

Federal Aviation Administration

FAA Perspective on GNSS RFI Challenges, Impact and Best Practices



Presented to: NAM/CAR/SAM Workshop on Radio Navigation
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**Federal Aviation
Administration**

Spoofing Trends

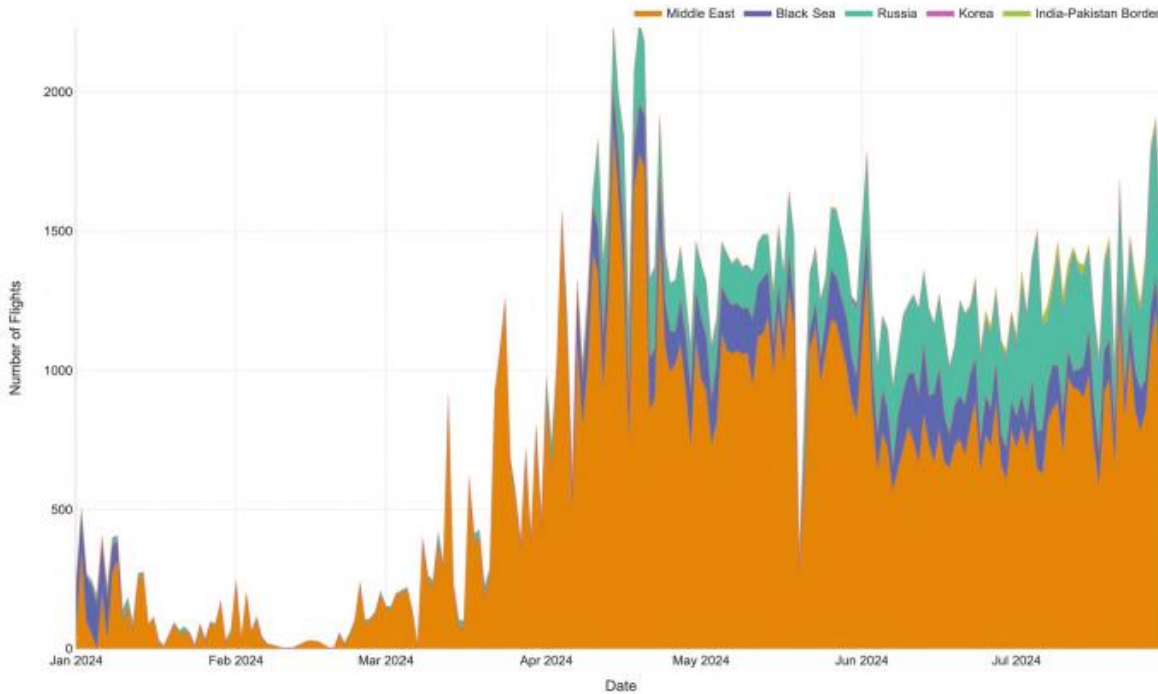
GNSS spoofing began to severely impact civil aviation in September 2023

- In January 2024 ~300 spoofed daily
- By August 2024 ~1,500 spoofed daily

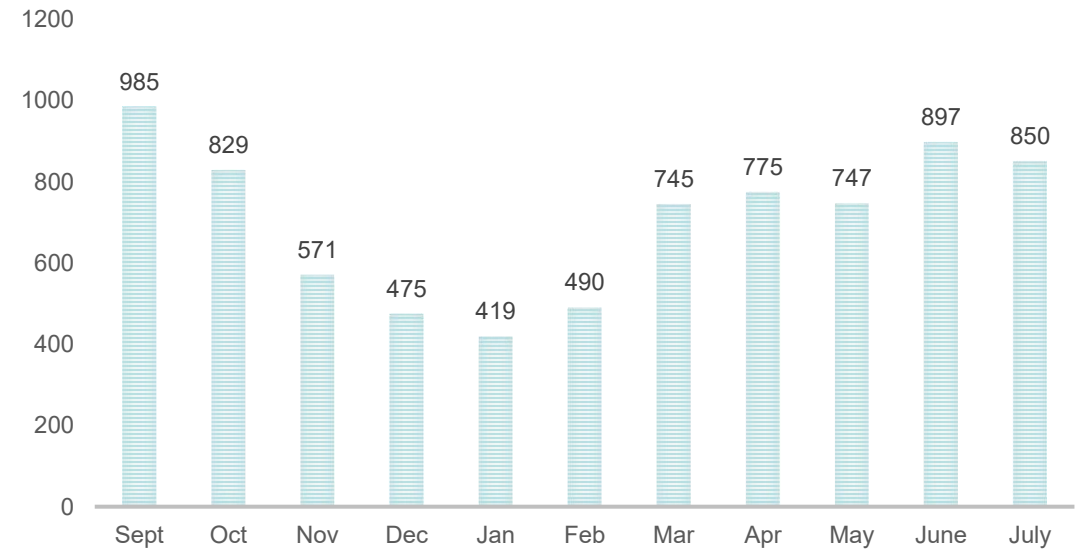
Currently trending back up from January 2025

