Global Navigation Satellite System GNSS-Radio Frequency Interference

Safety Risk Assessment

Version 3 September 2023

GNSS Radio Frequency Interference - Fact Sheet

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

Summary of the Safety Issue

Global Navigation Satellite System (GNSS), which involves systems such as Global Positioning System (GPS), Russia's GLONASS, China's BeiDou, and Europe's Galileo, includes navigation satellite infrastructure and constellations which provide position, navigation, and timing (PNT) information supporting aircraft and air traffic management operations.

Satellite navigation signals are weak and can easily be compromised by a range of growing threats, including intentional or unintentional signal interference, jamming, spoofing, and/or manipulating position and timing information. The effects of such threats vary greatly. Satellite signal jamming and spoofing can have a serious impact on the accuracy of navigation systems and, in some cases, result in unusual system behaviour.

Today, airspace users rely heavily on the accuracy of aircraft systems and the aircraft's ability to monitor its reliability. Aircraft avionics such as Flight Management Systems (FMS) require GNSS position for navigation and timing. GNSS position is also used for systems including the Terrain Avoidance Warning System (TAWS) or Enhanced Ground Proximity Warning Systems (EGPWS). Therefore, uninterrupted GNSS PNT service is essential for the safety and operation of flights.

Purpose and Scope of SRA:

This document provides a structured approach to assess the GNSS Radio frequency interference safety issue (GNSS-RFI) and proposes actions for IATA and recommendations to other stakeholders. It provides a standard description of potential threats and preventive controls.

This Safety Assessment serves as a resource to assist IATA members in assessing operational risks and limitations linked to the loss of onboard GNSS capability. Also, it helps in determining if member airline safety controls are effectively controlling GNSS Interference risks or if additional mitigation actions are required.

Introduction

According to EASA Safety Information Bulletin Operations – ATM/ANS SIB No.: 2022-02R1 GNSS RFI has become a significant safety risk, particularly in geographical areas surrounding conflict zones and in 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, 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, northeastern part of FIR Cairo HECC.
- Northern part of FIR Baghdad ORBB , northwestern part of FIR Tehran OIIX.
- Northern part of FIR Tripoli HLLL.

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

- Western part of FIR Vilnius EYVL, northeastern part of FIR Warszawa EPWW. southwestern part of FIR Riga EVRR.

Arctic area:

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

Air operators are encouraged to develop or update their own risk model using the appropriate assessment technique, considering the exposure to threats and the effectiveness of their safety controls within their own operation.

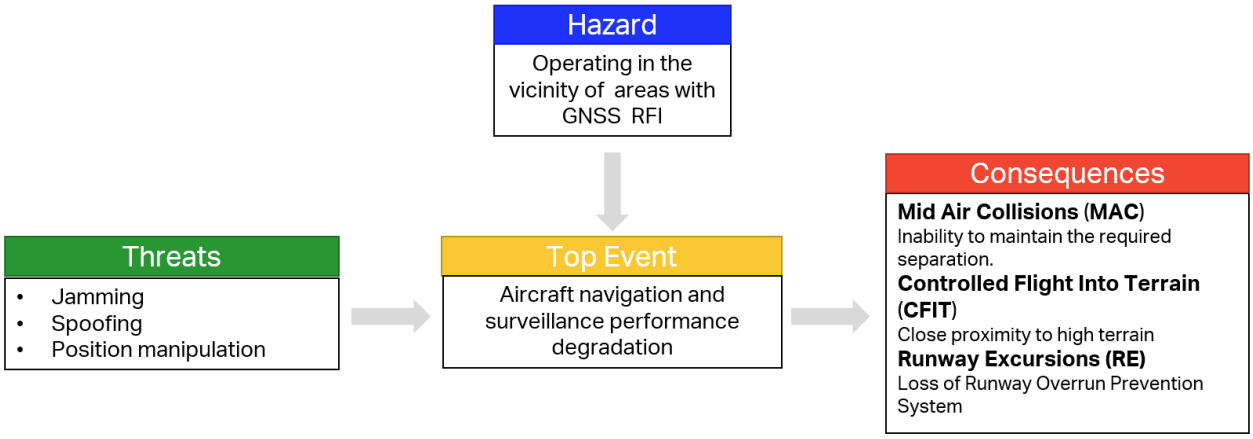

Figure 1 GNSS RFI - Risk Model

Hazard

Relates to a condition with the potential to cause a potential unsafe operational state, loss, or damage. This risk assessment points to operating in the vicinity of areas affected by GNSS RFI as the source of potential degradation of aircraft navigation and surveillance systems.

