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Addressing GNSS Radio Frequency Interference (RFI) in Malaysia: Challenges, Impact, and Mitigation Strategies

Mohd Fitri Bin Ishak

Deputy Director

Civil Aviation Authority of Malaysia

Overview

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01

Introduction

Global Navigation Satellite System (GNSS) Radio Frequency Interference (RFI)

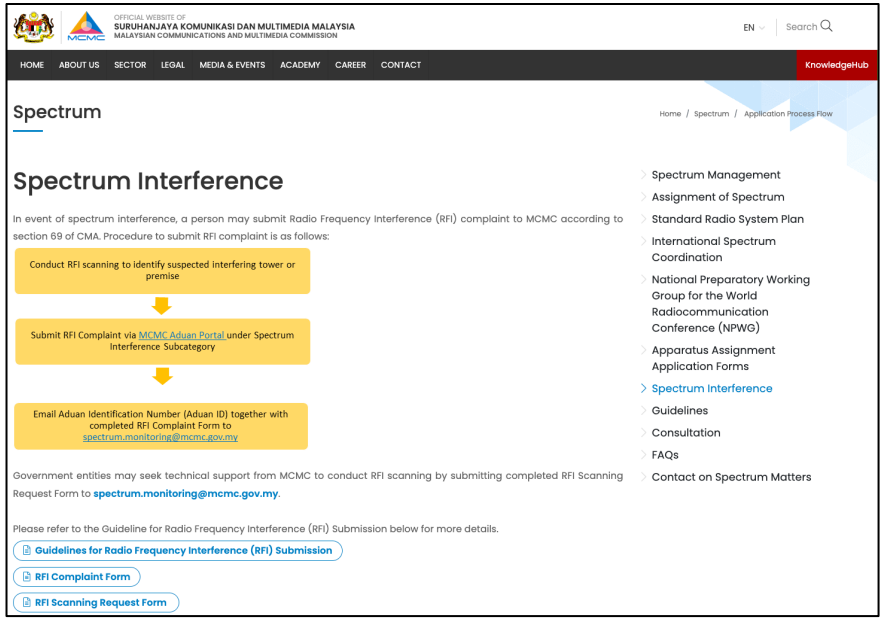
- The **Global Navigation Satellite System** (GNSS) support **precise navigation;**
- **Key challenge: RFI** disruptions degrade navigation and operations;
- **Study focus:** GNSS RFI reports (2023 – Q1 2025) show rising incidents; and
- **Mitigation strategies in Malaysia:** GNSS NMS, enhanced surveillance capability and alternative navigation aids usage

GNSS RFI Reporting Platform in Malaysia

Civil Aviation Reporting System (CAReS)

- In **April 2023**, CAAM launched **CAReS**, a **reporting platform** to **promote a strong reporting culture** within Malaysia's aviation sector.
- The regulatory division of CAAM is responsible for overseeing CAReS;
- CAReS supports two (2) types of reporting:
  - Mandatory Occurrence Report (**MOR**): Compulsory reporting for significant safety-related occurrences; and
  - Voluntary Occurrence Report (**VOR**): Allows stakeholders to voluntarily report safety-related concerns.

https://www.caam.gov.my/wp-content/uploads/2023/03/AI-04_2023_-CAReS.pdf



Other Reporting Channels

Malaysian Communication and Multimedia Commission (MCMC)

MCMC is the agency responsible for investigating harmful cases of radio frequency interference (RFI) in Malaysia.