- October-December 2024: 620 spoofed daily
- Last 3 months: 831 spoofed daily

Daily Estimated Number of Flights Affected by GPS Spoofing by Spoofed-to Region



DAILY GNSS SPOOFING



Disruption Trends

GNSS signal loss per 1,000 flights increased 65% in the first half of 2024 over that of 2023

- 2022/2023: 31 per 1,000 flights
- 2024 (January-July): 51 per 1,000 flights

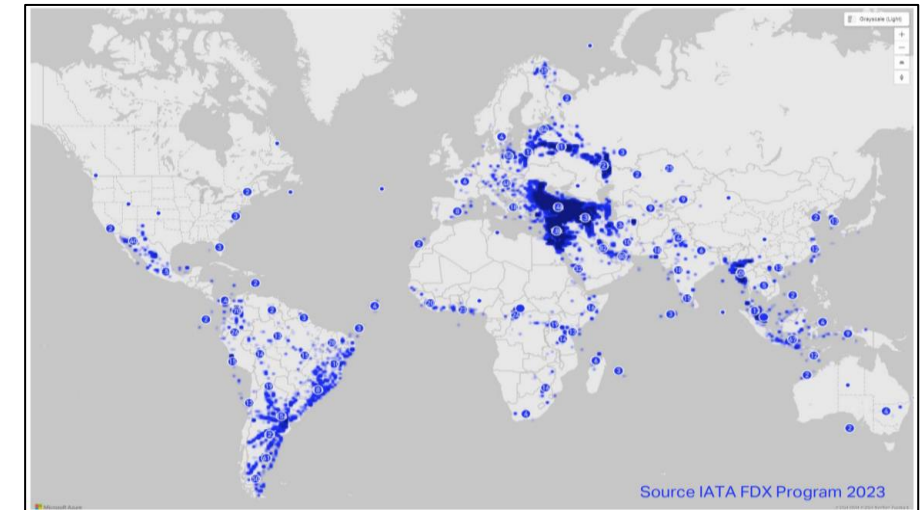
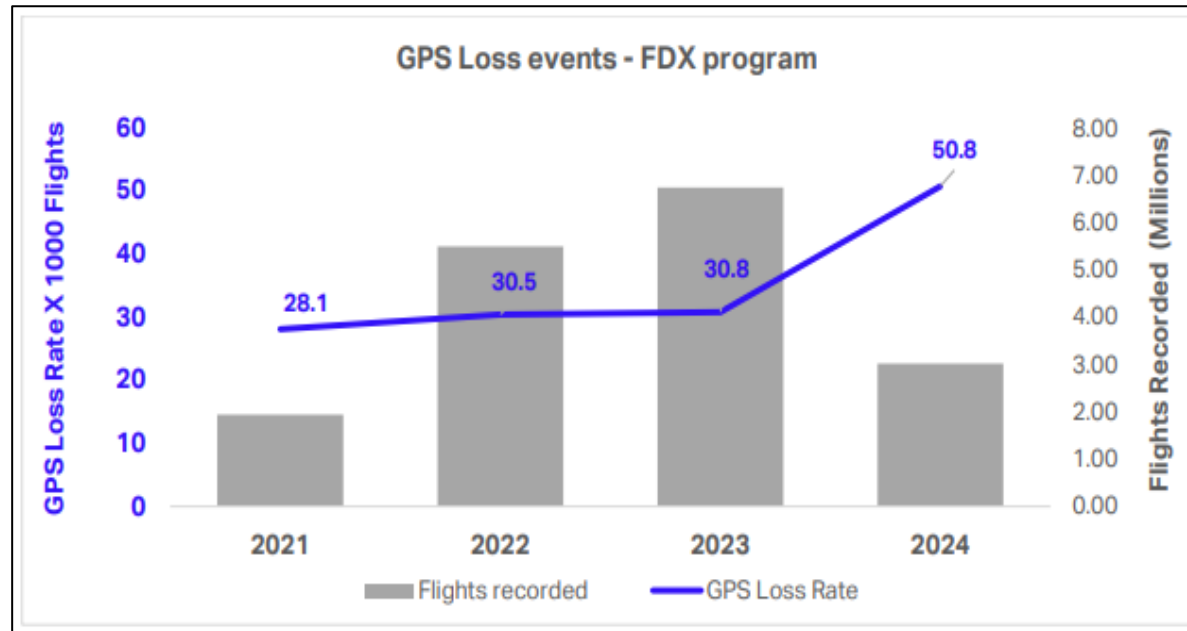