The exposure to GNSS RFI varies by region. According to industry data (Airbus), 10,843 RFI events were detected globally in 2021. In 2022, this number soared to 49,605, especially in regions such as the Middle East and Eastern Europe. However, events have been recorded across the globe, as depicted in figures 2 to 4. Some States, such as the USA, conduct regular and deliberate military interference with GPS in the USA National Airspace System (NAS) for testing purposes but typically issue notices in advance.

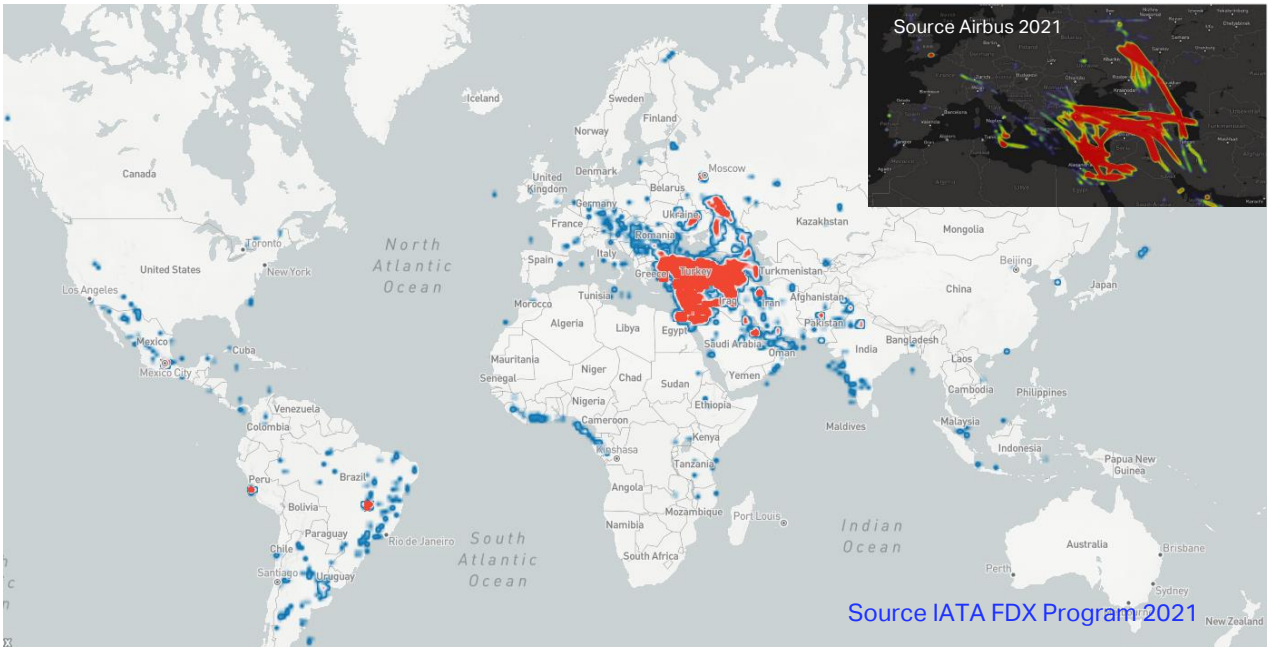

Figure 2 GNSS RFI Recorded events 2021.

