFI to react accordingly;

c) reinforce actions taken for Electronic Centralized Aircraft Monitor (ECAM) / Engine Indicating and Crew Alerting System (EICAS) reports and Flight Crew Operating Manual (FCOM), or supplemental procedures for loss of GNSS;

d) guidance from aircraft OEMs on flight deck effects and corresponding actions;

e) plan for rapid transitioning from GNSS to alternative navigation methods; and

f) explore the feasibility of using non installed spoofing detector and EFB to enhance situational awareness of the crew.

11.4 Post-flight:

a) technical report in the maintenance logbook in case any cockpit effects related to GNSS RFI are experienced;

b) establish maintenance/operations feedback after troubleshooting GNSS RFI reports;

c) report any suspected GNSS RFI events to relevant regional and international organizations (e.g. IATA, ANSPs); and

d) when GNSS RFI events have been experienced, aircraft data should be sent to OEMs for further investigation.

11.5 Future fitments:

a) training for mitigation of GNSS RFI onboard: development of Dual-Frequency/Multi-Constellation (DFMC) and Multi-Frequency Multi-Constellation (MFMC) receivers and Minimum Operational Performance Standards (MOPS).

ATS Units

11.6 Learning through briefings and reference to case studies:

a) recognition of GNSS RFI events;

Event	**Signs**
Jamming	Loss of surveillance tracks in ADS-B only environment Reversion to ADS-C tracks
Spoofing	Sudden appearance and disappearance of surveillance tracks in ADS-B only environment Surveillance tracks that do not comply with their flight plan route

b) understanding the impact to service provision; and

Services	**Impact**
ADS-B	Loss of surveillance tracks in ADS-B only environment. Potential reversion to procedural separation.
ADS-C	Loss of Data Link connection ADS-C tracks with low Figure of Merits ADS-C tracks with inaccurate position Potential reversion to traditional longitudinal separation instead of performance-based separation
CPDLC	Receipt of CPDLC messages with send time in the future Receipt of CPDLC messages with large latency Disconnection of CPDLC Potential need for reversion to alternate means of communication
GBAS/SBAS	Unavailability of GNSS-based landing procedures Potential need for reversion to alternate landing procedures (e.g. ILS or visual)
Free Route Airspace / Direct Routing Operations	Potential need for reversion to traditional ATS route for areas outside radar coverage
SATVOICE	Loss of SATVOICE connection Potential reversion to alternate means of communication

c) understanding the impact from flight crew actions.

Flight Crew Actions	**Impact**
Erroneous position reporting	Potential missed position report or need for confirmation of position with other sources
Response to false terrain awareness and warning system alerts	Sudden climb or descend that could result in conflict with other aircraft
Degraded navigation performance	Inability to fly certain route and approach procedures and may require radar vectors
Inability to recover even after leaving affected area	Inability to fly certain route and approach procedures and may require radar vectors

11.7 Training

a) besides recognizing GNSS RFI events and its consequential impact to services and potential actions by flight crew, it is important that these are also incorporated into refresher simulator trainings to ensure familiarity and competency in handling abnormal operations and activation of contingency procedures.

CNS Units

11.8 Learning through courses to improve knowledge in the following areas;

a) recognition of GNSS RFI events through monitoring of system health and time synchronisation errors; and

b) recognition of GNSS RFI events through analysis of available data fields that can signify suspected events.

11.9 Training:

a) software application training that support investigation and analysis of data; and

b) contingency procedures training to ensure time synchronisation issues can be mitigated through switching to alternate time sources.

12. CONCLUSION

12.1 The global aviation system has become increasingly dependent on GNSS to support CNS and timing functions. While GNSS enables significant operational efficiencies and capacity improvements, this reliance also introduces systemic vulnerabilities. Intentional and unintentional interference, signal manipulation, and broader space-based system disruptions have the potential to adversely affect aviation safety and operational continuity across wide geographic areas.

12.2 Beyond localized interference events, more complex crisis scenarios including deliberate disruption of satellite services, spoofing activities, satellite malfunction, or large-scale orbital debris events such as the Kessler Syndrome illustrate the importance of resilience planning. Although such scenarios may be low in probability, their operational consequences could be significant. Accordingly, strengthening resilience to GNSS RFI contributes not only to interference mitigation, but also to broader contingency preparedness and system robustness.

