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Tulum, Mexico, from 8 to 12 September 2025

Agenda Item 5: NACC/WG Collaborative Task Forces Working Session

Minimum Operating Network

(Presented by IATA)

EXECUTIVE SUMMARY	
This working paper presents information regarding GNSS radio frequency interference and proposes the development of a Regional Guidance Material to harmonize the implementation of a Minimum Operating Network by NACC States	
Action:	Suggested actions under item 3 of this working paper
Strategic Objectives:	• Safety • Air Navigation Capacity and Efficiency • Economic Development of Air Transport • Environmental Protection
References:	• ICAO Doc 10209 - AN-Conf/14 • IATA GNSS RFI Safety Assessment • Brazil - PCA 100-5 - Plano de Implementação da Rede Operacional Mínima (MON) em resposta à falha do GNSS • EUROCONTROL - Minimum Operating Network Concept and Design Criteria • EUROCONTROL - European MON Technical and Economic Assessment • FAA - SAFO 24002 • EASA SIB No.: 2022-02R3

1. Introduction

1.1 The Global Navigation Satellite System (GNSS), consisting of the USA’s Global Positioning System GPS, Russia’s GLONASS, China’s BeiDou, and Europe’s Galileo, includes ground infrastructure and satellite constellations that provide position, navigation, and timing (PNT) information supporting aircraft and air traffic management operations.

1.2 Satellite navigation signals are weak and can be compromised by Radio Frequency Interference (RFI), including intentional or unintentional signal interference, jamming, and/or spoofing. The effects of RFI vary. Signal jamming and/or spoofing can seriously impact aircraft navigation systems, resulting in non-normal avionic system behavior.

1.3 Airspace users rely on the normal functioning of aircraft systems, including automated monitoring, caution, and warning sub-systems. Avionics such as Flight Management Systems (FMS) require GNSS for navigation and timing. GNSS position is also used by the Terrain Avoidance Warning System (TAWS) or Enhanced Ground Proximity Warning Systems (EGPWS). Therefore, interference-free GNSS PNT service is essential for flight safety.

1.4 Several safety alerts were issued since 2023, including FAA SAFO 24002 and EASA SIB No.: 2022-02R3. IATA developed a comprehensive Safety Risk Analysis (SRA), which is attached as appendix A to this working paper. This SRA could also be obtained at IATA GNSS Interference RFI SRA.

1.5 One of the current initiatives to mitigate the effects of GNSS RFI is the planning and implementation of a Minimum Operating Network (MON). In accordance with definition of EUROCONTROL - MON Concept and Design Criteria, MON objective is to improve the cost-effectiveness of the CNS infrastructure through optimization, including the decommissioning of communications, navigation and surveillance assets, while providing an adequate level of resilience and maintaining an acceptable level of safety and security. The mentioned document also provides design criteria for the development of such a CNS MON.

1.6 Also, in accordance with EUROCONTROL, the term MON has traditionally been associated with the minimum navigation infrastructure that allows aircraft to revert to conventional navigation procedures after a loss of GNSS service. The approach developed on the Eurocontrol MON Concept and Design Criteria document aims to extend the MON concept to CNS, and to consider not only the minimum infrastructure required to support the reversion infrastructure enabling aircraft to continue operations in a seamless manner, but also contingency procedures.

1.7 The 14th ICAO Air Navigation Conference (AN-CONF/14) agreed on the importance of maintaining a sufficient network of VOR, DME and ILS, to ensure safety, as well as adequate airspace capacity during times of interference with GNSS. In considering the need to gradually eliminate traditional navigation systems, the conference concurs that such elimination should take into account the need to effectively mitigate RFIs with GNSS, and that aircraft minimum equipment lists should be updated to reflect this requirement.

1.8 The AN-CONF/14 formulated the Recommendation 2.2/2 – Interference with the Global Navigation Satellite System and Contingency, which refers to international efforts to address interference with Global Navigation Satellite Systems (GNSS) and the need for contingency planning to ensure safety and continuity in air navigation operations. This recommendation urges States and ICAO to take several initiatives to face this essential issue to the present and future of air navigation.

1.9 Related to MON, the recommendation 2.2/2 of the AN-CONF/14 requires the following:

a) States - Ensure that effective measures are implemented to mitigate radio frequency interference in the Global Navigation Satellite System (GNSS), based on measures developed by ICAO and the industry, including the need to maintain a sufficient network of navigation aids and adequate airspace capacity during periods of GNSS interference.
b) States - Review aircraft minimum equipment lists to ensure compatibility with the States' minimum operational networks.
c) ICAO - Develop a standardized implementation assistance package to support and guide States in effectively implementing measures to mitigate radio frequency interference in the Global Navigation Satellite System, including the optimization and rationalization of conventional navigation aids, in accordance with their local conditions, to ensure the continuity of air navigation services.
d) ICAO - Formulate recommendations for globally harmonized aircraft minimum equipment lists so that airspace users can utilize the existing navigation infrastructure according to the available air traffic services.

2. Minimum Operating Network

2.1 According to EASA Safety Information Bulletin Operations – ATM/ANS SIB No. 2022-02R3 - GNSS RFI has become a significant safety risk, particularly in geographical areas surrounding conflict zones and the eastern Mediterranean, Middle East, Baltic Sea, and Arctic area, where RFI can increase pilots' and air traffic controllers' workload.

2.2 GNSS RFI is not limited to the affected flight information regions (FIR) highlighted by EASA's safety bulletin. IATA FDX indicates it has become a safety risk in other geographical areas.

2.3 The chart below illustrates the trend of GNSS outages over the recent past. In the first half of 2024, GPS signal losses per 1000 flights have significantly increased compared to 2023.