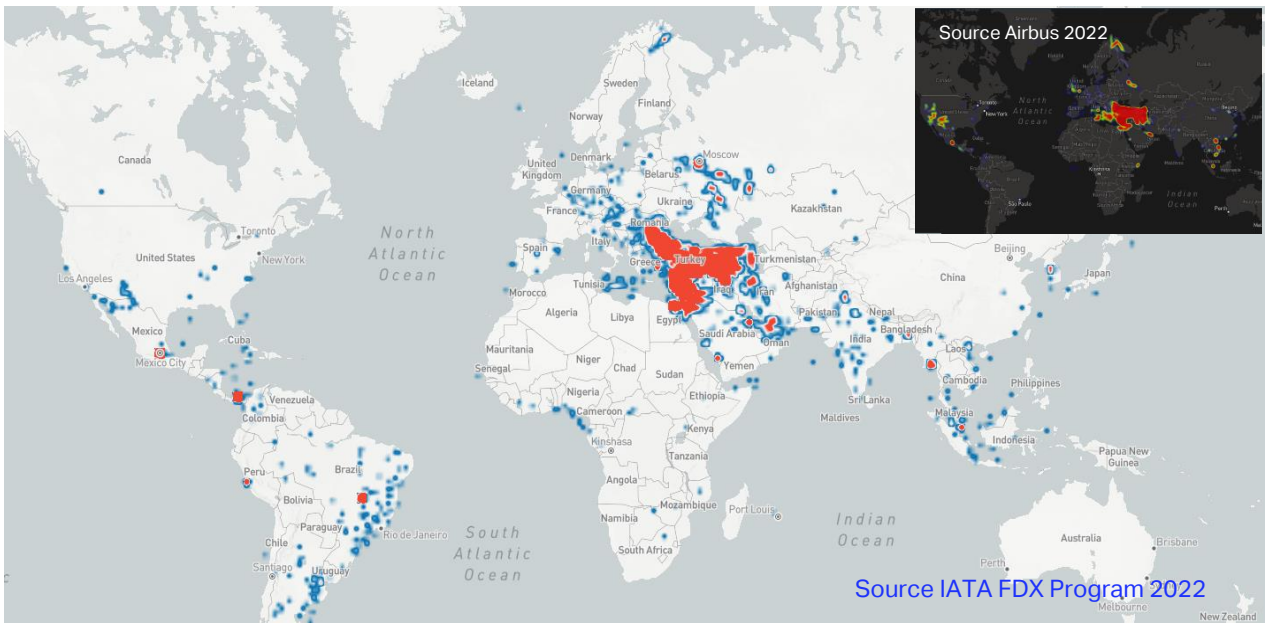

Figure 3 GNSS RFI Recorded events 2022.

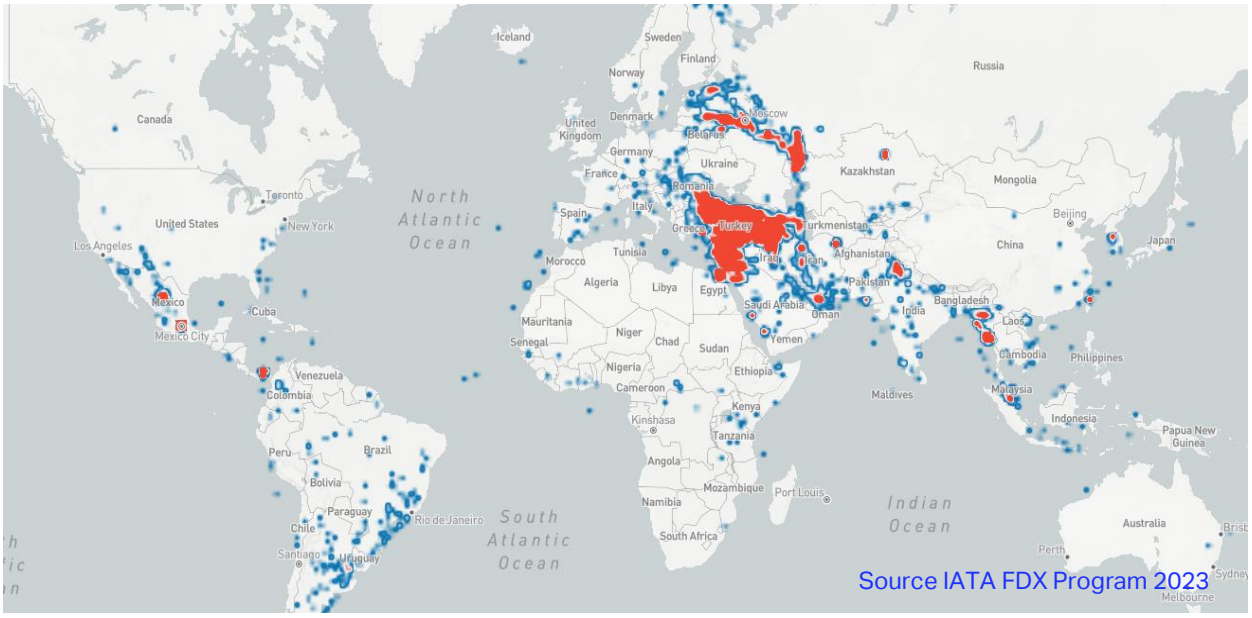

Figure 4 GNSS RFI Recorded events (Jan-Jun 2023)

Call to action. It is recommended that operators assess the exposure to GNSS RFI throughout their operational network. One way to gather information and monitor GNSS-RFI zones is by utilizing the IATA Flight Data Exchange (FDX) program. It provides GNSS loss data reported by over 300 operators and offers details such as regional and country route pairs. To stay informed and take necessary actions to mitigate risk.