12.3 This document provides a structured framework to assist States/Administrations, ANSPs, aircraft operators, aerodrome operators and other stakeholders in policy development, contingency planning, operational detection, reporting of GNSS RFI events, coordinated regional response, harmonized classification of GNSS RFI events, and post-event analysis and continuous improvement.

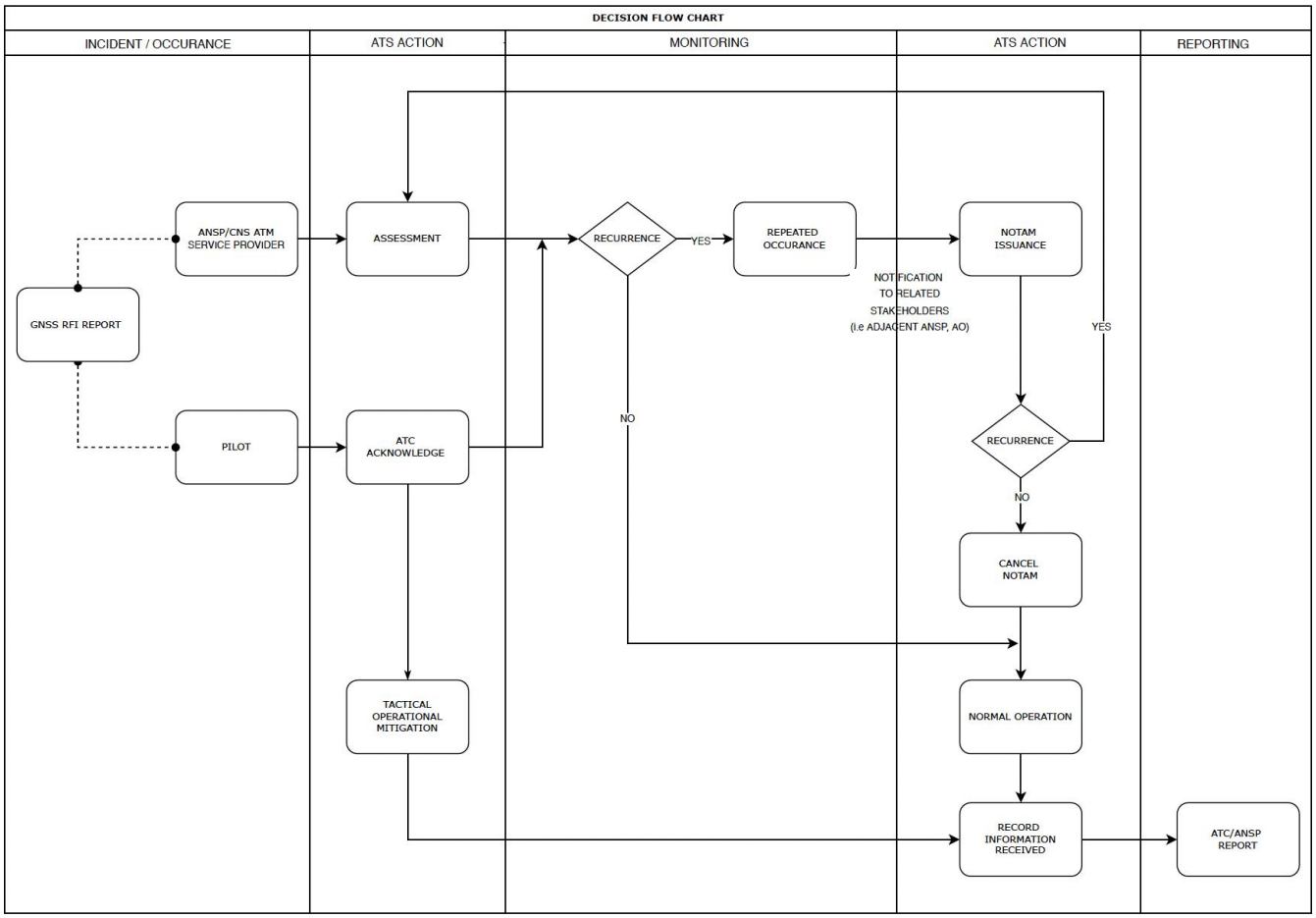
12.4 The establishment of standardized procedures for detection of GNSS and its associated data link disruption, classification and reporting support the development of an effective regional coordination network. Such harmonization enhances situational awareness, promotes transparency, and facilitates timely mitigation measures across FIR boundaries.