Figure 4 GNSS RFI Recorded events 2023

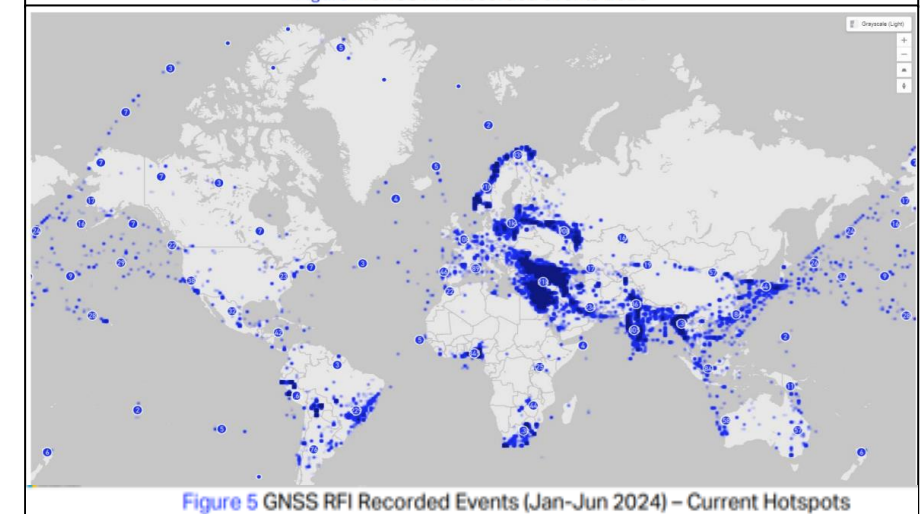



Figure 5 GNSS RFI Recorded Events (Jan-Jun 2024) – Current Hotspots

Oceanic Air Traffic Impacts of GNSS RFI



Loss of satellite communications (SATCOM)




Degraded navigational accuracy

- Impacts ability to provide correct position information via both methods available in the oceanic environment -automatic dependent surveillance -contract (ADS-C) and High Frequency (HF) voice




