

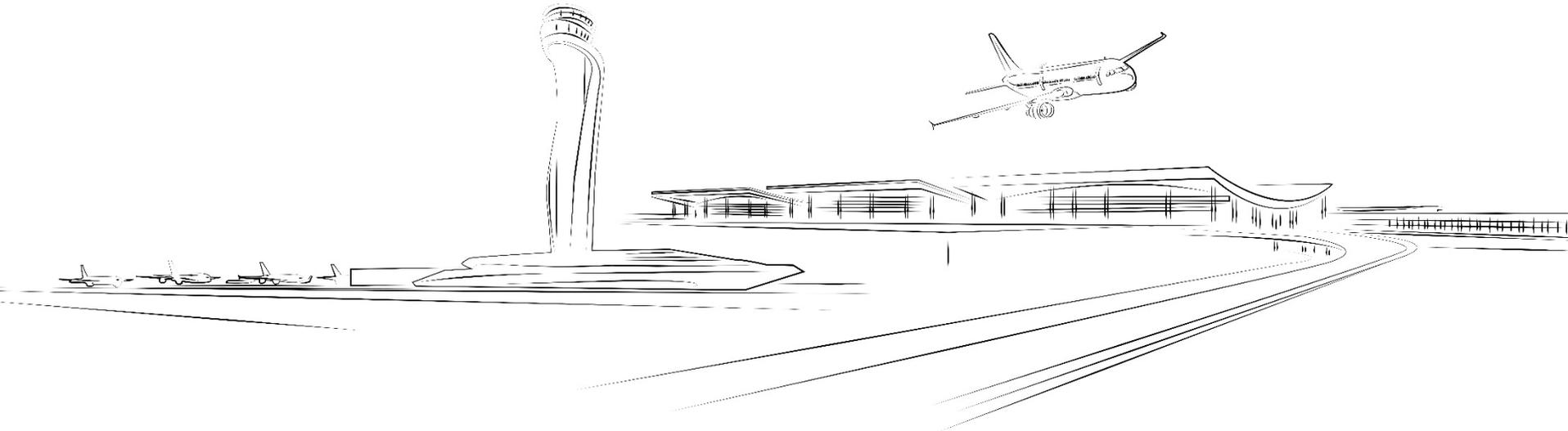


STATE AIRPORTS AUTHORITY of TÜRKİYE
(AIR NAVIGATION SERVICE PROVIDER)
DHMI



GPS Outages and Its Operational Impacts in Türkiye

Ufuk ŞAN





GPS Outages and Its Operational Impacts in Türkiye



Overview

- ❖ GPS Anomalies
- ❖ GNSS Vulnerabilities
- ❖ Operational Effects of GPS Loss
- ❖ Affected Regions
- ❖ An Outlook to GPS Losses



GPS Outages and Its Operational Impacts in Türkiye



GPS Anomalies:

GPS Outage: No signal

GPS Unreliable: There is a signal but not relied on.

GPS Unusable: This could be due to an outage or GPS being unreliable due to interference.

A population of aircraft in a particular area is reporting GPS outage/loss of GPS or Unable RNP, this would be a strong indication that GPS is unusable.

Duration of GPS unusable is categorised by Eurocontrol surveys:

Short (period) = is one of 2 hours or less

Medium (period) = between 2 hours 1-2 days

Long (period) => 2 days to 1 week

Extended(period) > 1 week



GPS Outages and Its Operational Impacts in Türkiye



GPS Normal Operations

REVERSION INFRASTRUCTURE	
Available Navaid Infrastructure	GPS; SBAS/GBAS ; DME/DME; VOR/DME; ILS
Fleet Positioning Capability for PBN	GPS + D/D > 90% + VOR/DME (10% can only do conventional); ILS; SBAS/GBAS 20%
Surveillance Sensors Used	PSR; MULTIPLE SSR; with ADS-B or MLAT
Communication Service Used	Voice; Data Link
Timing for On-Board Systems	Independent + GPS synchronised
Timing for Ground Systems	Independent + GPS synchronised