12.5 Given that GNSS RFI is inherently transnational in nature, sustainable solutions require coordinated regional and global approaches. Continued collaboration among ICAO regions, led by ICAO Headquarters, will support harmonization of procedures and future development of SARPs and related guidance material as the threat environment evolves.

12.6 Close coordination with international organizations such as Airports Council International (ACI), IATA, the International Federation of Airline Pilots' Associations (IFALPA), and the International Federation of Air Traffic Controllers' Associations (IFATCA) remains essential to ensure harmonized implementation across all aviation domains.

12.7 Through proactive coordination, standardized reporting, and collective commitment to resilience, the aviation community can mitigate the operational and safety risks associated with GNSS RFI and preserve the integrity, continuity and safety of international civil aviation.

APPENDIX 1: ATS UNIT HANDLING OF GNSS RFI EVENT



APPENDIX 2: SAMPLE POST-FLIGHT REPORTING DATA ELEMENTS

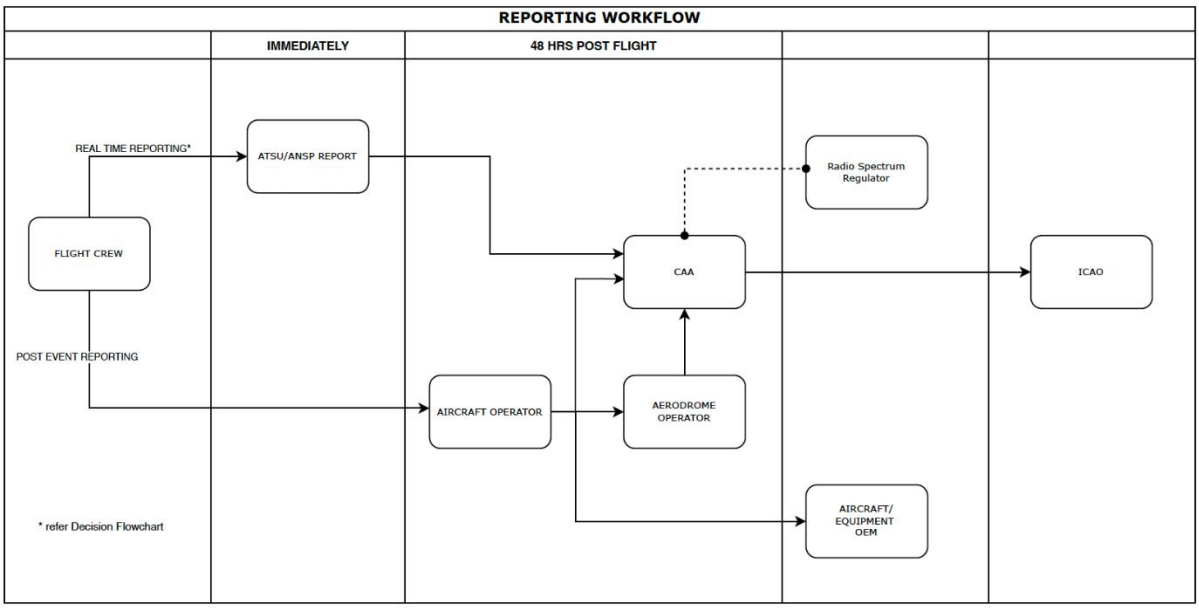
GNSS RFI REPORTING FORM FOR USE BY ANS PERSONNEL	
Description of interference	
Source of initial interference report	[ ] Flight crew [ ] Engineer/technician [ ] Other
Observability of the interference	Interference was noticeable: [ ] only on board the aircraft (flying, not on the ground) [ ] only on the ground (aircraft parked/taxiing) or by means of ground detection systems available [ ] both
Number of received reports	
Coordinates of the area of occurrence/time (UTC)	UTC: ___ Lat: ___ Long: ___ FL/Altitude: ___
Problem duration:	Days, hours, minutes, seconds _____ [ ] continuous [ ] intermittent
Affected GNSS element	[ ] GPS [ ] GLONASS [ ] GALILEO [ ] BDS [ ] Other constellation [ ] EGNOS [ ] WAAS [ ] BDSBAS [ ] Other SBAS [ ] GBAS (VHF data link for GBAS)
Affected constellation frequency	[ ] L1 [ ] L5 [ ] Both
Used GNSS contingency procedure	[ ] Radar vectoring [ ] Switch to procedures based on conventional navaids (e.g. DME/DME or VOR/DME-based PBN, DME and VOR-based conventional, ILS) [ ] Diversion to another airport [ ] Missed approach [ ] Use of alternate means for communication (e.g. VHF) [ ] Other: ___
In case of report by flight crew	
Airline name	
Aircraft type and registration	
Flight number	
Airway/route flown	
Reported on-board failure	[ ] Total loss of navigation capabilities [ ] Need to change the navigation procedure [ ] Inability to fly RNP and request for radar vectoring [ ] Inability to fly a GNSS-based approach (GLS, SLS) [ ] GNSS fault (1 or 2)

