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Cuestión 5 del Orden del Día: **Sesión de trabajo colaborativa de Grupos de Tarea NACC/WG**

Red Mínima Operacional (MON)

(Presentada por IATA)

RESUMEN EJECUTIVO

Esta nota de estudio presenta información sobre la interferencia de radiofrecuencia GNSS y propone el desarrollo de un Material de Orientación Regional para armonizar la implementación de una Red Mínima Operativa por parte de los Estados NACC.

Acción:	Acciones sugeridas bajo el ítem 3 de esta nota de estudio.
Objetivos Estratégicos:	• Seguridad Operacional • Capacidad y eficiencia de la navegación aérea • Desarrollo económico del transporte aéreo • Protección del medio ambiente
Referencias:	• 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. Introducción

1.1 El Sistema Global de Navegación por Satélite (GNSS) es compuesto por el Sistema de Posicionamiento Global GPS de EE. UU., el GLONASS de Rusia, el BeiDou de China y el Galileo de Europa, e incluye infraestructura terrestre y constelaciones de satélites que proporcionan información de posición, navegación y sincronización (PNT), apoyando las operaciones de aeronaves y la gestión del tránsito aéreo.

1.2 Las señales de navegación por satélite son débiles y pueden verse comprometidas por interferencias de radiofrecuencia (RFI), incluidas interferencias de señal intencionadas o no intencionadas, jamming y/o spoofing. Los efectos de la RFI varían. El jamming o spoofing de señales pueden afectar seriamente los sistemas de navegación de las aeronaves, provocando un comportamiento anómalo de los sistemas aviónicos.

1.3 Los usuarios del espacio aéreo dependen del funcionamiento normal de los sistemas de la aeronave, incluida la supervisión automatizada, los sistemas de precaución y alerta. Los sistemas aviónicos como los Sistemas de Gestión de Vuelo (FMS) requieren GNSS para navegación y sincronización. La posición GNSS también se utiliza en el Sistema de Advertencia de Evasión de Terreno (TAWS) o en el Sistema Mejorado de Advertencia de Proximidad al Suelo (EGPWS). Por lo tanto, un servicio PNT GNSS libre de interferencias es esencial para la seguridad del vuelo.

1.4 Desde 2023 se han emitido varias alertas de seguridad, entre ellas la FAA SAFO 24002 y EASA SIB No.: 2022-02R3. IATA ha desarrollado un Análisis Integral de Riesgos de Seguridad (SRA), adjunto como apéndice A a esta nota de estudio (solamente en inglés). Este SRA también puede obtenerse en IATA GNSS Interference RFI SRA.

1.5 Una de las iniciativas actuales para mitigar los efectos de la RFI en el GNSS es la planificación e implementación de una Red Mínima Operativa (MON). De acuerdo con la definición de EUROCONTROL – MON Concept and Design Criteria, el objetivo del MON es mejorar la rentabilidad de la infraestructura CNS mediante la optimización, incluyendo el retiro de equipos en tierra de comunicaciones, navegación y vigilancia, mientras se proporciona un nivel adecuado de resiliencia y se mantiene un nivel aceptable de seguridad y protección. El documento mencionado también ofrece criterios de diseño para el desarrollo de dicho MON CNS.

1.6 Asimismo, conforme a EUROCONTROL, el término MON se ha asociado tradicionalmente con la infraestructura de navegación mínima que permite a las aeronaves volver a los procedimientos de navegación convencionales tras la pérdida del servicio GNSS. El enfoque desarrollado en el documento de Concepto MON y Criterios de Diseño de Eurocontrol tiene como objetivo ampliar el concepto MON al CNS, considerando no solo la infraestructura mínima requerida para respaldar la infraestructura de reversión que permite a las aeronaves continuar las operaciones de manera continua, sino también los procedimientos de contingencia.