https://www.mcmc.gov.my/en/spectrum/spectrum-interference

02

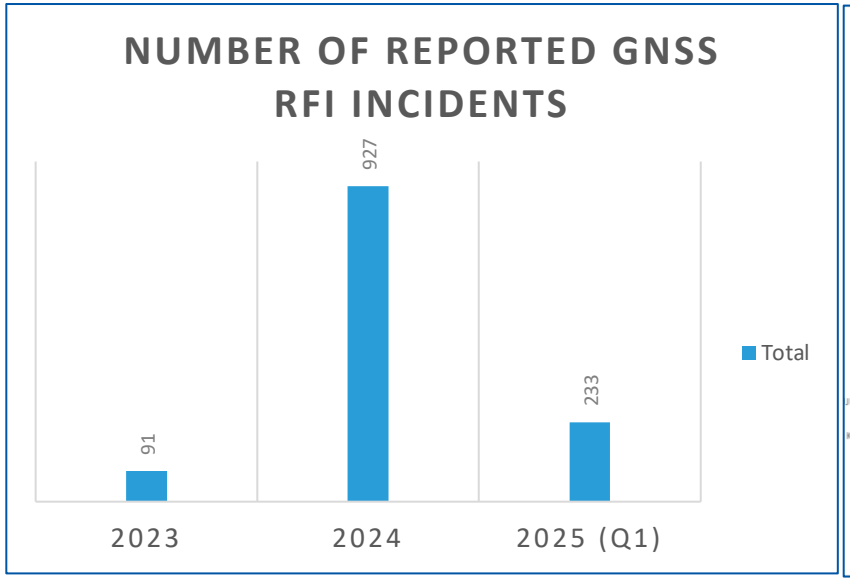
Reported GNSS RFI Incidents

on CAReS

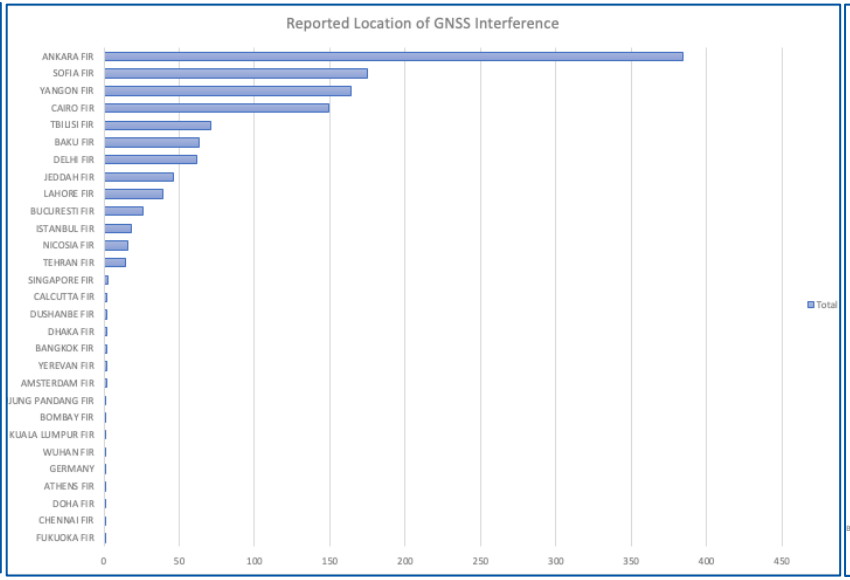
- Analysis of data from CAReS
- Affected Locations and Hotspots
- Affected Flight Phases

Reported GNSS RFI Incident Trends (2023 – 2025)

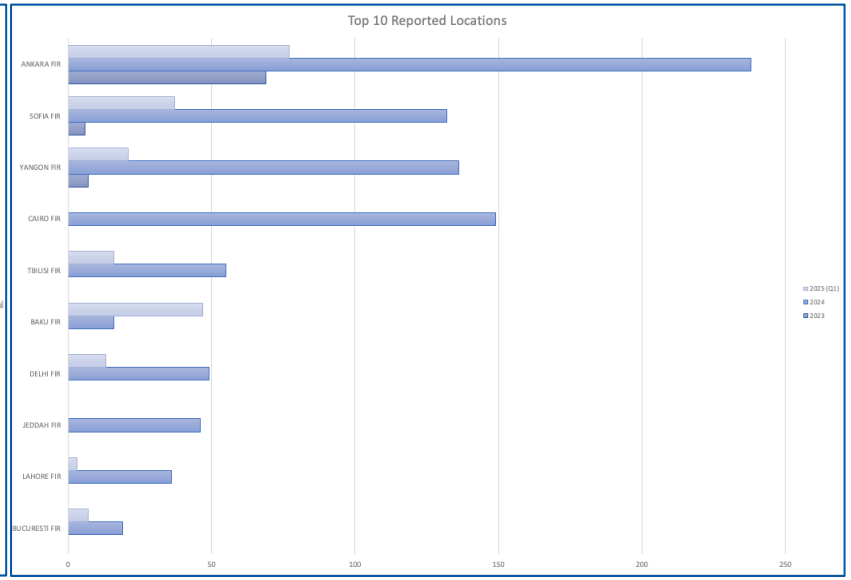
from CAReS platform



Total number of reported GNSS RFI incidents on CAReS



The reported affected locations and hotspots from CAReS



Top 10 Affected Locations

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Reported GNSS RFI Incident Trends (2023 – 2025)

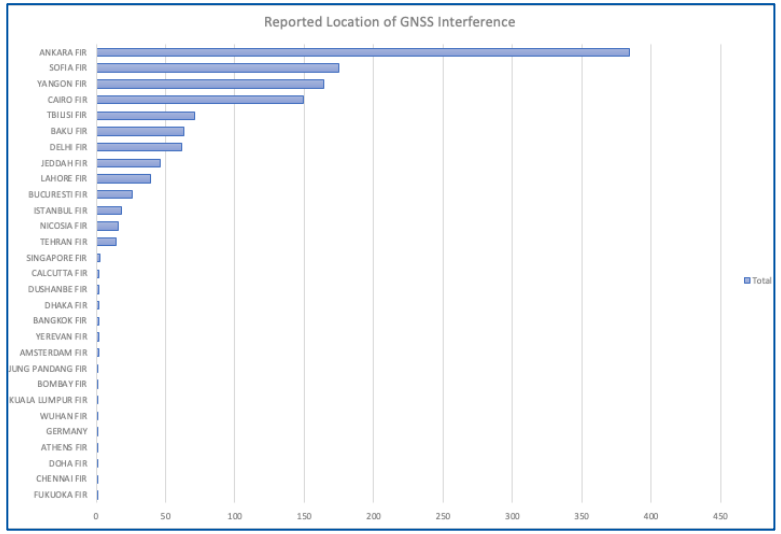
Key trends from CAReS reports:

