



**Thirty-Ninth Meeting of the
Informal South Pacific ATS Coordinating Group
(ISPACG/39)**

**Port Moresby, Papua New Guinea
10 April 2025**

Agenda Item 4: Information Papers

**Air Traffic Operational Impacts from Global Navigation Satellite System (GNSS) Interference on Aircraft
Transiting Oceanic Airspace**

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SUMMARY

This paper provides discussion on efforts to identify flights possibly impacted by GNSS Interference abroad which go on to transit US delegated Pacific airspace. It will also summarize actions in progress in the North Atlantic (NAT) region on GNSS Interference issues.

1. Introduction

- 1.1. GNSS Interference is commonly divided in to two categories. The first, “spoofing,” refers to when a GNSS receiver is made to calculate a false position. The second, “jamming,” is when GNSS signals are overpowered or interrupted so that the GNSS receiver can no longer operate.
- 1.2. Much like radar jamming, GNSS jamming appears to only impact flights which are in range of the jamming equipment. These flights recover their capabilities after the event and go on to complete their flights without resultant incident. A spoofed GNSS signal, however, can have a cascading effect on other avionics systems which incorporate GNSS data. Some impacted systems include the FMS, Hybrid IRS, the aircraft clock, GPWS, Weather Radar, CPDLC, ADS-B and ADS-C, as well as numerous others.
- 1.3. At the North Atlantic Technical Interoperability Group’s (NAT TIG) 17th meeting, Iceland presented a working paper (WP/11 from Iceland: GNSS JAMMING AND SPOOFING EFFECTS OBSERVED IN BIRD CTA) showcasing data on flights which had flown through known areas of GNSS Spoofing. Anomalies in the Figure of Merit (FOM) as well as in ADS-B quality indicators supported their conclusions that the flights were experiencing ongoing symptoms from exposure to spoofing.
- 1.4. The FAA has begun similar work, cross-referencing ADS-C data with unexpectedly degraded FOM values against routings through known areas of GNSS spoofing. While the analysis is in its early stages, there is reason to suspect that flights experiencing lasting impacts from spoofing are currently operating in the Pacific. This paper will provide a preliminary look at some of this data, as well as report on emerging discussions in the NAT region.



2. Discussion

- 2.1. To identify and assess potential GNSS spoofing impacted aircraft in Anchorage and Oakland oceanic airspace, ADS-C data from January 2024 to October 2024 was collected and analyzed. The analysis process identified all flights in which there were 10 or more ADS-C reports with a Figure of Merit (FOM) less than or equal to 2. The value of 2 was selected due to Advanced Technologies & Oceanic Procedures (ATOP) requiring a FOM of 3 or higher to allow PBCS-enabled separation standards. Filtered from the results were flights conducted by the US Military.
- 2.2. Figure 1 provides an excerpt from RTCA DO-258A, Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications (FANS 1/A Interop Standard), explaining the accuracy associated with each FOM value. Further consideration may be needed for which FOM values should be used to identify potential GNSS interference.

Figure of Merit Level	Accuracy of Position Determination (within 95% Probability)	Reason Navigation Accuracy Value Was Chosen
0	Complete loss of navigational capabilities	Inability to determine position within 30 nautical miles is considered total loss of navigation.
1	< 30 nautical miles	Consistent with INS on long flight without updates.
2	< 15 nautical miles	Consistent with INS on intermediate length flight without updates.
3	< 8 nautical miles	Consistent with INS on short length flight and beyond 50 nautical miles from VOR.
4	< 4 nautical miles	Consistent with VOR accuracies at 50 or less nautical miles and with GPS worldwide.
5	< 1 nautical mile	Consistent with RHO-RHO applications of ground-based DME, RNAV using multiple DME or GPS position updates.
6	< 0.25 nautical mile	Consistent with RNAV with GPS.
7	< 0.05 nautical mile	Consistent with augmented GPS accuracies.

Figure 1.

- 2.3. Figure 2 shows flights within the KZAK FIR which experienced an unexpected degradation of their FOM values. The PBN column displays Field 18 of these flights' specific flight plans, indicating that they expected to meet RNP4 requirements (L1).



Start	Acid	Reg	Type	PBN	Dept	Dest	Total_Report	FOM0	FOM1	FOM2
2024-02-21 15:15:37	CPA838	BKQE	B77W	A1B1C1D1L1O1S2T1	VHHH	CYVR	25	0	0	21
2024-05-03 16:49:40	UAL889	N2747U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	50	0	0	27
2024-06-01 11:18:37	KAL041	HL8009	B77W	A1B1C1D1L1O1S2T1	RKSI	KSEA	43	0	0	19
2024-06-05 15:27:52	UAL889	N2747U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	43	0	3	29
2024-06-09 15:39:50	UAL889	N2749U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	35	0	1	28
2024-06-12 09:26:12	AIC173	VTAEI	B77L	A1B1C1D1L1O2S2	VIDP	KSFO	54	0	0	28
2024-06-27 19:34:20	AIC175	VTAEI	B77L	A1B1C1D1L1O2S2	VOBL	KSFO	50	0	0	26
2024-07-11 13:47:56	UAL889	N2737U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	55	0	3	29
2024-07-31 07:46:14	AIC173	VTAEF	B77L	A1B1C1D1L1O2S2	VIDP	KSFO	58	0	5	32
2024-09-19 13:25:02	UAL889	N2250U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	47	0	0	24
2024-09-25 06:51:03	AIC173	VTAEI	B77L	A1B1C1D1L1O2S2	VIDP	KSFO	48	0	0	25
2024-10-01 21:03:45	AIC179	VTAEH	B77L	A1B1C1D1L1O2S2	VABB	KSFO	27	0	0	14
2024-10-19 05:18:08	AIC173	VTAEI	B77L	A1B1C1D1L1O2S2	VIDP	KSFO	52	0	5	26
2024-10-24 19:34:33	AIC175	VTAEF	B77L	A1B1C1D1L1O2S2	VOBL	KSFO	40	0	0	30
2024-10-30 15:44:56	KAL005	HL8007	B77W	A1B1C1D1L1O1S2T1	RKSI	KLAS	47	0	3	22