The portal GPSjam may be used as an alternative source of information. It uses data provided by ADS-B exchange to generate maps of likely GNSS-RFI based on aircraft reports of their navigation system accuracy.

Top Event

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

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

There are navigation and surveillance capability degradations that flight crews can experience in the cockpit during a GNSS RFI event. 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*)

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 closely 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 cockpit effects section.

Encouraging flight crews to submit GNSS RFI-related safety reports is also recommended as a complementary means to capture and follow up on the GNSS RFI Issue. However, it is recommended to join the FDX program to enable capturing of GNSS RFI occurrences recorded from a Digital Flight Data Recorder (DFDR). Navigation systems are unlikely to produce warnings for spoofing compared to jamming, as the systems do not detect spoofing. Ensure Flight crews are informed about how to recognize spoofing.

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

Monitoring Cockpit effects will determine specific airports, routes, flight levels, and flight phases where it is most likely to experience GNSS RFI interference. This intelligence will support and drive very specific mitigation actions. Each operator's risk of exposure to GNSS RFI varies based on their operational network.

Threats.

Should be understood as a potential cause of a top event or as precursors of an undesired safety state. The different threats and how likely they are to affect is key to conducting an accurate risk assessment. Broadly, the degradation of an aircraft's navigation and surveillance performance may result from the following precursors.

Precursors	Description
Jamming	Locally generated RF interference is used to "drown out" satellite signals. Main possible sources: PPD – Personal Privacy devices, TV Broadcast Station malfunction, and Military RFI.
Spoofing	Fake satellite signals are broadcast to fool it into believing it is somewhere else or at a different point in time. (Position Manipulation)
Solar Storms	Electromagnetic interference from solar flares and other solar Activity "drowns out" the satellite signals in space.
Signal Reflection	Reflection due to objects such as buildings

Table 1 GNSS RFI precursors.

With jamming, the GPS signal is interrupted to the point of being unusable. With spoofing, a false GPS signal is broadcasted, causing GPS systems to produce false positioning without warning flight crews. From the Air operator's standpoint, it is challenging to anticipate GNSS-RFI occurrence through safety monitoring activities.

Call to action. Integrate into the risk management activities a periodic evaluation of the exposure to threats identified in the GNSS RFI risk model. 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 the top event which might result in loss or damage. GNSS RFI may lead to the following scenarios.

Systems affected / Accident scenarios		CFIT	MAC	RE
Navigation	Downgraded Aircraft position computation GPS	X		
	Loss of FLS[1], GLS[2], SLS[3] deviations	X		
Surveillance	Loss of Terrain Awareness Warning System (TAWS) False TAWS Alerts false "Pull up" calls (or no calls)	X		
	Loss of ADS-B[4] Out Reporting False ADS-B Out Position Reporting		X	
	Loss of Traffic Collision Alerting System (TCAS)		X	
Communication	Loss of CPDLC[5]		X	
Others	Loss of Runway Overrun Prevention System – (ROPS), or Runway Situation Awareness Tools			X

Table 2 GNSS RFI potential consequences.

Additionally, GNSS RFI might impact multiple aircraft systems, resulting in operational constraints, including degradation of RNP/RNAV capability, among others.

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.

Preventive Controls

Should be understood as a barrier that prevents 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.

[1] FMS Landing System
[2] GBAS Landing System (Ground Based Augmentation System)
[3] SBAS Landing System (Satellite Base Augmentation Systems)
[4] Automatic Dependent Surveillance-Broadcast
[5] Controller Pilot Data Link Communication

Preventive Controls from the Operator's Perspective
Flight planning | Checking NOTAMS related to Know 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 ECAM/EICAS procedures for loss of GNSS.
Post-flight | Technical report in the maintenance logbook in case of experiencing any cockpit effects related to GNSS RFI
Post-flight | Establish Maintenance/Operations feedback after troubleshooting results for loss of GNSS-related reports.
Post-flight | Report any identified suspected GNSS RFI events to regional and international organizations (ANSPs)
Post-flight | When RFI is suspected, aircraft data should be sent to OEMs for further investigation.