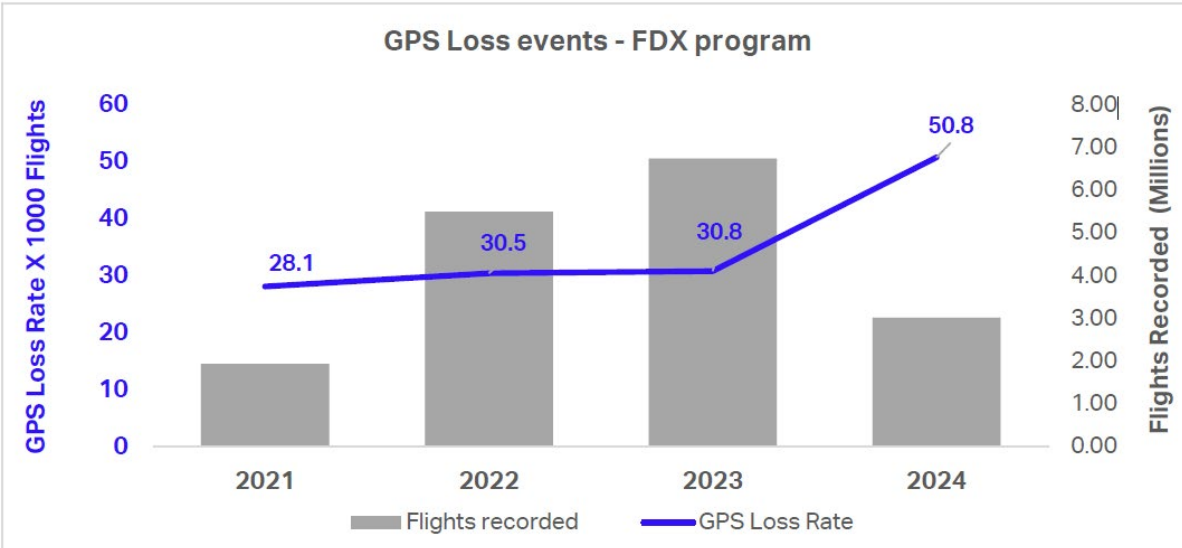

Figure 1 - GPS loss events evolution

2.4 From August 2021 to June 2024, FDX program members experienced +580K instances of GPS signal loss of around 18.4 million flights processed by the program. It is important to highlight that the figures are not based on voluntary reports but aircraft-recorded data. Therefore, FDX provides a good geographic identification of the RFI hotspots.

2.5 The FDX program continues to identify emerging hotspots where GNSS outages are increasing hazard exposure.

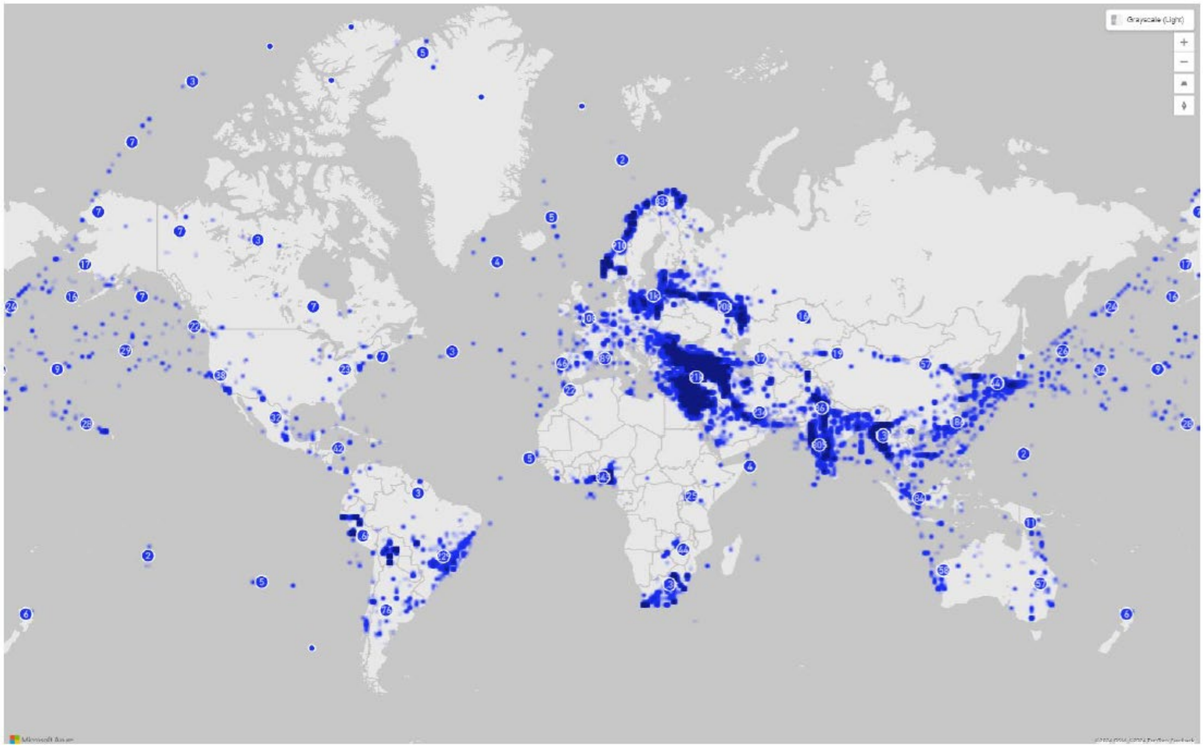

Figure 2 - GNSS RFI Recorded Events (Jan-Jun 2024) – Current Hotspots

2.6 IATA GNSS RFI SRA made a series of recommendations for Airlines, ANSPs, States ICAO and IATA. In relation to the MON, the following recommendations were made:

- ANSP - In coordination with airlines and other airspace users, periodically reassess the national CNS rationalization plan, ensuring a minimum operating network (MON) for operational resilience.
- States - Consider operational risks associated with GNSS RFI during the rationalization of conventional navigation and surveillance infrastructure and incorporate inputs from airspace users while developing a CNS MON.
- States - Ensure that contingency procedures are established in coordination with air navigation service providers and airspace users and that essential conventional navigation infrastructure, particularly Instrument Landing System (ILS), is retained and fully operational.
- ICAO - Develop a standardized implementation package to assist and guide States in implementing effective global navigation satellite system radio frequency interference mitigation measures, including optimization and rationalization of conventional navigation aids commensurate with their local conditions, to ensure continuity in the provision of air navigation services.

2.7 Based on recommendation 2.2/2 of the AN-CONF/14, ICAO should elaborate an assistance package to support and guide States to mitigate GNSS RFI, including the optimization and rationalization of conventional navigation aids, in accordance with their local conditions. These local conditions should take into account, among other aspects, volume/complexity of air traffic and GNSS RFI threat level in NACC region and in the States.