Figure 2. Oakland Flights

- 2.4. Figure 3 shows flights within the PAZN FIR which experienced an unexpected degradation of their FOM values. Notably, only one flight shows 10 or greater ADS-C reports with a FOM of 2 or less- GTI8611. This table displays an additional column- FOM 3- to draw attention to the rest of the aircraft observed, which flew through both KZAK and PAZN on the same days. These aircraft entered KZAK unqualified for PBCS standards, however appeared to partially recover their capabilities shortly after transitioning to PAZN airspace.

Start	Acid	Reg	Type	PBN	Dept	Dest	Total_Report	FOM0	FOM1	FOM2	FOM3
2024-02-21 12:43:51	CPA838	BKQE	B77W	A1B1C1D1L1O1S2T1	VHHH	CYVR	28	0	0	4	24
2024-06-05 13:48:57	UAL889	N2747U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	50	0	0	0	50
2024-06-09 13:25:30	UAL889	N2749U	B77W	A1L1B1C1D1O1S2T1	ZBAA	KSFO	26	0	0	2	24
2024-10-24 17:32:23	AIC175	VTAEF	B77L	A1B1C1D1L1O2S2	VOBL	KSFO	29	0	0	1	28
2024-10-31 22:23:18	GTI8611	N702GT	B77L	A1B1C1D1L1O1S2	RKSI	PANC	20	0	0	11	9

Figure 3. Anchorage Flights

- 2.5. Further investigation is needed on the routes being used for the affected flights, though casual comparison of filed routings against tools like GNSSjam.org indicate possible overlap of these routings against known areas of GNSS interference. The Republic of Korea brought a paper on GNSS Interference to the Fourteenth Air Navigation Conference. Within, they divulge that in May and June of 2024, more that 500 reports of GNSS signal interference and errant Ground Proximity Warnings (GPWS) were reported by pilots in the Incheon FIR. This could account for some of the aircraft observed within US delegated Pacific airspace.
- 2.6. Discussion is needed to determine if refinements are indicated for the logic used to identify flights operating in US delegated airspace that have potentially been affected by GNSS interference. Discussion items include other types of data that can be analyzed, development of a plan for monitoring these issues, and coordinating with the appropriate parties to understand and limit the effects to the extent possible.
- 2.7. The North Atlantic Implementation Management Group (NAT IMG) held their 65th meeting in Reykjavik, Iceland, from 28-31 October 2024. During discussions on the topic of GNSS Interference, the UK and Iceland noted a 300-500% increase in the number of aircraft exhibiting possible signs of being affected by GNSS interference. Each report observing 10 or more aircraft a day indicating degraded FOM and/or ADS-B performance.



- 2.8. The UK and Iceland noted that in instances where aircraft are experiencing degraded FOM and are no longer eligible for RNP-4 PBCS separation, they are changing the aircraft's flight plan to RNP-10 only. Both States noted that they verbally coordinate the flight plan change with the next receiving ANSP; however, it was not clear if this coordination is continued downstream beyond that by other ANSPs. This raises the question about the need for further coordination or inclusion of degradation information in the flight plan remarks.
- 2.9. NAT IMG was presented a draft NAT OPS Bulletin (Appendix A refers) on GNSS Interference that had been developed in follow up to the NAT SPG/60 (June 2024) agreement on further regionally coordinated efforts under the NAT IMG to develop harmonized Air Navigation Service Provider (ANSP) contingency procedures on GNSS interference. The purpose of the NAT OPS Bulletin was to provide background information and guidance to aircraft operators in the NAT on the requirement to notify Air Traffic Control (ATC) of GNSS interference, and the ANSP procedures that would be applied to aircraft that have been exposed to GNSS interference during their flight. Pending coordination with the NAT SOG, the meeting decided to endorse the draft.
- 2.10. The FAA is interested in the experience of JCAB as it regards GNSS interference; and hopes to foster a collaborative decision about cross-boundary coordination of flights with degraded FOM values or which have reported to have experienced GNSS interference in the Pacific.

3. Conclusion

The meeting is invited to-

- 3.1 Note the information provided.
- 3.2 Discuss experiences amongst ANSPs and aircraft operators with potential GNSS RFI; and
- 3.3 Provide any direction deemed necessary.