1.7 La 14ª Conferencia de Navegación Aérea de la OACI (AN-CONF/14) coincidió en la importancia de mantener una red suficiente de VOR, DME e ILS para garantizar la seguridad, así como una capacidad de espacio aéreo adecuada durante periodos de interferencia con el GNSS. Al considerar la necesidad de eliminar gradualmente los sistemas de navegación tradicionales, la conferencia coincidió en que dicha eliminación debe tener en cuenta la necesidad de mitigar eficazmente las RFIs con GNSS, y que las listas mínimas de equipamiento de las aeronaves deben actualizarse para reflejar este requisito.

1.8 La AN-CONF/14 formuló la Recomendación 2.2/2 – Interferencia con el Sistema Global de Navegación por Satélite y Contingencia, que hace referencia a los esfuerzos internacionales para abordar la interferencia con los Sistemas Globales de Navegación por Satélite (GNSS) y la necesidad de planificación de contingencia para garantizar la seguridad y continuidad en las operaciones de navegación aérea. Esta recomendación insta a los Estados y a la OACI a tomar varias iniciativas para abordar este tema esencial para el presente y el futuro de la navegación aérea.

1.9 En relación con MON, la recomendación 2.2/2 de la AN-CONF/14 requiere lo siguiente:

a) Estados - se aseguren de que se implementen medidas eficaces de mitigación de la interferencia de radiofrecuencias en el sistema mundial de navegación por satélite sobre la base de medidas elaboradas por la OACI y la industria, incluida la necesidad de mantener una red suficiente de ayudas para la navegación y suficiente capacidad del espacio aéreo durante épocas de interferencia en el sistema mundial de navegación por satélite;
b) Estados - examinen las listas de equipo mínimo de las aeronaves para que exista compatibilidad con las redes operacionales mínimas de los Estados.
c) ICAO - elabore un paquete de asistencia para la implementación normalizado para asistir y guiar a los Estados en la implementación efectiva de las medidas de mitigación de interferencia de radiofrecuencias en el sistema mundial de navegación por satélite, incluidas la optimización y racionalización de las ayudas para la navegación convencionales, acordes con sus condiciones locales, para garantizar la continuidad de la prestación de servicios de navegación aérea
d) ICAO - formule recomendaciones de listas de equipo mínimo de aeronave mundialmente armonizadas a fin de que los usuarios del espacio aéreo puedan utilizar la infraestructura de navegación existente con arreglo a los servicios de tránsito aéreo disponibles.

2. Red Operacional Mínima

2.1 Según el Boletín de Información de Seguridad de EASA – ATM/ANS SIB No. 2022-02R3 – la interferencia de radiofrecuencia GNSS (RFI) se ha convertido en un riesgo significativo para la seguridad, particularmente en áreas geográficas cercanas a zonas de conflicto y en el Mediterráneo oriental, Oriente Medio, Mar Báltico y zona ártica, donde la RFI puede aumentar la carga de trabajo de los pilotos y controladores de tránsito aéreo.

2.2 La RFI del GNSS no se limita a las regiones de información de vuelo (FIR) afectada destacada en el boletín de seguridad de EASA. Según IATA FDX, se ha convertido en un riesgo de seguridad en otras áreas geográficas.

2.3 El gráfico a continuación ilustra la tendencia de interrupciones en GNSS en el pasado reciente. En la primera mitad de 2024, las pérdidas de señal GPS por cada 1000 vuelos han aumentado significativamente en comparación con 2023.