No	Year	Number of GNSS RFI Incidents	Remarks
1.	2023	91	GNSS RFI incidents
2.	2024	927	A substantial increase of GNSS RFI incidents
3.	2025	233	Only Q1 on GNSS RFI incidents

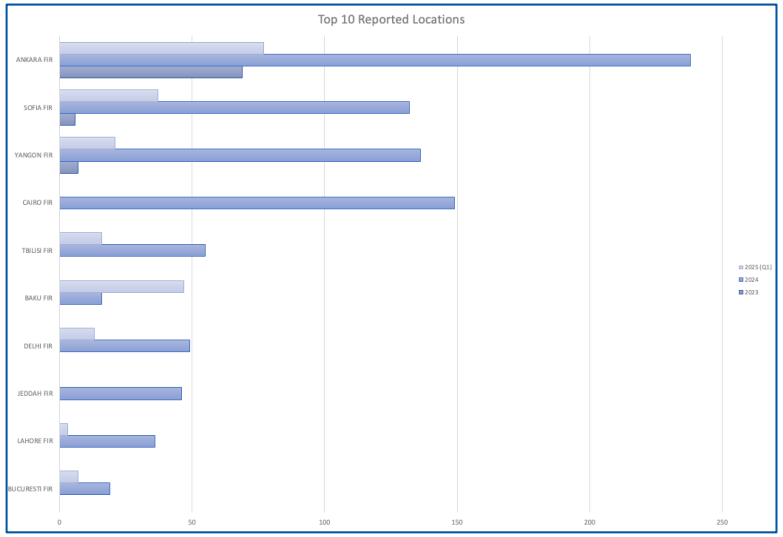
- **low number of reports in 2023** may be attributed to the **initial phase of CAReS**;
- the **increase** in reported incidents **in 2024 and 2025** is attributed to **better reporting mechanisms** and **stakeholder engagement sessions**.
- there is likely **underreporting of in-flight GNSS RFI** incidents due to the **lack of real-time** pilot **reporting;**
- **if a pilot reports** an interference via radio VHF, **ATC is expected to document** and file a report **on the CAReS platform**.
- No **reports on GNSS RFI** from ATC
- **the primary challenge** in mitigating GNSS RFI **is the delayed reporting process;**

Reported GNSS RFI Incident Trends (2023 – 2025)