2.8 It is important to reiterate that the MON requires the rationalization of the CNS equipment network and indicates that it will be necessary to implement more ground equipment, for example, DMEs, and maintain equipment that could be removed if GNSS RFI were not an issue, such as, for example, some VORs, ILSs, and radars. Likewise, said rationalization indicates that unnecessary equipment, such as NDBs, should be removed, and that VORs and ILSs should not be considered at the same airport, as long as a DMEs network is implemented that allows RNAV 1 applications for STARs and SIDs. Furthermore, in the medium/long term, with the implementation of ADS-B, the removal of radars should be considered where the volume and complexity of air traffic are not significant. It should be noted that the degree of GNSS RFI in CAR/SAM is not similar to that in Europe and the Middle East, and the MON must consider the corresponding threat level. The MON should be appropriate to each State's operational scenario, but it is important to have a Regional Guide, with a view to harmonizing the criteria applied by States

2.9 In this sense, it is highly recommended that the implementation of the National MON be regionally harmonized via the development of a corresponding Guidance Material based documentation already developed by Eurocontrol (MON Concept and Design Criteria) and Brazil (PCA-100-5).

3. Suggested actions

3.1 The meeting is invited to:

a) Take note of the information provided in this working paper.
b) Evaluate the feasibility of requesting NACC/WG to elaborate a Regional Guidance Material related to the planning and implementation of National Minimum Operating Network.

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Unrestricted

Global Navigation Satellite System GNSS Radio Frequency Interference

Safety Risk Assessment

Version 5 July 2025

GNSS Radio Frequency Interference (RFI) - Fact Sheet

Safety Issue			
Global Navigation Satellite System Radio Frequency Interference – GNSS-RFI			
Regional Exposure	**AFI/ASPAC/EUR/LATAM MENA/NAM/NASIA**	**Sector Exposure**	**All sectors**
Key Risk Area	**Controlled Flight Into Terrain (CFIT), Mid Air Collision (MAC), Runway Safety**	**Proximity**	**Current/~~Emerging/Future~~**

Summary of the Safety Issue

The Global Navigation Satellite System (GNSS), consisting of the USA's Global Positioning System (GPS), Russia's GLONASS, China's BeiDou, and Europe's Galileo, includes ground infrastructure and satellite constellations that provide position, navigation, and timing (PNT) information supporting aircraft and air traffic management operations.

Satellite navigation signals are weak and can be compromised by RFI, including intentional or unintentional signal interference, jamming, and/or spoofing. The effects of RFI vary. Signal jamming and/or spoofing can significantly impact aircraft navigation and communications systems, leading to abnormal avionic system behavior.

Airspace users depend heavily on global navigation satellite systems (GNSS) to ensure the normal operation of avionic systems, including automated monitoring, caution, and warning subsystems. Avionics, such as Flight Management Systems (FMS), rely on GPS for navigation and timing. Additionally, GNSS positioning is crucial for systems such as the Enhanced Ground Proximity Warning Systems (EGPWS)/Terrain Avoidance Warning System (TAWS) and ADS-B out reporting GPS time is also used for Controller Pilot Data Link Communications (CPDLC). Therefore, uninterrupted GNSS positioning, navigation, and timing (PNT) services are vital for flight safety.

Purpose and Scope of SRA:

This document provides a structured approach to assess the GNSS Radio Frequency Interference (RFI) safety issue, proposes actions for airlines, ANSPs, States, ICAO, and IATA, and makes recommendations to other stakeholders. It provides a standard description of potential threats and preventive controls.

This document serves as a resource to assist IATA members in assessing operational risks and limitations linked to the degradation of onboard GNSS-related functionality. It also helps determine if member airline safety controls effectively mitigate GNSS interference risks or if additional measures are required.

Introduction

Operators experience the effects of GNSS-RFI in different phases of flight. In some cases, these effects have resulted in rerouting or diversions.

According to EASA Safety Information Bulletin Operations – ATM/ANS SIB No. 2022-02R3 GNSS-RFI has become a significant safety risk, particularly in geographical areas surrounding conflict zones and the eastern Mediterranean, Middle East, Baltic Sea, and Arctic area, where RFI can increase pilots' and air traffic controllers' workload. **The Black Sea area:**

- FIR Istanbul LTBB, FIR Ankara LTAA.
- Eastern part of FIR Bucuresti LRBB, FIR Sofia LBSR.
- FIR Tbilisi UGGG, FIR Yerevan UDDD, and FIR Baku UBBA.

The southeastern Mediterranean area, Middle East:

- FIR Nicosia LCCC, FIR Beirut OLBB, FIR Damascus OSTT, FIR Tel Aviv LLLL, FIR. Amman OJAC, the north-eastern part of FIR Cairo HECC, the eastern part of FIR Athinai LGGG
- Northern part of FIR Baghdad ORBB, FIR Kuwait OKAC, FIR Bahrain OBBB, the northwestern part of FIR Tehran OIIX, and the northern part of FIR Tripoli HLLL.

The Baltic Sea area (FIRs surrounding FIR Kaliningrad UMKK):

- Western part of FIR Helsinki EFIN, FIR Tallin EETT, FIR Riga EVRR, FIR Vilnius EYVL,
- The eastern part of FIR Warszawa EPWW and the southern part of FIR Sweden ESAA

Arctic area:

- Northern part of FIR Helsinki EFIN, and the northern part of FIR Polaris ENOR.

Eastern Europe area:

- FIR Bratislava LZBB, FIR Budapest LHCC, and FIR Chisinau LUUU.

GNSS-RFI is not limited to the affected flight information (FIR) highlighted by EASA's safety bulletin. IATA FDX indicates it has become a safety risk in other geographical areas.

North Atlantic Region

- FIR Icelandic BIRD[1]
- FIR Greenlandic NUUK[1]

SAM region

- FIR Ezeiza SAEF, FIR Resistencia SARR
- FIR Brasilia SBBS, FIR Recife SBRE

[1] North Atlantic Technology And Interoperability Group Eighteenth Meeting - Information Paper NAT TIG/18 IP/08

MID-Asia region

- FIR Delhi VIDF, FIR Mumbai VABF
- FIR Yangon VYYF, FIR Kunming ZPKM

Africa region

- FIR Cape town FACA and FIR KANO DNKK

Operators are encouraged to develop or update their risk model using the proper assessment technique, considering their exposure to threats and the effectiveness of safety controls within their operations.