Table 3 GNSS RFI Preventive controls

According to The GNSS RFI Correspondence Group (CG), the reporting of confirmed GNSS RFI occurrences to the spectrum authority is important as the spectrum authority oversees investigating to solve the interference. Therefore, it is important to confirm that GNSS outage events were not due to equipment failure. Refer to Airbus recommendations to establish a mechanism to confirm GNSS RFI events. (*available to subscribers of the Airbus customer portal*)

To reduce the impact of GNSS RFI, reporting in a timely manner would allow them to improve risk area identification and information services, as well as to take enforcement action.

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

Additionally, establish feedback with maintenance organizations to confirm RFI or equipment malfunction. And 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 Air operators

The interference susceptibility of GNSS can be reduced using multiple navigation receivers operating on different frequencies. Frequency diversity could employ receivers of the same type. Interference reduction is one of the reasons for the introduction and further expansion of the new civil channel on L5 1176.45 MHz (GPS - American constellation).

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

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

Preventive controls from National/International organizations and OEMs
Regulatory control or interference emissions - ITU regulations to protect civil aviation from GNSS RFI. - 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 Multi-Frequency / Multi-Constellation (DFMC) receivers and Minimum Operational Performance Standards (MOPS).

Table 4 GNSS RFI External to Operators preventive controls

Call to action to operators. Identify the SIRRS Administration Manager role in the applicable ANSPs/national authorities to ensure any potential air operator's reporting requirements are met and gaps are addressed when reporting interference cases.

An online application has been developed by the Radiocommunication Bureau in response to Resolution 186 of ITU Plenipotentiary Conference 2014 with the aim to facilitate administrations and space stakeholders to report a case of harmful interference affecting space services.

Recovery controls

Considered the barriers that prevent a top event from developing into an accident.

Operators / Recovery controls
En route – Enforce Abnormal/emergency procedures
En route – Establish/enforce procedures to cross-checking position using other available navigation systems (radio Navaids 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 the GNSS outage, loss, or degradation of ADS-B OUT due to interference.
Approach - Establish/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 to identify additional safety controls, such as dead reckoning as an alternative navigation method (If applicable) to avoid non-desire outcomes.

Additional Recommendations

To address this issue of harmful interference to GNSS, IATA invites:

Airlines

- To develop/update their own risk model using the appropriate assessment technique to evaluate the operator's exposure to GNSS RFI hazards across the operational network.
- To establish a safety Performance Indicator (SPI) related to GNSS RFI and the aircraft navigation and surveillance performance degradation.
- To enforce flight crews to submit GNSS RFI-related safety reports is also recommended as a complementary means to capture and follow up on the GNSS RFI Issue.
- Periodically evaluate established SPIs and exposure to GNSS RFI to determine the effectiveness of controls.
- To ensure preventive controls listed in Table 3 *GNSS RFI Preventive controls* are documented, implemented, and trained as required.

- To establish a mechanism to report confirmed RFI events to ANSPs, national authorities, and IATA.
- To ensure SIRRS reporting requirements are met and any potential gaps are addressed when reporting interference cases.
- To Ensure recovery controls listed in *Table 5 GNSS RFI recovery controls* are documented, implemented, and trained as required.

IATA

- To assist operators in identifying GNSS interference hotspots, evaluating the feasibility of providing near real-time source information such as FDX could help assess exposure to jamming and spoofing threats.

ANSP

- To promptly notify airlines and airspace users once interference to GNSS was notified.
- To inform flight crews and air traffic controllers about the impact of GNSS interference and establish effective contingency procedures and capabilities as appropriate.

STATES

- To implement appropriate mitigation measures as contained in ICAO GNSS Manual (Doc 9849) as a matter of high priority and to report progress and any difficulties to ICAO.
- While using GNSS jammers during military exercises and operations, to recognize the intended impact of harmful interference to civil flight operations and to exercise caution to the maximum extent possible to protect the safety of civil aircraft.

- To establish and ensure appropriate frequency regulations are in place and maintained to protect allocated GNSS frequencies from harmful interference in line with ITU Radio Regulations.
- To carefully consider operational risks associated to harmful interference to GNSS during their planning for rationalization of conventional navigation and surveillance infrastructures and to incorporate inputs from airspace users while developing a CNS rationalization plan.
- To 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), are retained and fully operational.

ICAO

- In coordination with manufacturers and airspace user communities, to develop a global strategy on Alternative Position, Navigation, and Timing. This A-PNT strategy should aim to ensure continuity of flight and ATM operations during interruptions of GNSS and should include the increasing capabilities and roles of onboard INS/IRU.
- In cooperation with the International Telecommunications Union (ITU) to analyze the reported cases of harmful interference to GNSS and establish appropriate measures to address the safety impact on aviation.