GPS Outages and Its Operational Impacts in Türkiye



Inoperative GPS Signal

REVERSION INFRASTRUCTURE	
Available Navaid Infrastructure	GPS ; SBAS/GBAS ; DME/DME; VOR/DME; ILS
Fleet Positioning Capability for PBN	GPS + D/D > 90% + VOR/DME (10% can only do conventional); ILS; SBAS/GBAS-20%
Surveillance Sensors Used	PSR; MULTIPLE SSR; with ADS-B or MLAT
Communication Service Used	Voice; Data-Link
<i><u>Explanation:</u> Whilst Data Link & MLAT may not be lost immediately, time de-synchronisation may occur in the longer term.</i>	
Timing for On-Board Systems	Independent + GPS-synchronised
Timing for Ground Systems	Independent + GPS-synchronised



GPS Outages and Its Operational Impacts in Türkiye



GNSS Vulnerabilities:

GNSS is vulnerable certain threats. These are:

- ❖ Constellation Weakness
- ❖ Radio Frequency Interference
 - Intentionally
 - Spoofing or jamming
 - Unintentionally
 - Equipment Failure
 - Radio Operator Error



GPS Outages and Its Operational Impacts in Türkiye



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)





GPS Outages and Its Operational Impacts in Türkiye



Symptoms of GPS spoofing or jamming;

- ❖ Incoherence in navigation position, such as GNSS/FSM position disagree warnings,
- ❖ Abnormal differences between Ground speed and True airspeed,
- ❖ Time shift
- ❖ Problems with INS/IRS



GPS Outages and Its Operational Impacts in Türkiye



Systems affected / Accident scenarios

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

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



GPS Outages and Its Operational Impacts in Türkiye



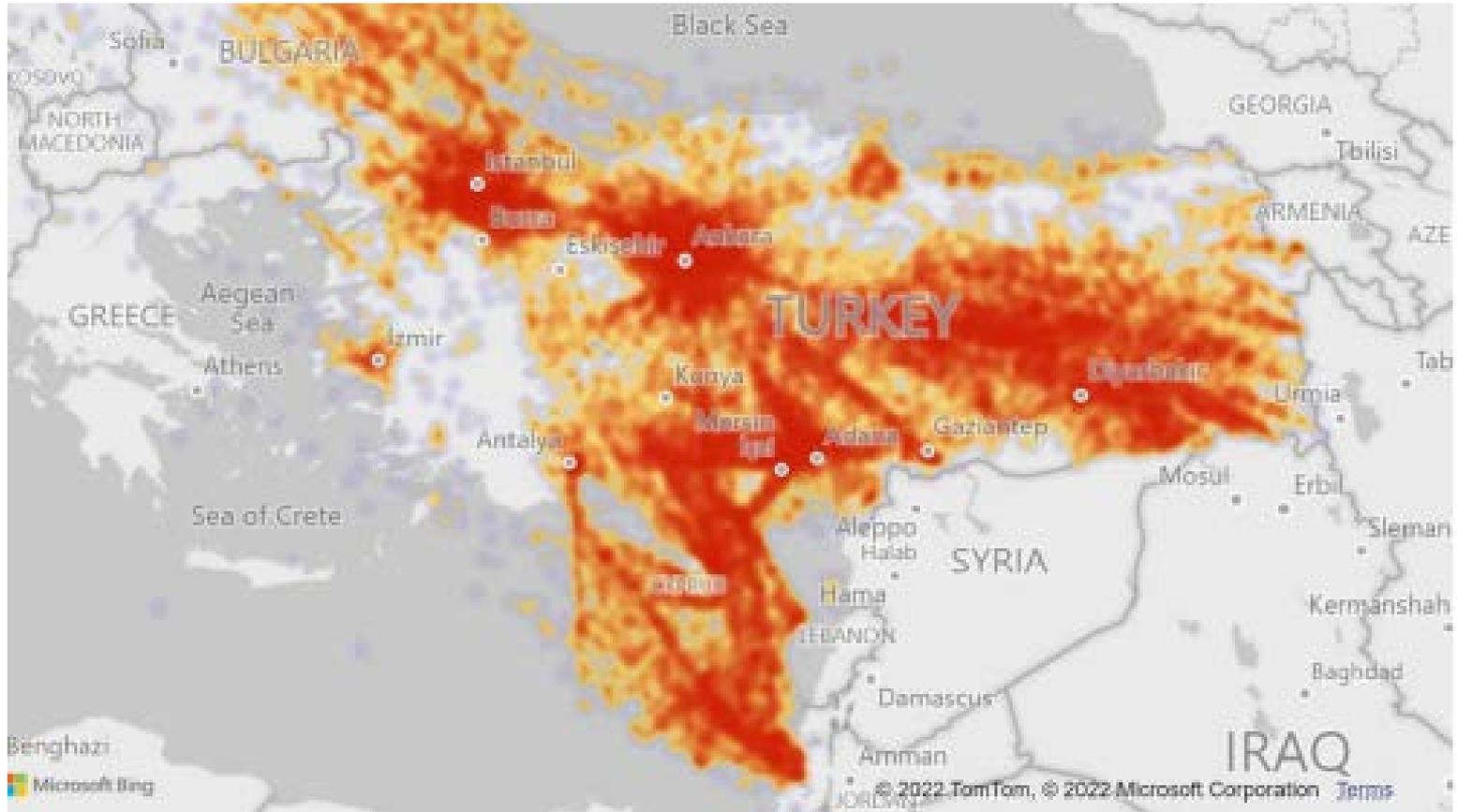
Affected Regions:

According to EASA Safety Information Bulletin Operations – ATM/ANS SIB No.: 2022-02R1 Mainly affected FIR regions:

- ❖ The Black Sea area:
- ❖ The South and Eastern Mediterranean Area and the Middle East:
- ❖ The Baltic Sea Area (FIRs surrounding FIR Kaliningrad UMKK):
- ❖ Arctic Area:

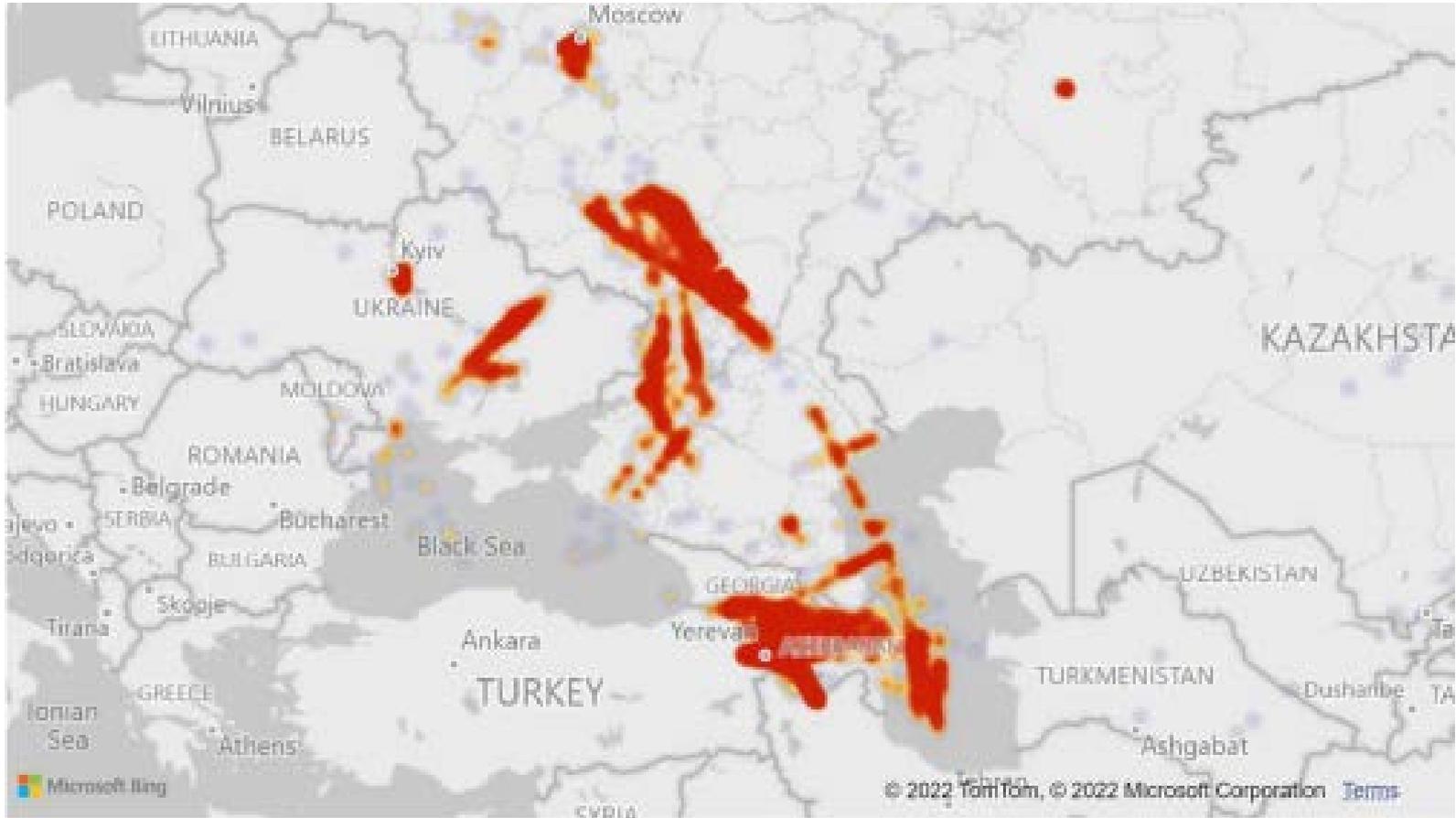


GPS Outages and Its Operational Impacts in Türkiye