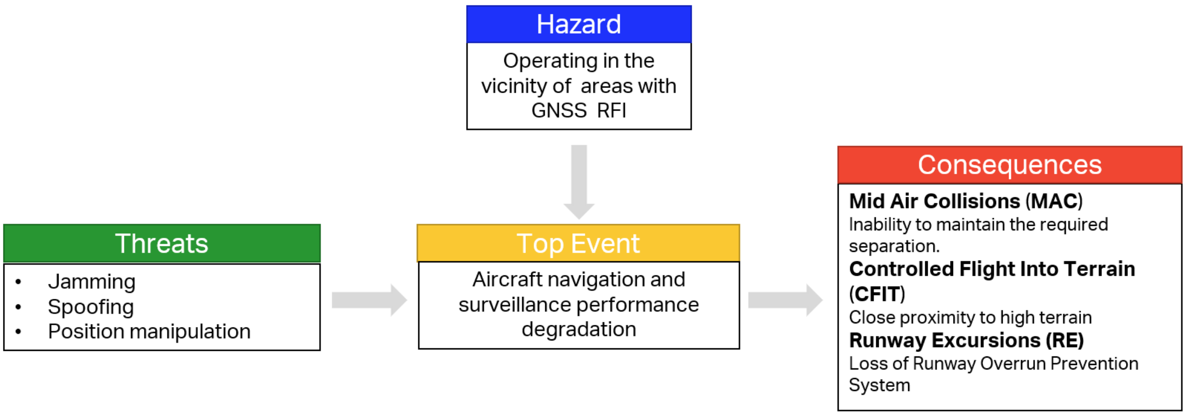

Figure 1 GNSS-RFI - Risk Model

Hazard

A hazard is a condition with the potential to cause an unsafe operational state, loss, or damage. This risk assessment considers operating in the vicinity of areas affected by GNSS-RFI as the source of potential degradation of aircraft communications (CPDLC), navigation, and surveillance systems.

The chart below illustrates the trend of GNSS outages over the recent past. In the first half of 2025, GPS signal losses per 1000 flights have increased compared to 2024.

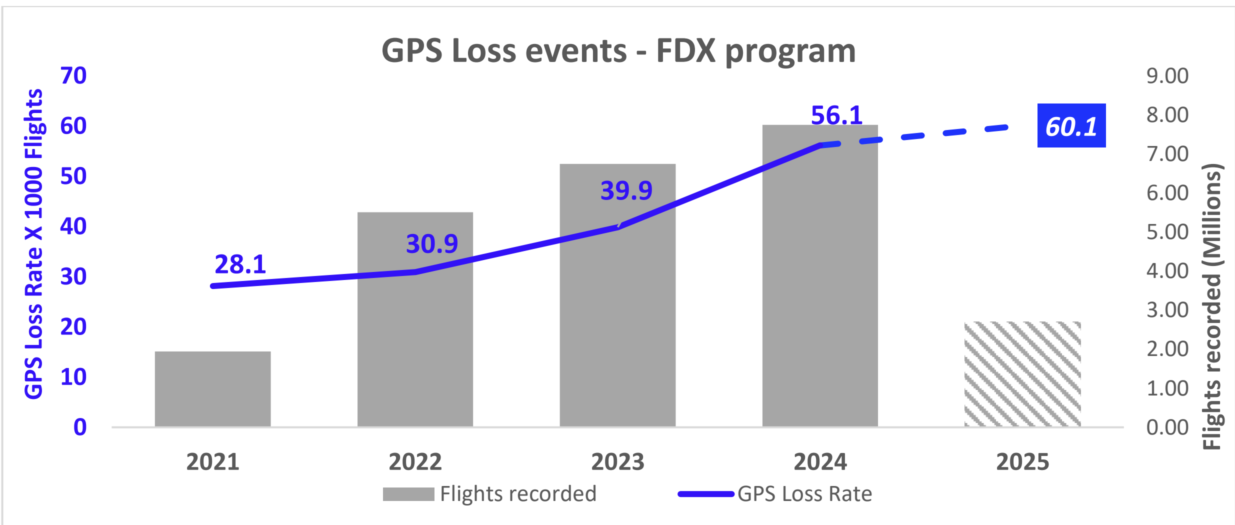

Figure 2 GPS loss events evolution

From August 2021 to June 2025, FDX program members experienced +1M instances of GPS signal loss of around 24.6 million flights processed by the program. It is important to highlight that the figures are not based on voluntary reports but aircraft-recorded ADS-B data. Therefore, FDX provides a good geographic identification of the RFI hotspots.

Over the past three years, the picture of RFI hotspots has evolved. The FDX program continues to identify emerging hotspots where GNSS outages are increasing hazard exposure.