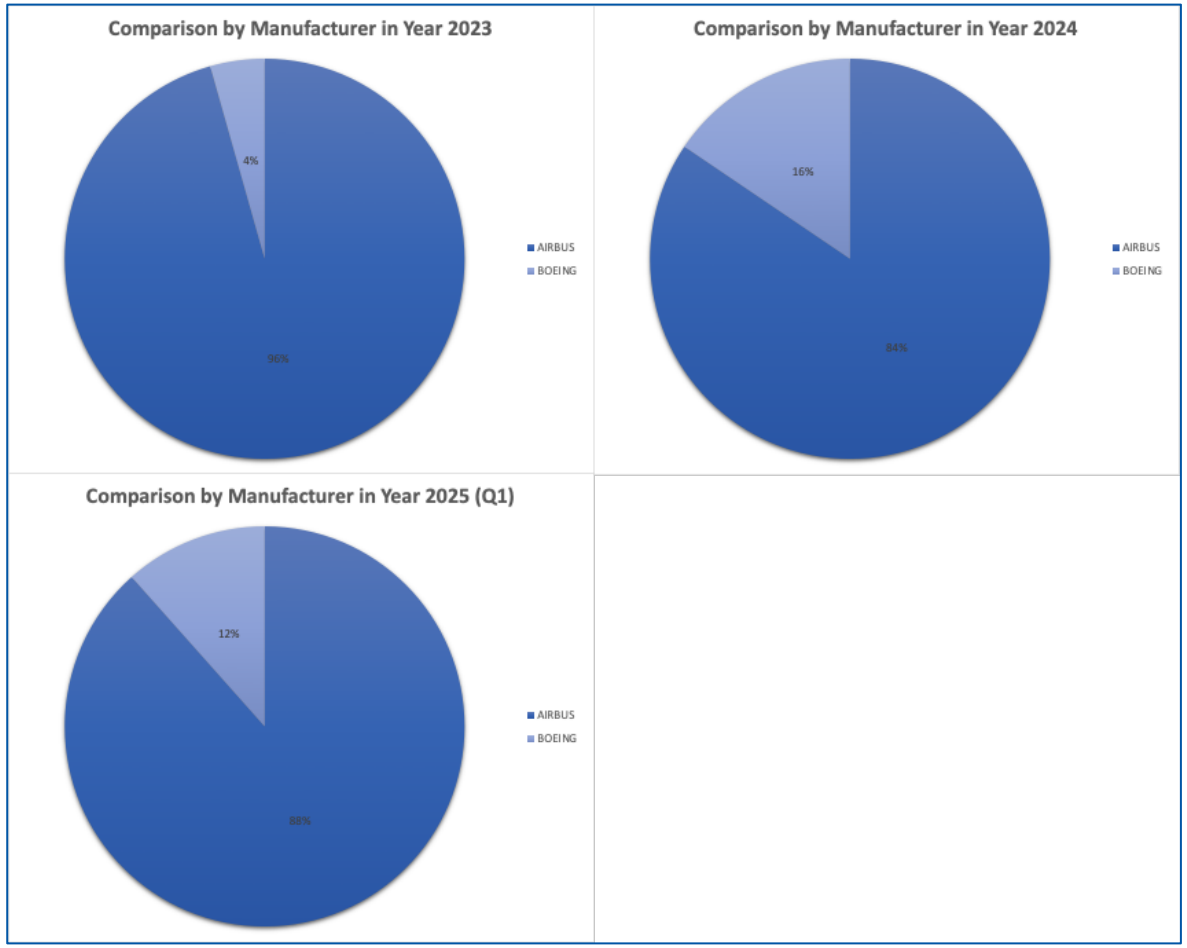
Affected Locations and Hotspots



No	Location	Number of GNSS RFI Incidents
1.	ANKARA FIR	384
2.	SOFIA FIR	175
3.	YANGON FIR	164
4.	CAIRO FIR	149
5.	TBLISI FIR	71
6.	BAKU FIR	63
7.	DELHI FIR	62
8.	JEDDAH FIR	46
9.	LAHORE FIR	39
10.	BUCURESTI FIR	26



- The **highest number of incidents** reported in **ANKARA, SOFIA** and **YANGON FIR**.
- **No reported** incident in **Cairo FIR** after 2024



Reported GNSS RFI Incident Trends (2023 – 2025)

Comparison between two Aircraft Manufacturers

- In general, **Airbus** (86%) more affected than **Boeing** (14%)