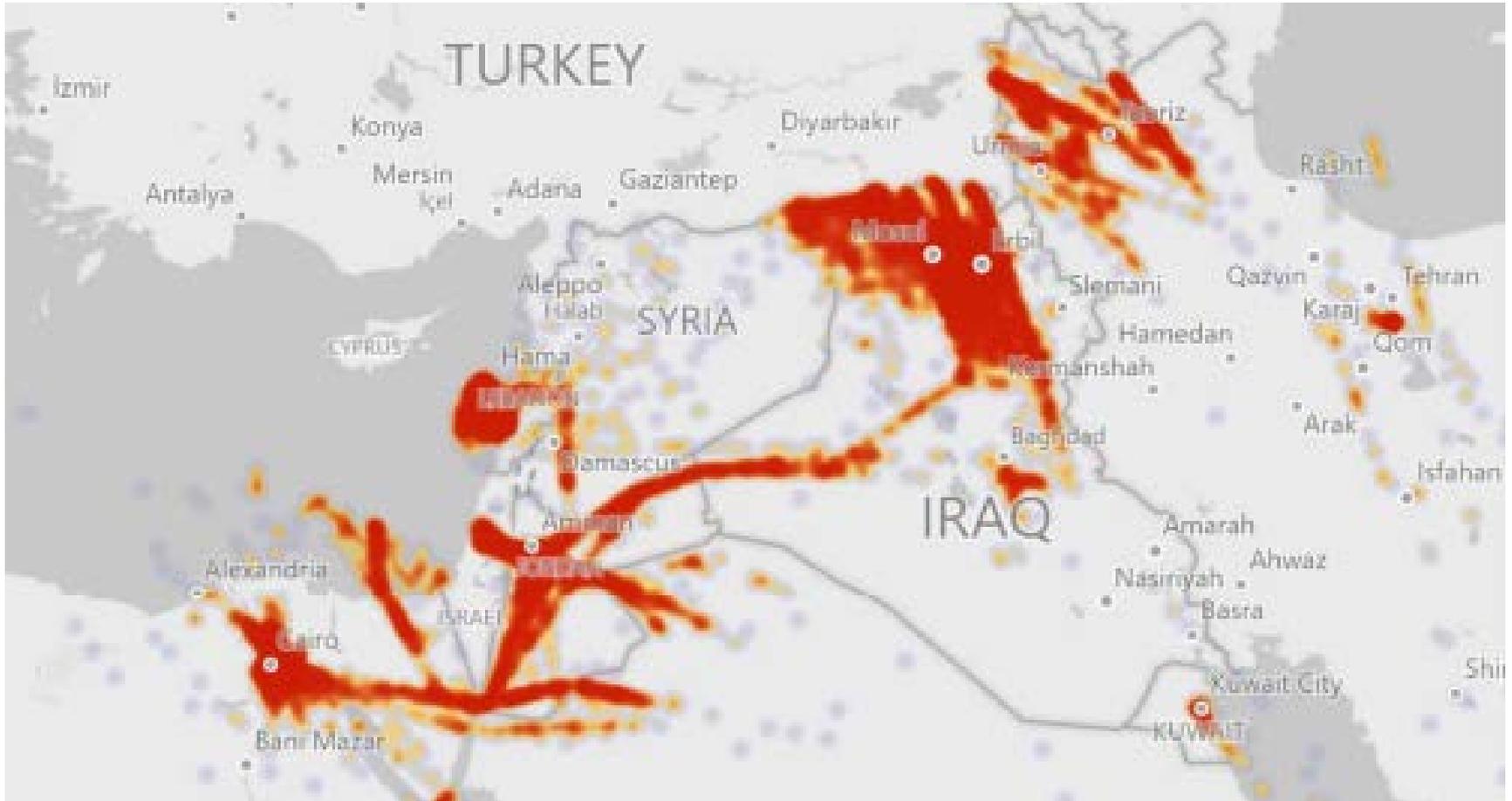


GPS Outages and Its Operational Impacts in Türkiye





GPS Outages and Its Operational Impacts in Türkiye





GPS Outages and Its Operational Impacts in Türkiye



GPS Signal Loss Events Global Map



FDX Analysis - GPS Signal Loss



Flight Data SPIs: GPS Signal Loss

Flight Period: Aug 2021 - Dec 2022 Region of Occurrence: Global