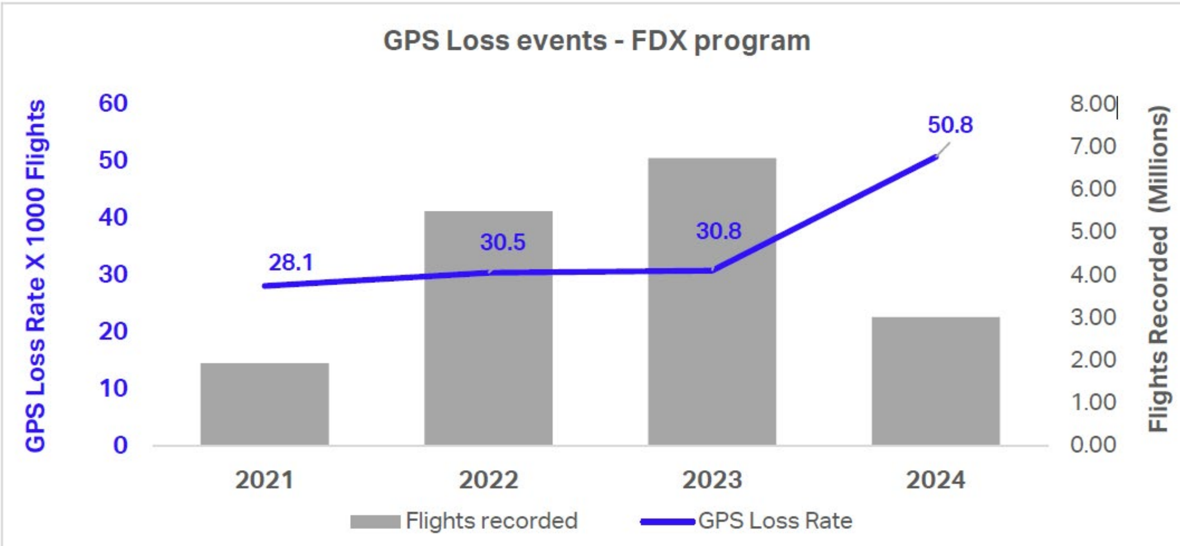

Figura 1 - Evolución de los eventos de pérdida de GPS

2.4 Desde agosto de 2021 hasta junio de 2024, los miembros del programa FDX experimentaron más de 580 000 casos de pérdida de señal GPS en aproximadamente 18,4 millones de vuelos procesados por el programa. Es importante destacar que estas cifras no se basan en reportes voluntarios, sino en datos registrados por las propias aeronaves. Por lo tanto, FDX ofrece una buena identificación geográfica de los puntos críticos de interferencia RFI.

2.5 El programa FDX continúa identificando nuevos puntos críticos emergentes donde los cortes GNSS están aumentando la exposición al riesgo.