Airbus 86%

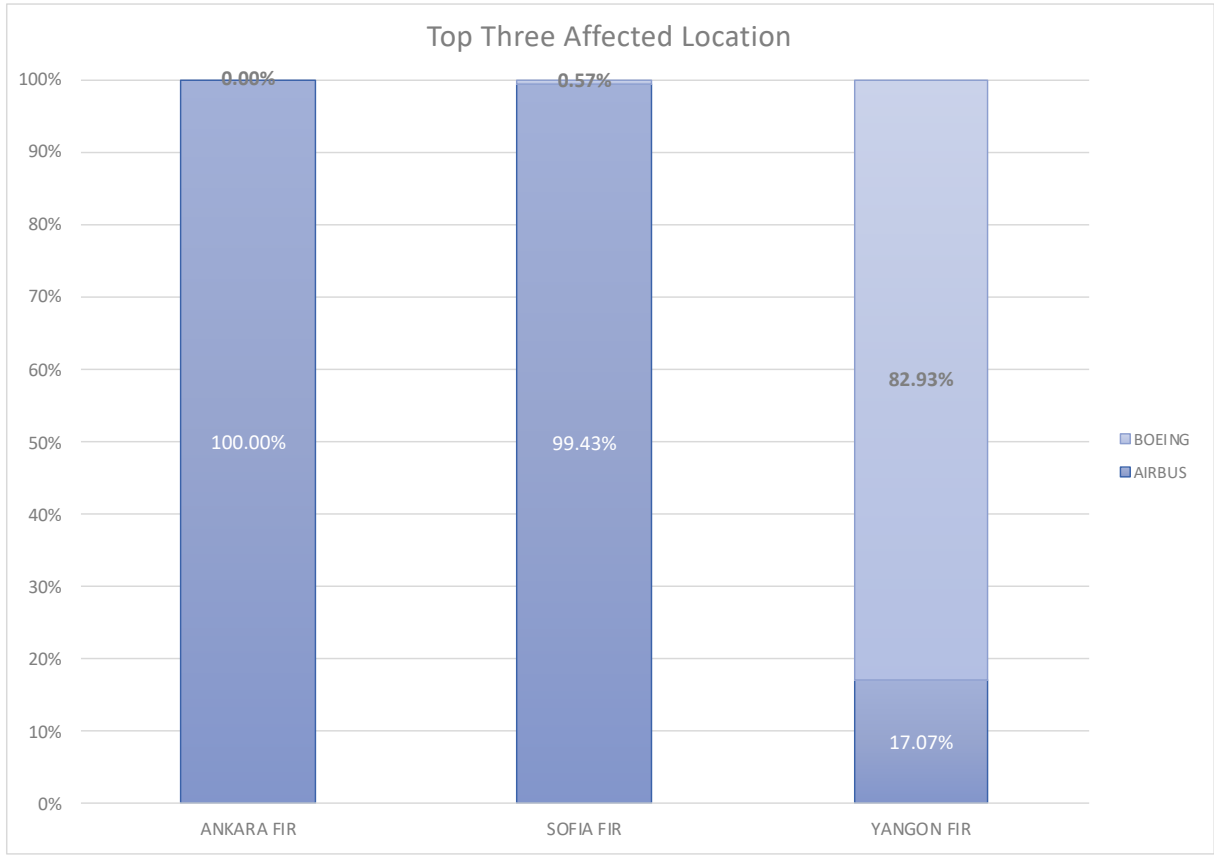
14% Boeing

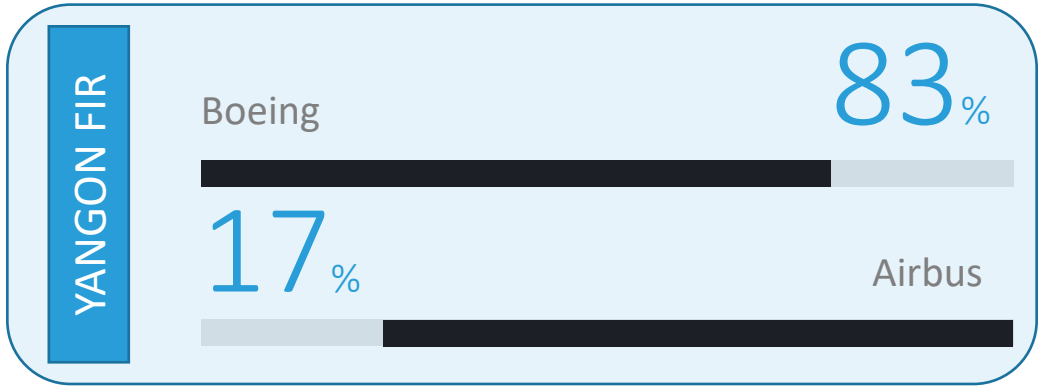
Reported GNSS RFI Incident Trends (2023 – 2025)

Comparison between two Manufacturers over Top Three Affected Locations

However, among the top three affected locations, **Boeing** (83%) is more affected than **Airbus** (17%) in **Yangon FIR**.

To validate this hypothesis, further analysis and insight from aviation analysts or experts would be beneficial.





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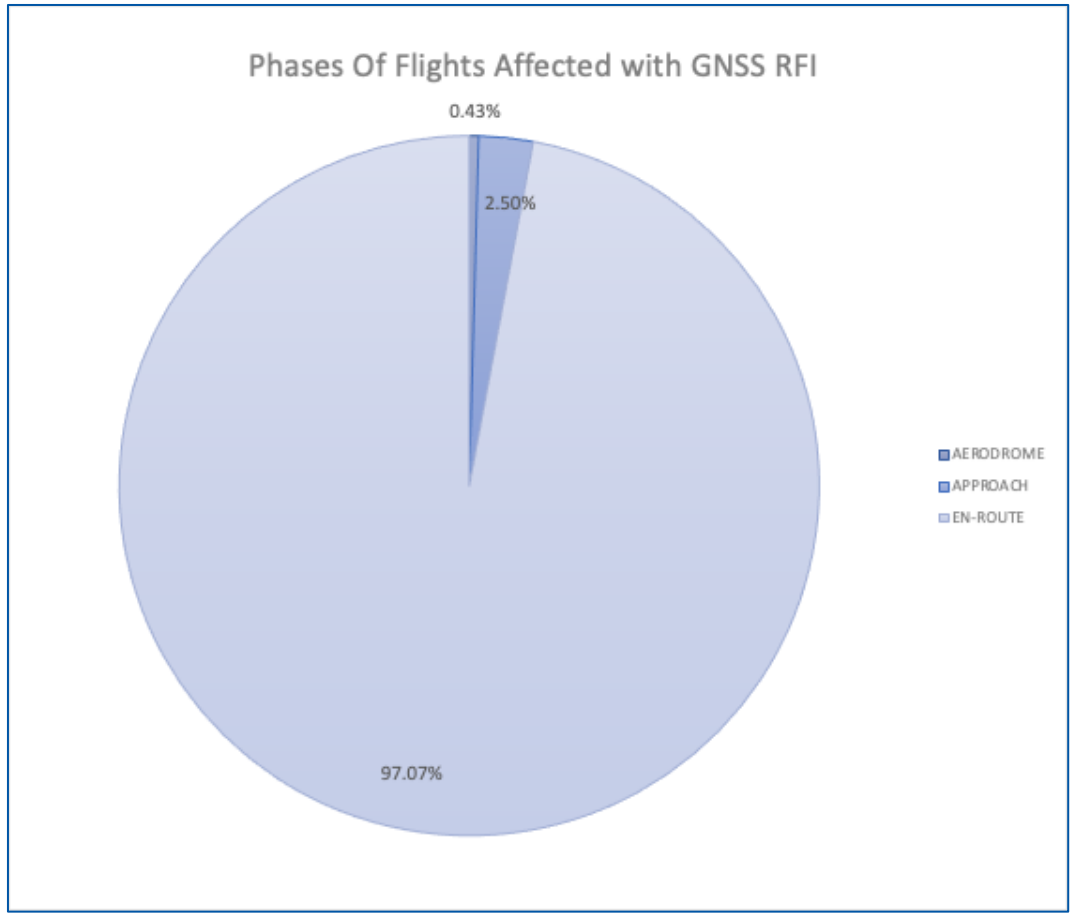