	[ ] TAWS/EGPWS warnings or loss of terrain and surface functionalities [ ] Loss of ADS-B [ ] Wind and ground speed wrong presentations [ ] Aircraft clock anomaly [ ] Loss of situational awareness (SVS, Cockpit Display of Traffic Information) [ ] Loss of communication functions (CPDLC, ACARS) [ ] AHRS failure [ ] Map shift [ ] Other: ___
Information on presumed source of interference	
Presumed location of interference source	Lat: ___ Long: ___ or Nearest city or landmark:
Interfering frequency (if known)	
Signal strength and reference bandwidth (if known)	
Further descriptions of the interference case	[ ] Spectrum plot [ ] Map [ ] Other material:

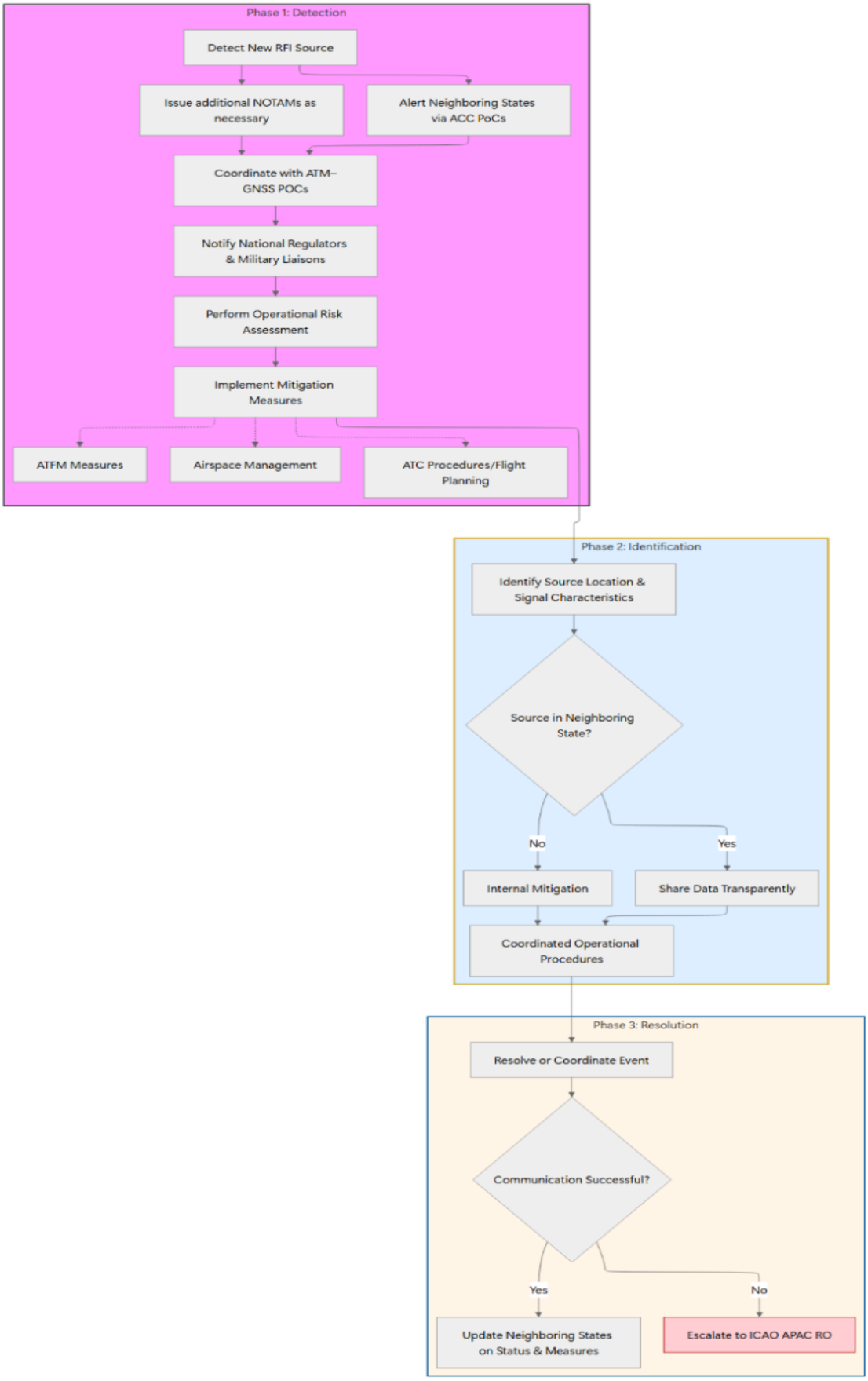
GNSS RFI REPORTING FORM FOR USE BY FLIGHT CREW	
Description of interference	
Reported failure and operational impact	[ ] Total loss of navigation capabilities [ ] Need to change the navigation procedure [ ] Inability to fly RNP and request for radar vectoring [ ] Inability to fly a GNSS-based approach (GLS, SLS) [ ] GNSS fault (1 or 2) [ ] TAWS/EGPWS warnings or loss of terrain and surface functionalities [ ] Loss of ADS-B [ ] Wind and ground speed wrong presentations [ ] Aircraft clock anomaly [ ] Loss of situational awareness (SVS, Cockpit Display of Traffic Information) [ ] Loss of communication functions (CPDLC, ACARS) [ ] AHRS failure [ ] Map shift [ ] Other: ___
Used GNSS contingency procedure	[ ] Request for radar vectoring [ ] Switch to another mean of navigation (e.g. DME/DME, VOR/DME, ILS) [ ] Diversion to another airport [ ] Missed approach [ ] Use of alternate means for communication (e.g. VHF) [ ] Other: ___
Affected GNSS element	[ ] GPS [ ] GLONASS [ ] GALILEO [ ] BDS [ ] other constellation