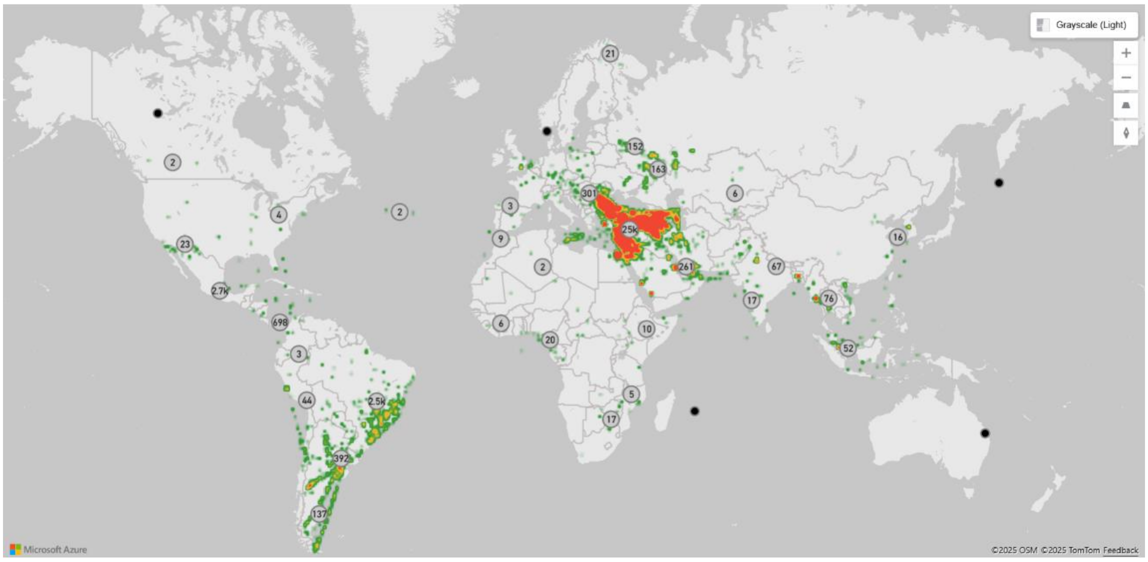

Figure 3 GNSS-RFI Recorded events 2022.