Reported GNSS RFI Incident Trends (2023 – 2025)

Affected Flight Phases

No	Phase of Flight	Number of GNSS RFI Incidents
1.	En-route	1126
2.	Approach	29
3.	Aerodrome	5

- The **GNSS RFI primarily affects aircraft at cruising altitudes**, potentially disrupting navigation and requiring alternative solutions;

03

Mitigation Efforts in Malaysia

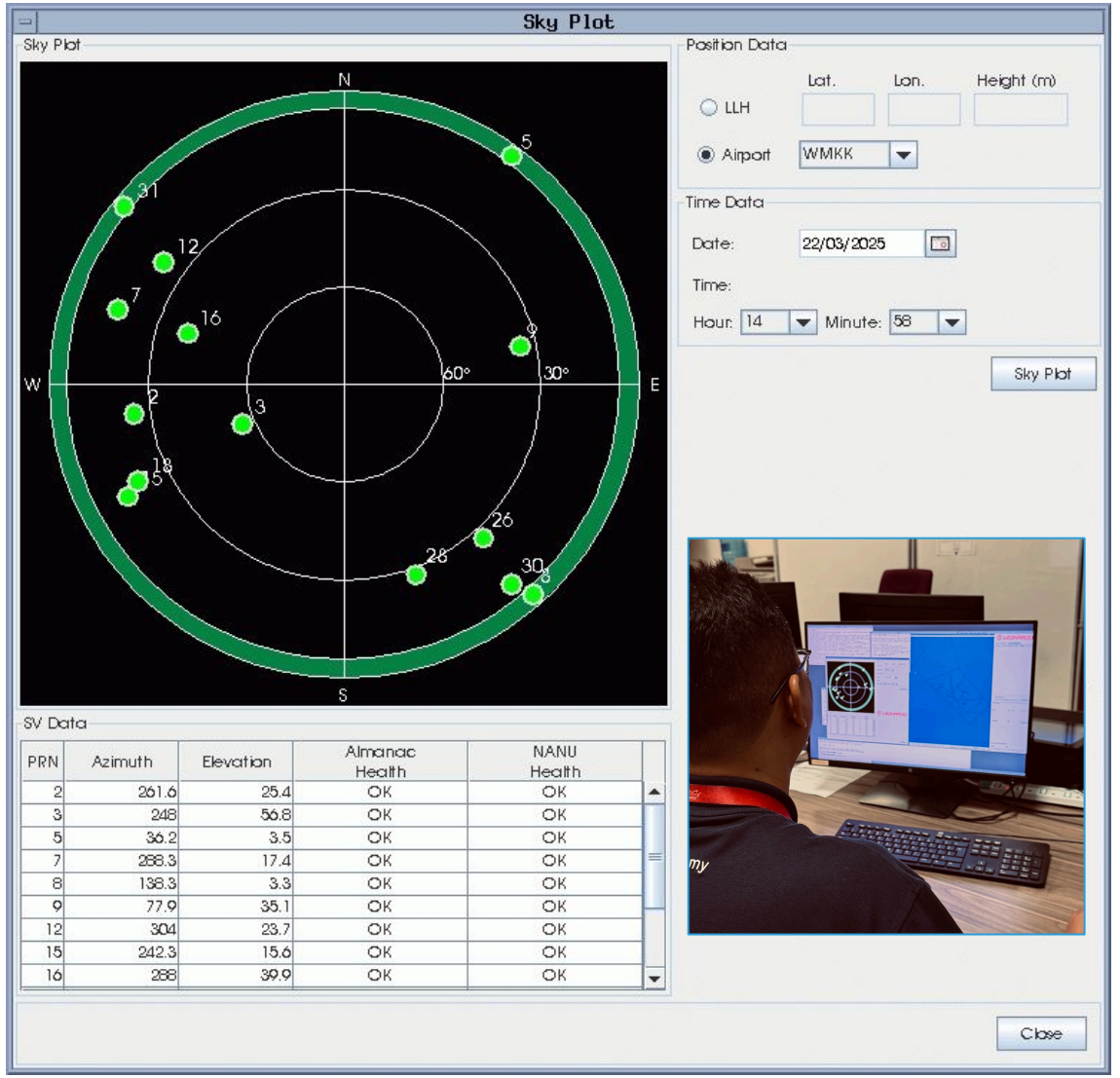
- GNSS National Monitoring Systems (NMS)
- Enhanced Surveillance Capability
- Maintaining Ground-Navigation Aids