	[ ] EGNOS [ ] WAAS [ ] BDSBAS [ ] other SBAS [ ] GBAS (VHF data link for GBAS)
Affected constellation frequency	[ ] L1 [ ] L5 [ ] Both
Aircraft type and registration	
Flight number	
Airway/route flown (airport RWY/gateway/parking gate in case of on ground detection)	
Coordinates of the area of occurrence/time (UTC)	UTC: ___ Lat: ___ Long: ___ FL/Altitude: ___
Problem duration	Days, hours, minutes, seconds _____ [ ] continuous [ ] intermittent

APPENDIX 3: GNSS RFI AND ASSOCIATED DATA LINK DISRUPTION REPORTING WORKFLOW



APPENDIX 4: CROSS-BORDER COORDINATION PROCEDURES



Phase 1: Detection

1.1. Upon detecting a new GNSS RFI event, the affected ATS units should:

a) immediately alert adjacent ATS units of the affected area via established ATS unit level POCs;

b) assess the need for issuance or amendment of NOTAMs; and

c) implement immediate tactical mitigation measures, as required.

1.2. Concurrently, ATS unit level POCs should coordinate with and notify the national level ATM POCs to enable:

a) coordination with national frequency regulators and military liaisons;

b) technical investigation and analysis of the GNSS RFI source; and

c) coordination of additional operational mitigation measures with affected States/Administrations and relevant service providers after completing the operational risk assessments (details in Chapter 8).

1.3. Mitigation measures may include:

a) airspace management actions;

b) air traffic flow management measures;

c) revised air traffic control procedures; and

d) flight planning advisories.

1.4. Operational risk assessment should guide the selection of mitigation measures.

Phase 2: Identification

1.5. National level ATM POCs should cooperate to identify:

a) the source location;

b) signal characteristics (e.g. centre frequency and bandwidth), and

c) expected duration or operational parameters.

1.6. Where the source is located within another State/Administration, relevant data should be shared transparently. It must be noted that while some sources (e.g. national security) may not be deactivated, their impact can be mitigated through coordinated operational procedures.

Phase 3: Resolution

1.7. Once the RFI event is resolved or sufficiently coordinated, the national level ATM POC should provide an update to relevant States/Administrations regarding the status of the interference, any remaining limitations, and the specific mitigation measures taken.

1.8. If coordination or resolution between the national level ATM POCs is unsuccessful, the ICAO APAC Regional Office should be informed to assist in facilitating resolution and safeguarding aviation safety.