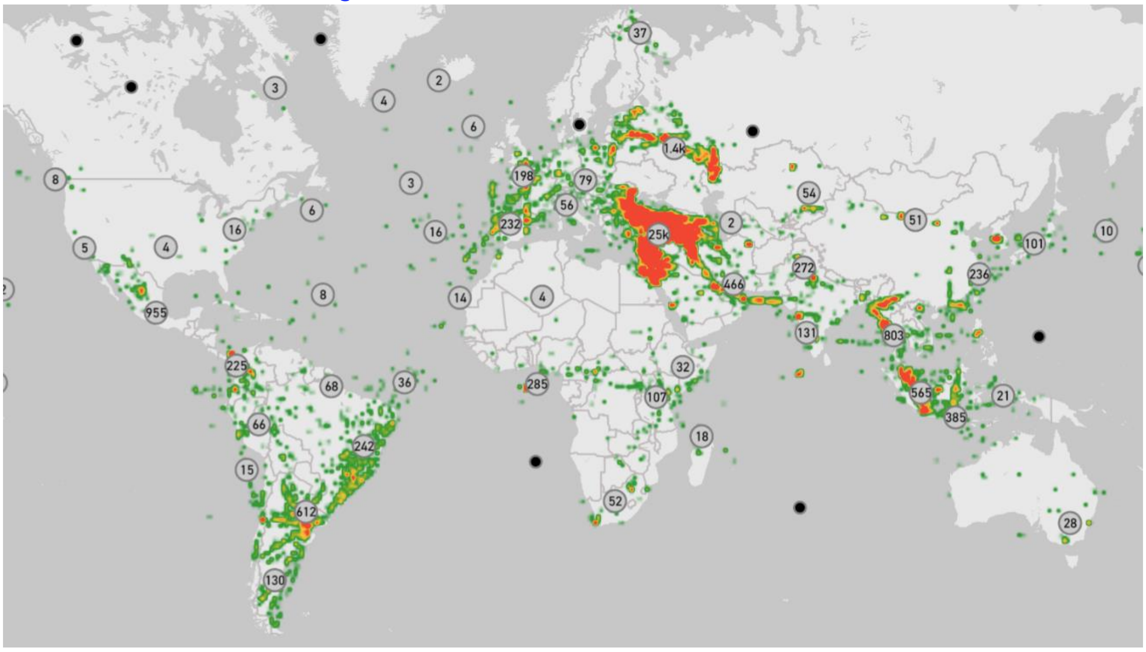

Figure 4 GNSS-RFI Recorded events 2023

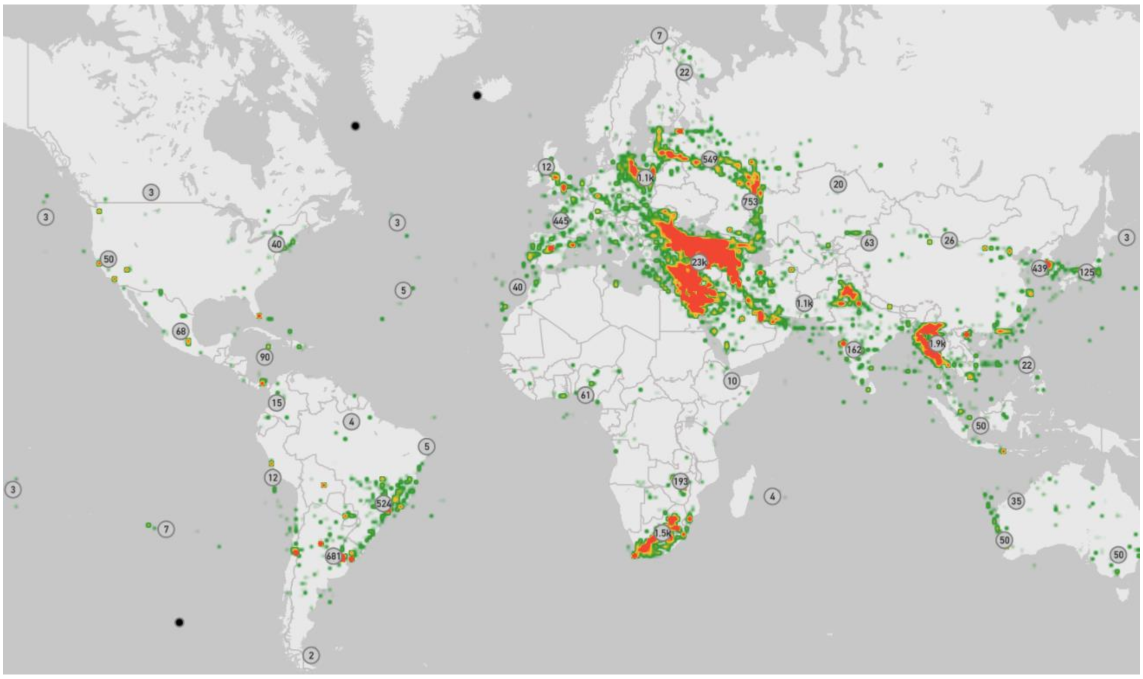

Figure 5 GNSS-RFI Recorded events 2024

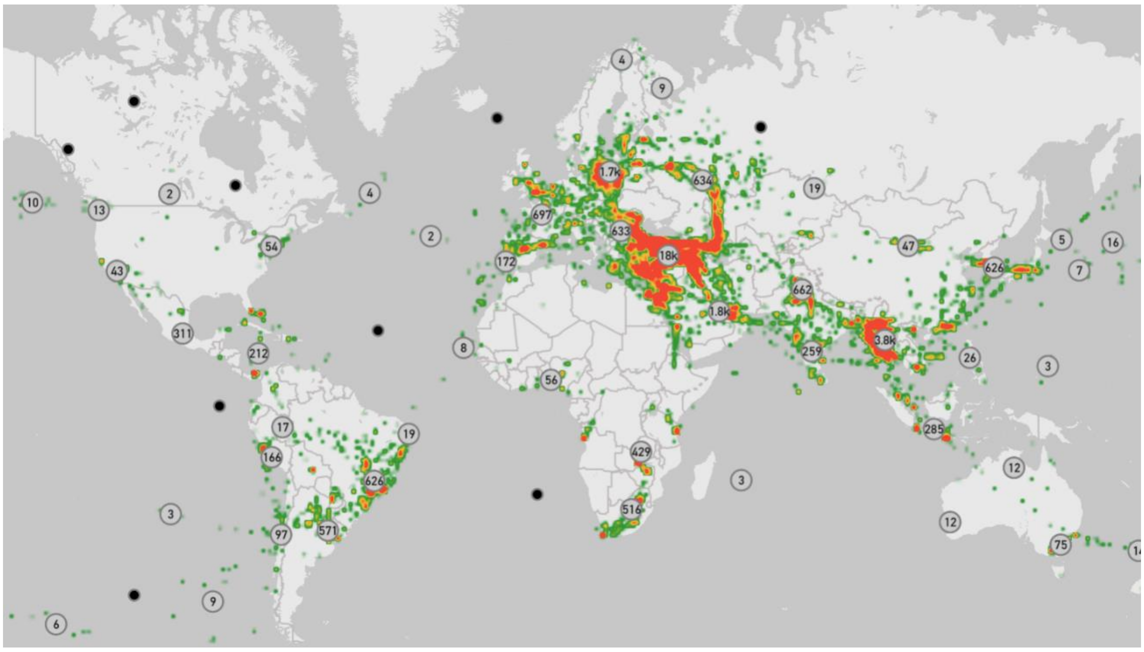

Figure 6 GNSS-RFI Recorded events Jan-Jun 2025 | Current Hotspots.

Call to action. It is recommended that operators continually assess their exposure to GNSS-RFI. One way to gather information and monitor GNSS-RFI zones is by utilizing the [IATA Flight Data Exchange (FDX) program](), which incorporates reporting from over 300 operators. It offers regional and country route pair granularity and can help airlines formulate risk mitigation.

The IATA FDX program is currently developing a new parameter to address GPS spoofing. Additionally, analysis of EGPWS activations and events during arrival and departure related to spoofing and jamming has been proposed. Furthermore, improvements are being made to provide members with accurate and relevant information by integrating FDX data with ADS-B outage information.

The portals GPSjam, Flightradar24, and Live GPS Spoofing tracker map may also be useful, understanding that the data they present is not validated by IATA. They use ADS-B data to generate maps of GNSS-RFI based on aircraft reports of their accuracy in their navigation systems. These sources typically give a snapshot of RFI during recent days.

Top Event

Is defined as a point in time when an organization loses control over a hazard, resulting in an unsafe operational or undesired safety state. This risk assessment defines degradation of communications (CPDLC), navigation, and surveillance performance as the top event.

Call to action. Establish a set of Safety Performance Indicators (SPI) related to GNSS-RFI and aircraft communications, navigation, and surveillance performance degradation.

A detailed description of these cockpit effects is given in the Airbus In service information 34.36.00049 - GNSS loss and GNSS Interferences on Airbus A/C. (*available to subscribers of the Airbus customer portal*).

Likewise, Boeing has provided the flight deck effects associated with GPS RFI in its model-specific Flight Operations Technical Bulletins (FOTB) accessible in MyBoeingFleet.For a more accurate analysis of the impact of GNSS-RFI events on an air operator's network, it is advisable to establish a set of SPIs that can be monitored through the operator's flight data monitoring program. These SPIs could relate to navigation display/primary flight display annunciations, Electronic Centralized Aircraft Monitor (ECAM) alert status, or inoperative system ECAM messages as described in the Airbus in-service information - GNSS loss and GNSS Interferences on Airbus A/C- cockpit effects section.

Encouraging flight crews to submit GNSS-RFI reports is also recommended as a complementary measure to enrich GNSS outage information. However, as automated reporting is more consistent, airlines are encouraged to join the FDX program, which enables the capture of GNSS-RFI occurrences recorded by Digital Flight Data Recorder (DFDR).

Additionally, ensure the established safety reporting program captures the required details to report GNSS-RFI events to Air Navigation Service Providers (ANSPs), other Authorities, OEMs, and IATA through IDX when GNSS-RFI events are confirmed.

Analysis of cockpit effects will identify specific airports, routes, flight levels, and flight phases where GNSS-RFI is likely. This intelligence will support specific mitigation actions as each operator's risk of exposure to GNSS-RFI varies based on their operational network.

Threats.

Are understood as a potential cause of a top event or precursors of an undesired safety state. The different threats and their likelihood to affect normal operations are key considerations in conducting an accurate risk assessment. Broadly, the degradation of an aircraft's communications (CPDLC), navigation, and surveillance performance may result from the following precursors.

Precursors	Description
Jamming	Locally generated RFI is used to "drown out" satellite signals. Possible sources: PPD – Personal Privacy devices, TV broadcast station malfunction, and military RFI. Easier recognition. The effects of jamming are typically immediate and noticeable by the flight crew, as systems fail to receive GNSS signals.
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). Detecting spoofing is more challenging and not immediate for flight crews, which poses a greater safety risk than jamming.
Solar Storms	Electromagnetic interference from space weather events such as solar CMEs "drowns out" the GNSS satellite signals.
Signal Reflection	Reflection and/or refraction of GNSS signals due to objects such as buildings or ionospheric scintillation.

Table 1 GNSS-RFI precursors.