Mitigation Efforts in Malaysia

GNSS National Monitoring System (NMS)

- **Detects RFI** in real-time;
- **Generate automated NOTAM proposals** for GNSS disruptions;
- **Integrates ADS-B & radar** for enhanced surveillance

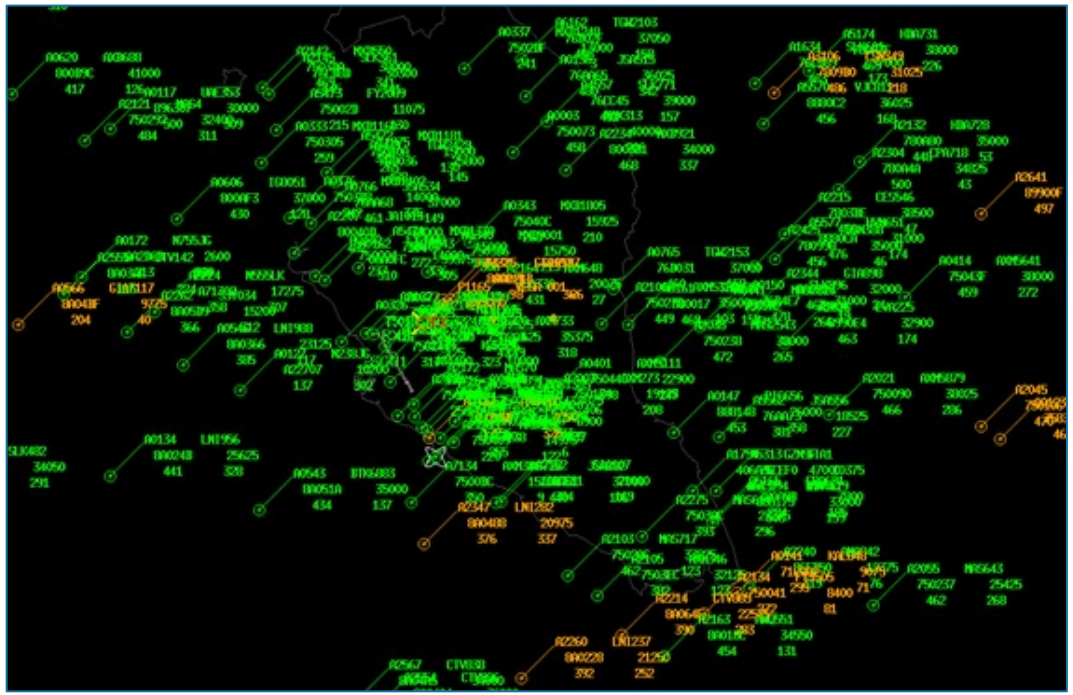
- The GNSS NMS is structured as follows:
  - National Monitoring Centre (NMC);
  - Two (2) Local Monitoring Stations (LMS) (Penang and KL International Airport);
  - Interference and Performance Monitoring.



Mitigation Efforts in Malaysia

Enhanced Surveillance Capabilities (ADS-B with GNSS Receiver)

- **ADS-B** system with ADS-B Ground Data Processing (A-GDP) system.
- The A-GDP has advanced GNSS verification capabilities;.
- The system includes:
  - **dual transceiver ADS-B units operating at 1030/1090 MHz;**
  - work as **Multi-lateration (MLAT)**;
  - **connected with dual GNSS receiver unit;** and
  - **Time Difference of Arrival (TDOA) techniques** to validate ADS-B target positions;



Green means Validated ADS-B positional information

Mitigation Efforts in Malaysia

Enhanced Surveillance Capabilities

- **validated positional information** (**green** indicates **validated ADS-B** position);
- improving the confidence of ATC to **utilise the information for providing Air Traffic Services**;
- **robust surveillance coverage** (**PSR/SSR Mode-S and ADS-B systems)**
- **utilise radar vectoring techniques in the event of GNSS RFI**.