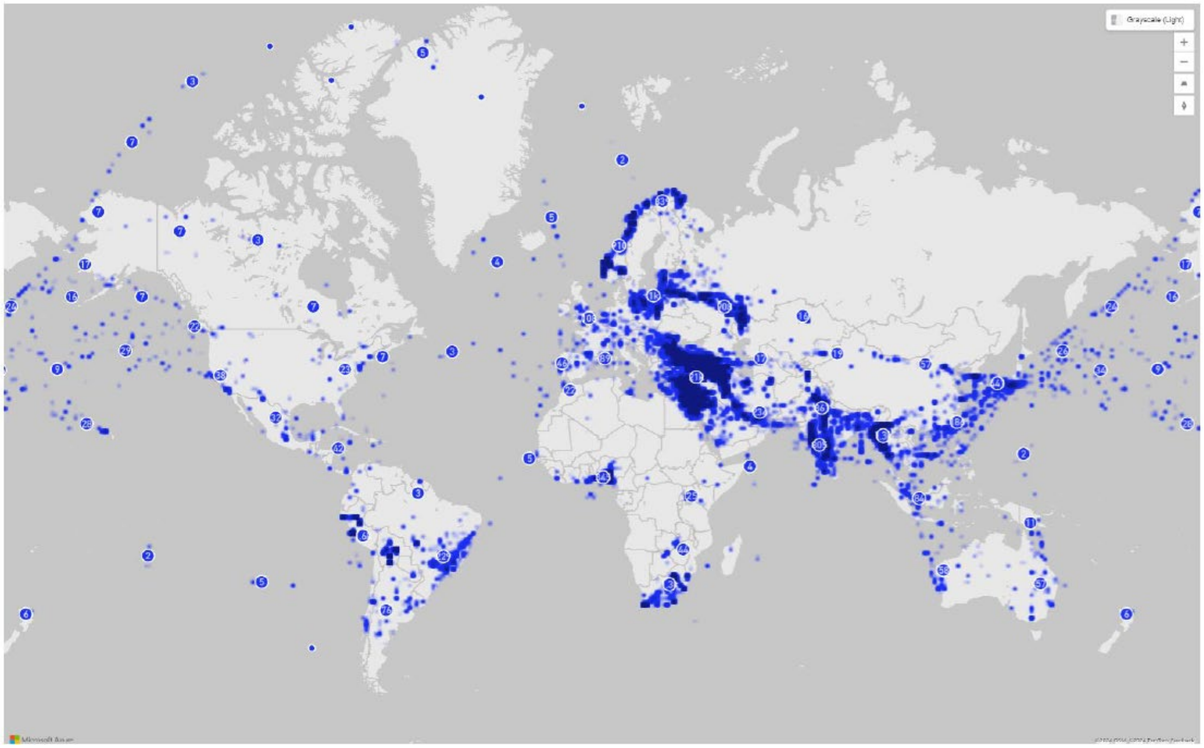

Figura 2 - Eventos registrados por RFI GNSS (enero-junio de 2024): puntos críticos actuales

2.6 El SRA de IATA sobre interferencias GNSS RFI formuló una serie de recomendaciones para aerolíneas, proveedores de servicios de navegación aérea (ANSP), Estados, la OACI y la propia IATA. En relación con la Red Mínima Operativa (MON), se realizaron las siguientes recomendaciones:

- ANSP – En coordinación con las aerolíneas y otros usuarios del espacio aéreo, reevaluar periódicamente el plan nacional de racionalización del CNS, garantizando una MON para la resiliencia operativa
- Estados – Considerar los riesgos operativos asociados con la RFI del GNSS durante la racionalización de la infraestructura de navegación y vigilancia convencional e incorporar aportes de los usuarios del espacio aéreo en el desarrollo de una MON CNS.
- Estados – Asegurar que se establezcan procedimientos de contingencia en coordinación con los proveedores de servicios de navegación aérea y los usuarios del espacio aéreo, y que se conserve operativa la infraestructura esencial de navegación convencional, en particular el ILS.
- OACI – Desarrollar un paquete de implementación estandarizado para asistir y guiar a los Estados en la aplicación de medidas eficaces de mitigación de interferencias de radiofrecuencia del GNSS, incluyendo la optimización y racionalización de ayudas a la navegación convencionales acorde con sus condiciones locales, para garantizar la continuidad en la prestación de servicios de navegación aérea.

2.7 En base a la Recomendación 2.2/2 de la AN-CONF/14, la OACI debería elaborar un paquete de asistencia para apoyar y orientar a los Estados en la mitigación de las interferencias GNSS RFI, incluyendo la optimización y racionalización de ayudas a la navegación convencionales, de acuerdo con sus condiciones locales. Estas condiciones deberían tomar en cuenta, entre otros aspectos, el volumen/complejidad del tráfico aéreo y el nivel de amenaza RFI GNSS en la región NACC y en los Estados.

2.8 Es importante reiterar que la MON tiene como requerimiento la racionalización de la red de equipos CNS e indica que será necesario implementar más equipos en tierra, por ejemplo, DMEs, y mantener equipos que se podría retirar si no hubiera el GNSS RFI, como, por ejemplo, algunos VOR, ILS y radares. De igual manera, dicha racionalización indica que se deberá remover equipos que no son necesarios, tales como NDBs, que no se debería considerar VORs y ILS en un mismo aeropuerto, desde que se implemente una red de DMEs que permitan las aplicaciones RNAV 1 para STARs y SIDs. Además, en mediano/largo plazo, con la implementación ADS-B se debería considerar la remoción de radares donde el volumen y complejidad de tránsito aéreo no sean significativos. Se debe tomar nota de que el grado de GNSS RFI en CAR/SAM no es similar al que ocurre en Europa y Oriente Medio y la MON debe considerar el grado de amenaza correspondiente. La MON debería ser adecuada al escenario operacional de cada Estado, pero es importante tener una Guía Regional, con miras a armonizar los criterios aplicados por los Estados