With jamming, the GPS signal is interrupted to the point of being unusable. With spoofing, a false GNSS signal is transmitted, causing airborne receivers to produce false position outputs, sometimes without triggering cockpit warning annunciations.

Call to action. Integrate a periodic evaluation of exposure to threats identified in the GNSS-RFI risk model into risk management activities. This approach is key to reducing exposure, especially to spoofing.

The industry is currently developing solutions to detect RFI areas, determine their source and location, and improve notifications to airspace users.

Consequences.

Defined as a potential accident scenario resulting from a top event, which might result in loss or damage. The impact of RFI is specific to the model and modification status of the GNSS receiver, the aircraft manufacturer's integration of the receiver in a particular aircraft make/model, and the radio frequency (RF) performance of the GNSS antenna(s). The information provided below indicates possible consequences. However, any potential impact on your fleet should be considered in consultation with the Original Equipment Manufacturer (OEM)[2].

Systems affected / Potential Accident scenarios		CFIT	MAC	RE
Navigation	Downgraded aircraft position computation. GPS (Loss of GPS primary)	X		
	Loss of FLS[3], GLS[4], SLS[5] deviations, and loss of RNP[6] and RNAV[7] 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 ND	X		
	Loss of ADS-B[8] Out Reporting False ADS-B Out Position Reporting		X	
	Loss of Traffic Alert and Collision Avoidance System (TCAS)		X	
Communication	Loss of CPDLC[9] and SATCOM[10]		X	
Others	Loss of Runway Overrun Prevention System – (ROPS) or Runway Situation Awareness Tools			X

Table 2 GNSS-RFI potential consequences.

Using a sample size of approximately 370,000 flights, IATA data shows that when exposed to RFI, airborne GNSS receiver recovery time can, in a significant number of cases, exceed 30 minutes with consequent elevation in the risk of operational disruption.

Call to action. Review the consequences mentioned above. The purpose is to ensure that all consequences and weakened recovery controls are included in the risk model. This will provide information to assess recovery controls' effectiveness.

[2] Refer to the OEM technical information to determine the effects on the aircraft-type systems.
[3] FMS Landing System
[4] GBAS Landing System (Ground Based Augmentation System)
[5] SBAS Landing System (Satellite Base Augmentation Systems)
[6] Required Navigation performance
[7] GNSS Based area Navigation
[8] Automatic Dependent Surveillance-Broadcast
[9] Controller Pilot Data Link Communication
[10] Satellite Communications

Preventive Controls

Should be understood as a barrier preventing a threat from becoming a top event. A set of prevention controls configures the organization's mitigation strategy to reduce and control the risk of GNSS-RFI.

Preventive Controls from the Operator's Perspective
Flight planning | Checking NOTAMS related to known or expected GNSS-RFI.
Flight Planning | Checking the availability of non-GNSS-based routes, procedures, and approaches (ILS, VOR, and DME).
Flight Planning | Consider limitations caused by inoperative radio navigation systems to operate in GNSS-RFI-affected areas.
En route | Enforce action ECAM/EICAS and FCOM or supplemental procedures for loss of GNSS.
Post-flight | Technical report in the maintenance logbook in case any cockpit effects related to GNSS-RFI are experienced.
Post-flight | Establish maintenance/operations feedback after troubleshooting GNSS-RFI reports.
Post-flight | Report any suspected GNSS-RFI events to relevant regional and international organizations (e.g., IATA, ANSPs,).
Post-flight | When RFI is identified, aircraft data should be sent to OEMs for further investigation.

Table 3 GNSS-RFI Preventive controls

According to The GNSS-RFI Correspondence Group (CG), reporting confirmed GNSS-RFI to the applicable spectrum authority for the airspace where the RFI occurred is important as the spectrum authority oversees the investigation to, if possible, resolve the interference. Therefore, confirming that GNSS outage events were not due to equipment failure is important. Refer to Airbus recommendations to establish a mechanism to confirm GNSS-RFI events. (*available to subscribers of the Airbus customer portal*).

On the other hand, refer to the corresponding Fleet Team Digest (FTD) released by Boeing for the specific Boeing aircraft you operate.

Prompt airspace user reporting may assist spectrum authorities in negating the RFI in a timely manner.

Call to action. Ensure preventive controls are documented, implemented, and trained as required. It is recommended that a contingency/mitigation procedure be outlined to prevent threats from degrading navigation, surveillance, and other avionic system performance.

Ensure flight crews are informed and provided with relevant guidance to safely identify and respond to GNSS-RFI.

Feedback should be established with maintenance organizations to confirm RFI or equipment malfunction. Establish a mechanism to report confirmed RFI events to ANSPs, national authorities, and IATA. Airlines participating in the Incident Data Exchange (IDX) program are encouraged to share GNSS interference-related occurrences.

Additional Preventive Controls – External to Air Operators

The use of multi-constellation receivers can improve availability and reliability. However, their higher cost and effectiveness against broadband interference across the entire GNSS frequency range should be evaluated.

The following table summarizes initiatives to mitigate the effect of GNSS-RFI on civil aviation.

Preventive controls from National/International organizations and OEMs
Regulatory control of RFI - ITU regulations and the resolution on GNSS-RFI agreed at WRC23. - Coordination activities for civil/military GNSS interference testing.
Identification and localization of interfering sources - ITU's Satellite Interference Reporting and Resolution System (**SIRRS**).
Mitigation of RFI onboard - Development of Dual-Frequency/Multi-Constellation (DFMC) and Multi-Frequency Multi-Constellation (MFMC) receivers and Minimum Operational Performance Standards (MOPS).

Table 4 GNSS-RFI External to Operators preventive controls

Call to action. Identify and establish communications with the SIRRS manager(s) in the applicable airline State of Registry (ANSP/Spectrum Regulator) to ensure any potential air operator’s reporting requirements are met, and gaps are addressed when reporting interference cases.

The ITU Radio Communication Bureau has developed an online application in response to Resolution 186 of the Plenipotentiary Conference 2014. The aim is to facilitate administrations and space stakeholders' reporting of cases of harmful interference affecting space services.

In May 2025, EASA and IATA hosted a workshop on Positioning, Navigating, and Timing (PNT) resilience. The workshop aimed to explore how to strengthen resilience and ensure operational continuity in response to the growing challenges posed by GNSS- RFI.