GPS Outages and Its Operational Impacts in Türkiye



Increase of GPS Outages:

GNSS RFI event numbers have been soaring year by year across the World:

In 2021, 10,843 RFI events were detected.

In 2022, 49,605 RFI events were detected.

These events were recorded especially in the Middle East and Eastern Europe.



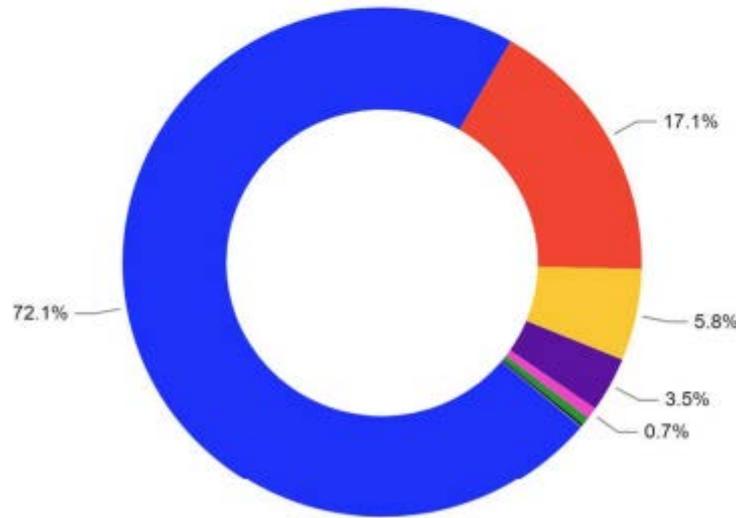
GPS Outages and Its Operational Impacts in Türkiye