2.9 En este sentido, se recomienda fuertemente que la implementación de la MON nacional se armonice regionalmente a través del desarrollo del Material de Orientación correspondiente basado en la documentación ya elaborada por Eurocontrol (MON Concept and Design Criteria) y Brasil (PCA-100-5).

3. Acciones Sugeridas

3.1 Se invita a la reunión a:

a) Tomar nota de la información proporcionada en esta nota de estudio.
b) Evaluar la viabilidad de solicitar al NACC/WG, en estrecha coordinación con el GREPECAS, la elaboración de un Material de Orientación Regional relacionado con la planificación e implementación de la Red Mínima Operacional Nacional

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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

<table>
<tr><th colspan="4">Safety Issue</th></tr>
<tr><td colspan="4">Global Navigation Satellite System Radio Frequency Interference – GNSS-RFI</td></tr>
<tr><td>Regional Exposure</td><td>AFI/ASPAC/EUR/LATAM MENA/NAM/NASIA</td><td>Sector Exposure</td><td>All sectors</td></tr>
<tr><td>Key Risk Area</td><td>Controlled Flight Into Terrain (CFIT), Mid Air Collision (MAC), Runway Safety</td><td>Proximity</td><td>Current/<s>Emerging/Future</s></td></tr>
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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.

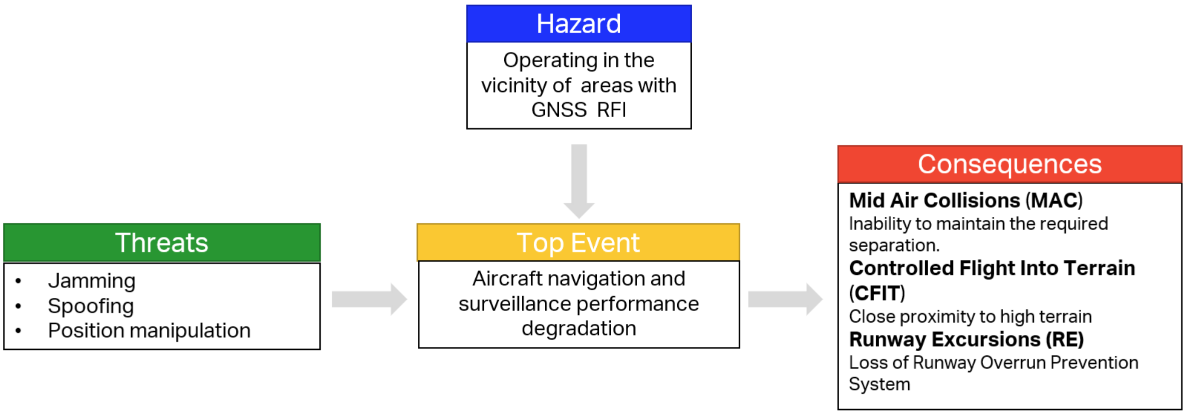

Figure 1 GNSS-RFI - Risk Model

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.