Further, IATA will propose to the 42nd ICAO Assembly a multifaceted approach based on the following considerations.

1. **Effective ICAO / State Coordination: Military RFI**
   a) Military entities are currently the most significant originators of deliberate, debilitating GNSS-RFI impacting civil aviation. Despite prior requests from ICAO, some states persist in jamming and spoofing international civil aviation.

2. **Enhanced Monitoring and Reporting: Non-military RFI**

   a) Standardized Incident Reporting: Development and implementation of a robust, standardized global reporting mechanism for GNSS-RFI events, including details on location, duration, characteristics, and impact on operations. This data is crucial for trend analysis, source identification, and risk assessment.

   b) Improved Detection Capabilities: Encouraging and supporting the development and deployment of advanced RFI detection and localization systems, terrestrial, airborne, and space-based.

Recovery controls

Consider the barriers listed in Table 5, which can enhance air operators' operational systems based on standard operating procedures and policies to prevent a top event from escalating into an accident.

Operators / Recovery controls
En route – Enforce abnormal/emergency procedures as appropriate.
En route – Establish/enforce procedures regarding cross-checking position using other available navigation systems (radio navaids, e.g., VOR, DME), INS, and visual references.
En route - Establish/enforce procedures for location cross-check with air traffic control (ATC) before attempting troubleshooting.
En route - Establish/enforce procedures to revert to available alternate navigation systems (VOR, DME, INS) radar vectors from ATC.
En route - Establish/enforce requirements to notify ATC about GNSS-RFI, and if cockpit annunciation of ADS-B OUT failure is available, add that information to communications with ATC.
Approach - Enforce procedures to conduct conventional arrival/approach procedures.

Table 5 GNSS-RFI recovery controls

Call to action. Ensure recovery controls are documented, implemented, and trained as required. It is recommended that additional safety controls, such as dead reckoning, be identified as an alternative navigation method (If applicable).

Call to Action. Review and establish a process for continuously updating technical information about GNSS interference from OEMs. This will ensure that necessary changes to operational procedures are communicated and implemented across the organization.

Recommendations

Airlines

- Develop or update the risk model using the appropriate assessment technique to evaluate the operator's exposure to GNSS-RFI hazards across the operational network.
- Establish Safety Performance Indicators (SPI) related to GNSS-RFI consequences on aircraft navigation and communication performance degradation, focusing on navigation display alerts in line with OEM technical information that can be tracked using the operator's flight data monitoring program.
- Encourage flight crews to submit GNSS-RFI-related safety reports.
- Establish a mechanism to report confirmed RFI events to ANSPs, national authorities, and IATA.
- Ensure the safety reporting program captures all required details.
- Integrate a periodic evaluation of the exposure to threats identified in the GNSS-RFI risk model into risk management activities.
- Ensure that the preventive controls listed in Table 3 are documented, implemented, and trained as required.
- Ensure that the recovery controls listed in Table 5 are documented, implemented, and trained as required.
- Consider circulating aircrew notices, special crew briefings and supplementary procedures to enhance crew awareness of cockpit effects and required actions before, during and after GPS interference.
- Stay in contact with aircraft and equipment manufacturers to receive guidance on operating aircraft and systems during jamming or spoofing and integrate their recommendations into standard procedures.
- Consider using simulator training sessions to explore RFI-related CRM and crew mitigation.

IATA

- Assist operators in identifying GNSS interference hotspots.
- Evaluate the feasibility of providing near real-time information via tools such as FDX.

ANSP

- Promptly notify airlines and airspace users once GNSS-RFI is detected.
- Inform flight crews and air traffic controllers about the impact of GNSS interference and establish effective contingency procedures and capabilities as appropriate.
- Coordinate with the State spectrum regulator to establish monitoring, notification, and mitigation processes.
- In coordination with airlines and other airspace users, periodically reassess the national CNS rationalization plan, ensuring a minimum operating network (MON) for operational resilience.
- Ensure that flights impacted by GNSS-RFI are instructed (by NOTAM) to inform ATC so that ANSPs can plan route realignment and other mitigations for longer-term RFI issues.
- Implement and maintain Minimum Safe Altitude Warning (MSAW) as a ground-based safety net to mitigate risks of GNSS-RFI. MSAW shall:

  - Continuously compare aircraft transponder reported pressure-altitude data to defined minimum safe altitudes - independent of GNSS inputs.
  - Provide timely (visual/audible) alerts to controllers if an aircraft is detected or predicted to descend below safe altitude.
  - Ensure parameters are up to date, controllers are trained to manage alerts in GNSS-RFI scenarios, and system performance is regularly verified.
- Monitoring ADS-B Quality factor: Ensure the ATM system monitors ADS-B Out quality indicators to detect GNSS-RFI. When ADS-B quality factors - NUCp, NIC, NACp, and SIL are significantly degraded, the ATM system shall:
  - Prompt controllers of the degraded state and identify affected aircraft.
  - Controllers to advise aircraft to transition to suitable conventional navigation aids until GNSS performance is restored.

STATES

- Implement appropriate mitigation measures as contained in the ICAO GNSS Manual (Doc 9849) as a matter of high priority and report progress and any difficulties to ICAO.
- Through the planning and implementation of regional groups (PIRGs), regional or global navigation satellite system reporting mechanisms are developed, as described in the Global Navigation Satellite System (GNSS) Manual (Doc 9849).
- Review aircraft minimum equipment lists to ensure compatibility with States implemented minimum operational networks.
- While using GNSS jammers during military exercises and operations, recognize the impact of harmful interference to civil flight operations and exercise caution to the maximum extent possible to protect the safety of flight.
- Establish appropriate spectrum regulations to protect GNSS frequencies in line with ITU Radio Regulations.
- Consider operational risks associated with GNSS-RFI during the rationalization of conventional navigation and surveillance infrastructure and incorporate inputs from airspace users while developing a CNS MON.
- Ensure that contingency procedures are established in coordination with air navigation service providers and airspace users and that essential conventional navigation infrastructure, particularly Instrument Landing System (ILS), is retained and fully operational.

ICAO

- To endorse the multifaceted approach and to accelerate work under its program to achieve those actions.

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