Time/date shift in controller pilot data link communication (CPDLC) messages

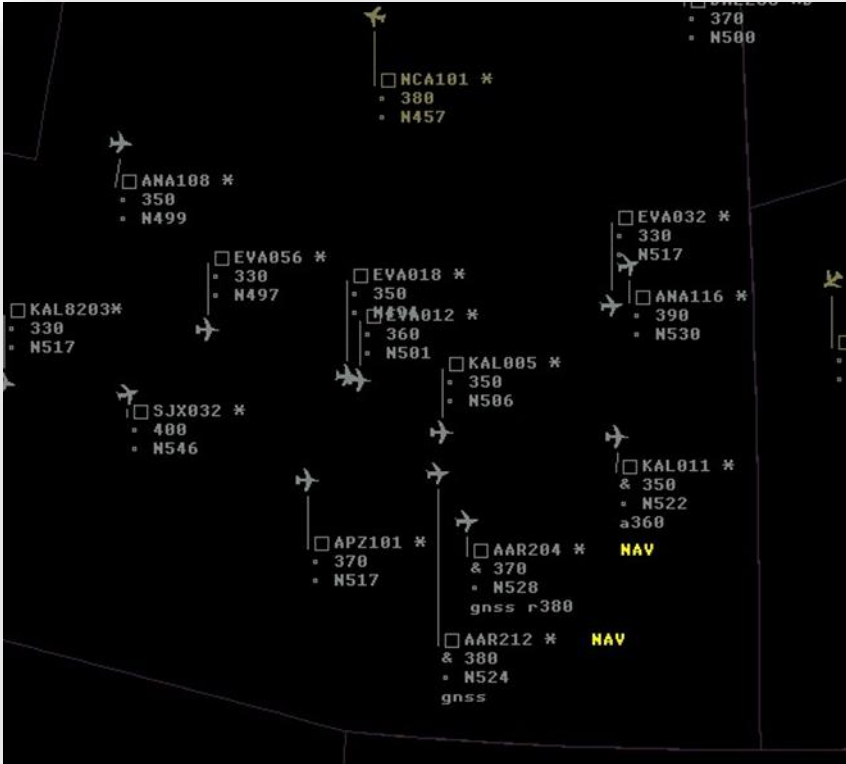


Increased separation standards, decreased efficiency

- Separation minima between two aircraft is determined by the most restrictive standard, so nearby aircraft with functional ADS-C are also impacted.



Decreased situational awareness and increased controller workload

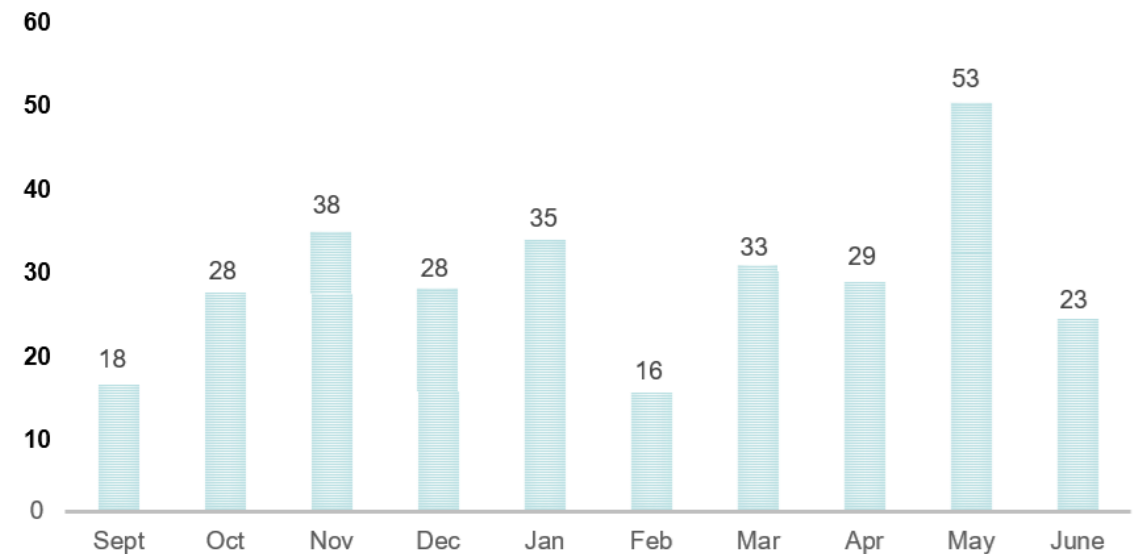


FANS 1/A	
Accuracy of position	Remarks
Complete loss of navigational capabilities	Inability to determine position within 30 nautical miles is considered total loss of navigation. Includes the inability to associate a valid time with the position.
< 30 NM (55.5 km)	Consistent with inertial navigation on long flight without updates.
< 15 NM (28 km)	Consistent with inertial navigation on intermediate length flight without updates.
< 8 NM (15 km)	Consistent with inertial navigation on short length flight and beyond 50 nautical miles from VOR.
< 4 NM (7.4 km)	Consistent with VOR accuracies at 50 nautical miles or less and with GPS worldwide.
< 1 NM (2 km)	Consistent with RHO-RHO applications of ground-based DME, RNAV using multiple DME or GPS position updates.
6 < 0.25 NM (0.46 km)	Consistent with RNAV using GPS.
7 < 0.05 NM (0.09 km)	Consistent with augmented GPS accuracies.