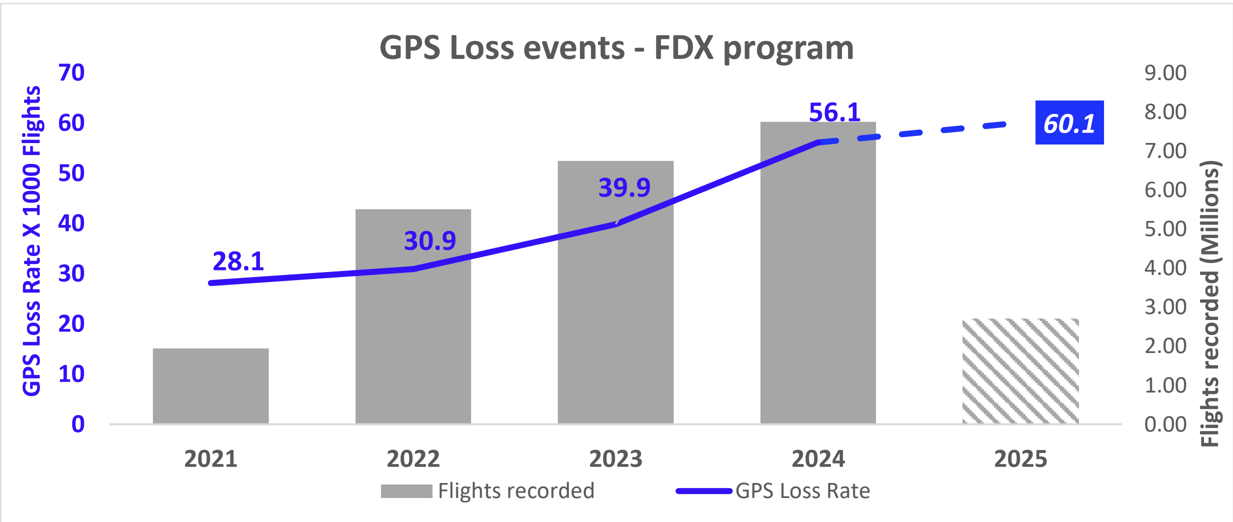

Figure 2 GPS loss events evolution

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.

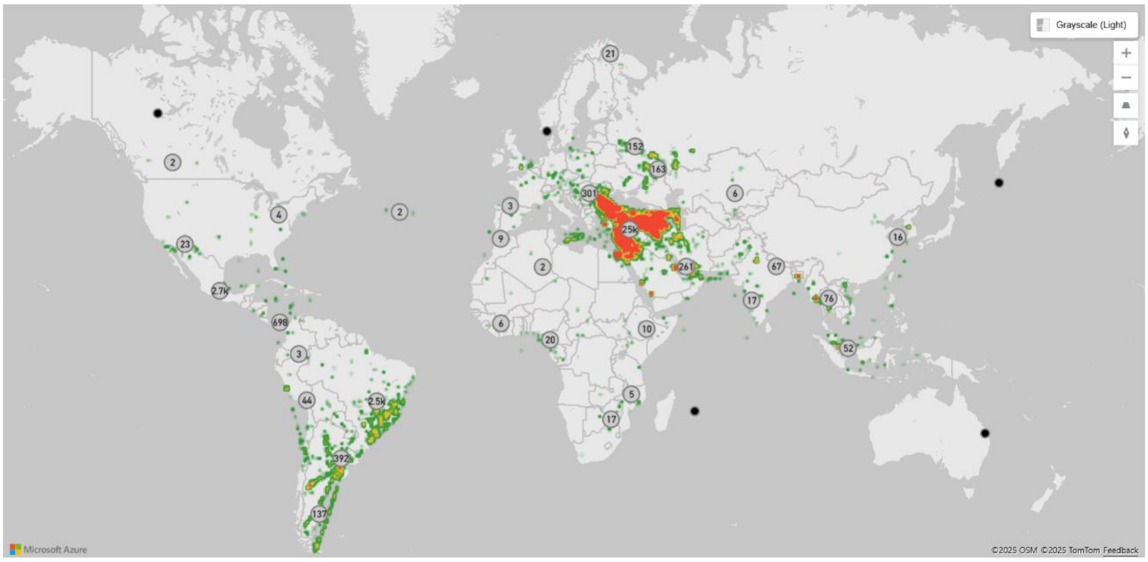

Figure 3 GNSS-RFI Recorded events 2022.