Mitigation Efforts in Malaysia

Maintaining Alternative Navigation Capabilities

- Continue **expanding PBN airways and IFP** to enhance ATC and Airline's efficiency;
- with **overlapping surveillance & NMS** to ensure rapid GNSS RFI response;
- with **Backup navigation** (DVOR/DME, ILS) to support safe recovery during GNSS outages;
- to **ensure operational continuity** in case of GNSS disruptions

No	Airport	ICAO CODE	Runway	PBN SID	PBN STAR	PBN APPROACH			ILS	DVOR/DME
						LNAV	LNAV/VNAV	RNP (AR)		
1	Johor Bahru	WMKJ	16	✓	✓	✓	✓	✓	✓	✓
			34	✓	✓	N/U	N/U	✓	N/A	N/A
2	KLIA	WMKK	32L	✓	✓	✓	✓	N/A	✓	N/A
			32R	✓	✓	✓	✓	✓	✓	✓
			14L	✓	✓	✓	✓	N/A	✓	N/A
			14R	✓	✓	✓	✓	N/A	✓	N/A
			33	✓	✓	✓	✓	✓	✓	N/A
			15	✓	✓	✓	✓	N/A	✓	✓
3	Langkawi	WMKL	03	✓	N/U	✓	✓	✓	✓	✓
			21	N/U	✓	N/U	N/U	N/U	N/A	N/A
4	Penang	WMKP	04	✓	✓	✓	✓	✓	✓	✓
			22	✓	✓	✓	✓	✓	N/A	✓
5	Kuching	WBGG	07	✓	✓	✓	✓	✓	N/A	✓
			25	✓	✓	✓	✓	✓	✓	✓
6	Kota Kinabalu	WBKK	02	✓	✓	✓	✓	✓	✓	✓
			20	✓	✓	✓	✓	✓	N/A	✓
7	Alor Star	WMKA	04	N/U	✓	✓	✓	✓	✓	✓
			22	✓	N/U	N/U	N/U	N/U	N/A	N/A
8	Kota Bharu	WMKC	10	✓	✓	✓	✓	✓	✓	N/A
			28	✓	✓	✓	✓	✓	N/A	✓
9	Kuantan	WMKD	18	✓	✓	✓	✓	N/A	N/A	✓
			36	✓	✓	✓	✓	N/A	✓	N/A
10	Ipoh	WMKI	04	✓	N/U	✓	✓	✓	✓	✓
			22	N/U	✓	N/U	N/U	N/U	N/A	N/A
11	Melaka	WMKM	03	✓	✓	✓	✓	N/A	✓	N/A
			21	✓	✓	✓	✓	N/A	N/A	✓
12	Kuala Terengganu	WMKN	04	✓	✓	✓	✓	✓	✓	✓
			22	✓	✓	✓	✓	✓	N/A	N/A
13	Subang	WMSA	15	✓	✓	✓	✓	N/A	✓	✓
			33	✓	N/U	✓	✓	N/A	N/A	N/A
14	Bintulu	WBGB	17	✓	✓	✓	✓	✓	✓	✓
			35	✓	✓	✓	✓	✓	N/A	N/A
15	Miri	WBGR	02	✓	✓	✓	✓	✓	✓	✓
			20	✓	✓	✓	✓	✓	N/A	N/A
16	Sibu	WBGS	13	✓	✓	✓	✓	✓	✓	✓
			31	✓	✓	✓	✓	✓	N/A	N/A
17	Labuan	WBKL	14	✓	✓	✓	✓	✓	✓	✓
			32	✓	✓	✓	✓	✓	N/A	N/A
18	Sandakan	WBKS	08	✓	✓	✓	✓	N/A	✓	✓
			26	✓	✓	✓	✓	✓	N/A	N/A
19	Tawau	WBKW	06	✓	✓	✓	✓	✓	N/A	✓
			24	✓	✓	✓	✓	✓	✓	N/A
20	Mukah	WBGK	15	✓	✓	✓	✓	N/A	✓	✓
			33	✓	✓	✓	✓	N/A	N/A	N/A

04

Identified Key Challenges

Key challenges related to GNSS RFI:

- **Rising** GNSS RFI incidents;
- **Lack** of real-time mitigation mechanisms & reliance on outdated reports;
- **Operational** and **safety risks** GNSS-based navigation overdependence;
- Limited awareness of existing reporting mechanisms (CAReS, MCMC).

05

Future Plan and Recommendation

- **Strengthen real-time reporting & monitoring** via ATC-Pilot integration;
- **Ensure alternative navigation solutions** (DME/DME, VOR/DME, radar vectoring);
- **Invest in mitigation technologies,** including adaptive GNSS interference monitoring, TDOA surveillance systems
- continuous **stakeholder engagement initiatives to enhance cooperation and awareness** on GNSS RFI;

06

Conclusion

- GNSS RFI remains a growing challenge to aviation safety and efficiency;
- Despite mitigation efforts, **real-time reporting gaps** persist;
- **Continuous monitoring, stakeholder collaboration, and technology investment** are key to resilience;
- Future efforts should focus on **proactive detection, real-time reporting,** and **integrated response strategies;**
- **Seamless coordination** between ATC, pilots and equipment integration such as GNSS NMS is essential to strengthening air navigation system resilience;

Thank You

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