U.S. NAS GPS Event Trends & Activity

- **Scheduled/Coordinated Testing**
 - Increase in GPS scheduled test requests
- **Unscheduled Anomalies: Increase in reports of GPS interference**
 - No Confirmed nefarious interference
 - Likely due to increased awareness

U.S. NAS GNSS UNSCHEDULED ANOMALY EVENTS



FAA Actions with Partners

- International: FAA and Industry are working to maintain global safe operations
 - U.S. state of design aircraft, U.S. operators (any aircraft), U.S. passengers, aviation safety
 - All aviation users of GPS and its augmentations
- Domestic: planning and developing capabilities to mitigate jamming and spoofing
- GPS resiliency is pervasive, multi-faceted issue necessitating complex/layered mitigations
 - Include training/education, policy/procedure development, and technical solutions
 - Strike a balance between safety, efficiency, security, and compliance
 - Anticipate threat evolution to “targeted” spoofing & potential catastrophic consequences
- Implementation of mitigations requires a unified response from federal government, international partners, and the “collective” aviation industries

Threats from GPS interference, as cybersecurity threats, are many and evolving daily




Safety Alert for Operators (SAFO) 01/25/24

Recognizing and Mitigating Global Positioning System (GPS) / Global Navigation Satellite System (GNSS) Disruptions

Goals:

- Increase awareness of jamming and spoofing
- Emphasize the importance of reporting events
- Improve knowledge of impacted systems
- Encourage development of mitigations and guidance



SAFO
Safety Alert for Operators
SAFO 24002
DATE: 01/25/24
Flight Standards Service
Washington, DC

U.S. Department of Transportation
Federal Aviation Administration

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safo

A SAFO contains important safety information and may include recommended action. Besides the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide clarity to the public regarding existing requirements under the law or agency policies.

Subject: Recognizing and Mitigating Global Positioning System (GPS) / Global Navigation Satellite System (GNSS) Disruptions.

Purpose: This SAFO provides information and guidance to operators and manufacturers regarding operations in a GPS/GNSS disrupted environment.

Background: Recent GPS/GNSS jamming and spoofing activities reported by civil air operators operating globally pose a potential safety of flight risk to civil aviation. GPS/GNSS disruptions often occur in and around conflict zones, military operations areas, and areas of counter unmanned aircraft systems (UAS) protection. The term GNSS includes satellite augmentation systems.

The recent jamming and spoofing incidents may pose increased safety of flight risks due to possible loss of situational awareness and increased pilot and regional Air Traffic Control (ATC) workload issues. Due to the increasing frequency of GPS/GNSS disruptions, the Federal Aviation Administration (FAA) recommends flightcrews put additional emphasis on closely monitoring aircraft equipment performance for any discrepancies or anomalies, promptly informing ATC of any apparent GPS/GNSS degradation, and being prepared to operate without GPS/GNSS navigation systems.

Discussion: The effects of GPS/GNSS jamming and/or spoofing have been observed by crews in various phases of flight. In some cases, these effects led to re-routing or diversions, due to the inability to perform safe instrument procedures. The magnitude of the issues generated by these disruptions would depend upon the impacted area, the duration of the event, type of aircraft, type of avionics, and the phase of flight of the affected aircraft. To improve analysis and dissemination of these issues, the FAA stresses the need for "real time" pilot reporting to ATC and the use of the Pilot Reporting site, [Report a GPS Anomaly - Federal Aviation Administration](https://www.faa.gov/air_traffic/nas_gps_reports), (https://www.faa.gov/air_traffic/nas_gps_reports) for reporting of GPS/GNSS anomalies, to enable tracking and mitigation. Safety impacts should be reported through normal safety channels.

Aircraft operators should be aware of impacts to their specific aircraft systems identified by Original Equipment Manufacturers (OEMs). Manufacturers, operators, and ATC should be aware of the general impacts of GPS/GNSS interference, jamming, and spoofing, such as:

Distributed by: Flight Standards

Core Focus: Original Equipment Manufacturers Working with Operators

Potential Aircraft Impacts of GNSS RFI

- **Aircraft Position/Navigation:** Aircraft may not be able to align their systems on ground; pilot must rely on conventional navigation aids, radar vectors or visual references to navigate
- **Communication:** Loss of Datacom, SATCOM, networks; pilot must use UHF/VHF voice radios
- **Surveillance:** Automatic Dependent Surveillance (ADS-B Out/In and ADS-C) inop; use primary and secondary radar; ATC will need to change separation minimums for applicable traffic
- **Safety:** Loss of TAWS forward-looking function, loss of runway awareness systems, etc.
- **Pilot displays:** Head-up Display (HUD) and Synthetic/Combined Vision Systems (SVS/CVS) unusable, electronic moving map on navigation display inop, electronic flight bag unreliable, etc.
- **Regulatory:** ADS-B circular allows flight through NOTAM'd testing area; TAWS regulatory requirement may not be complied with.



Increased safety/human factors risks--possible loss of situational awareness; increased pilot and ATC workload



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Questions?