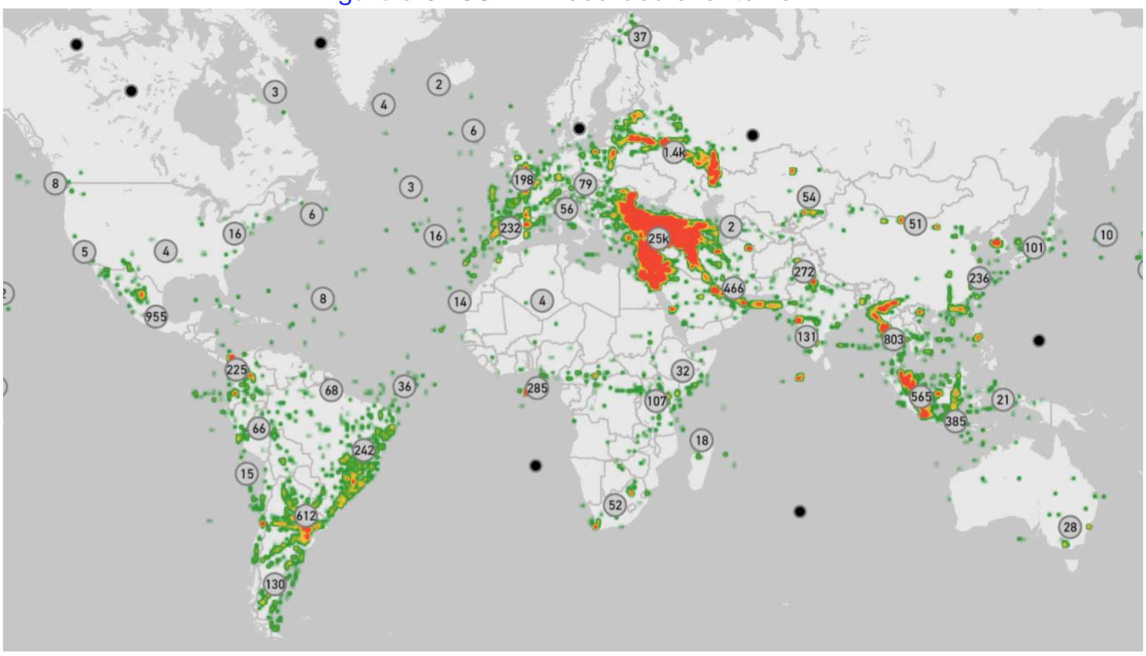

Figure 4 GNSS-RFI Recorded events 2023

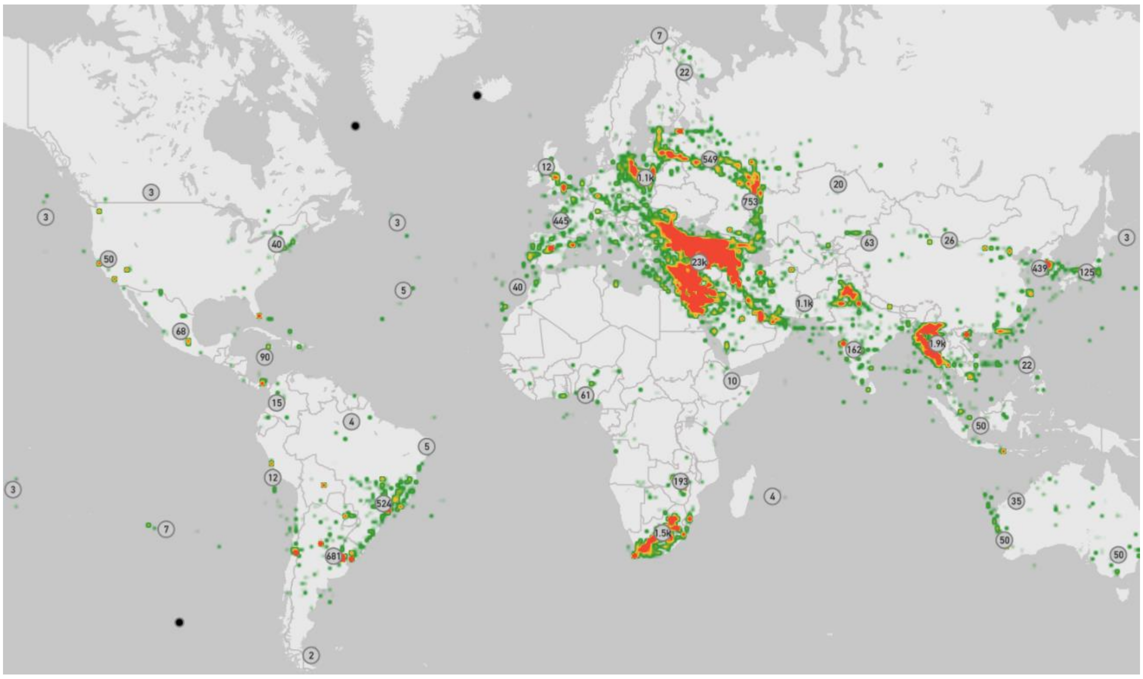

Figure 5 GNSS-RFI Recorded events 2024

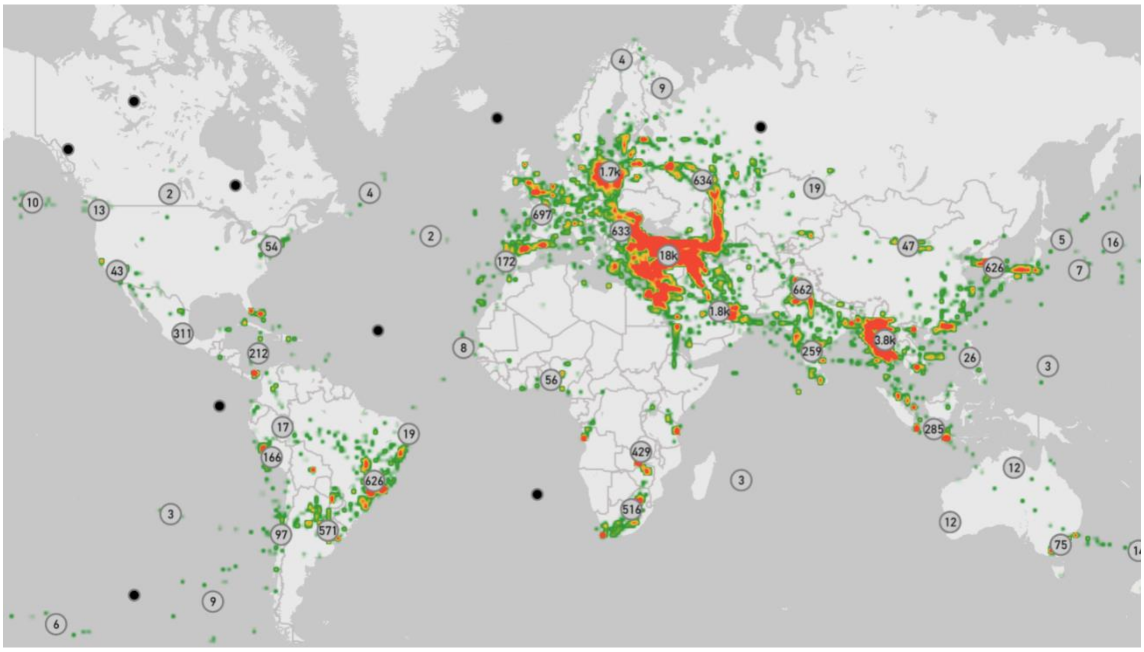

Figure 6 GNSS-RFI Recorded events Jan-Jun 2025 | Current Hotspots.

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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