GPS Signal Loss Event Count Per Region

Events Count

EUR MENA LATAM/CAR CIS AFI ASPAC NAM NASIA



Gps Signal Loss (Aug 2021 – July 2022)

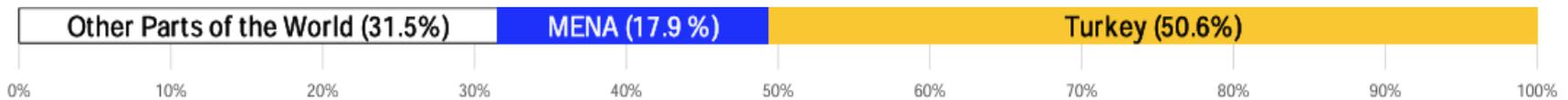
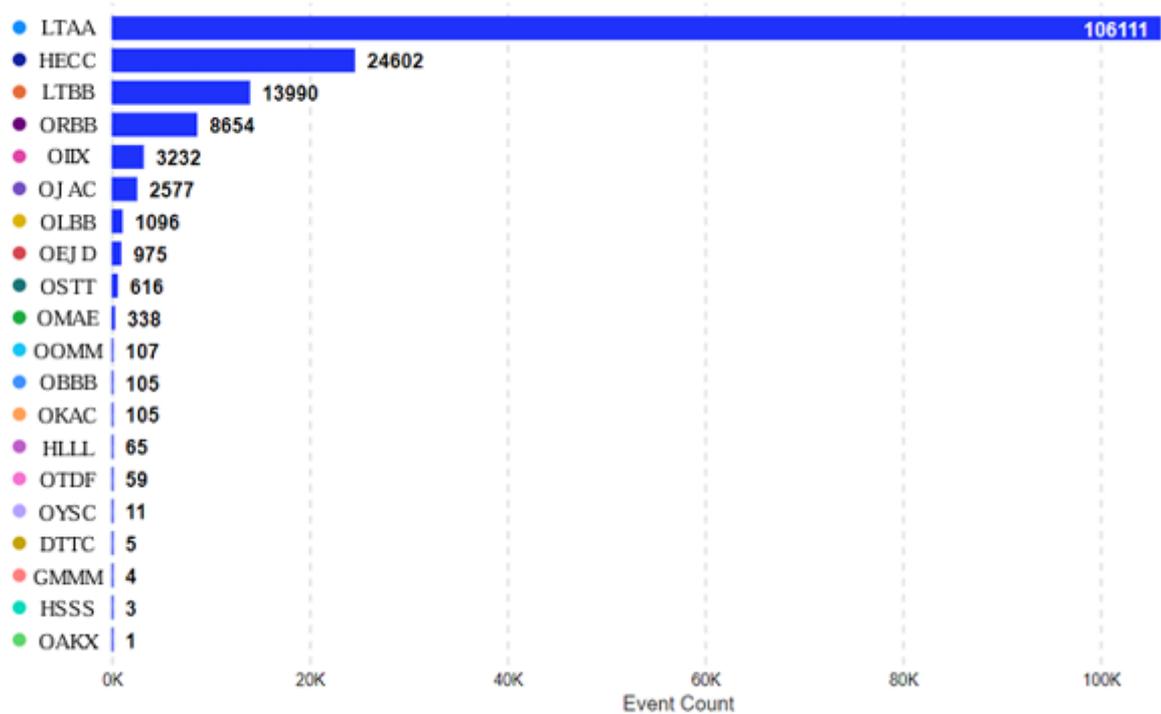
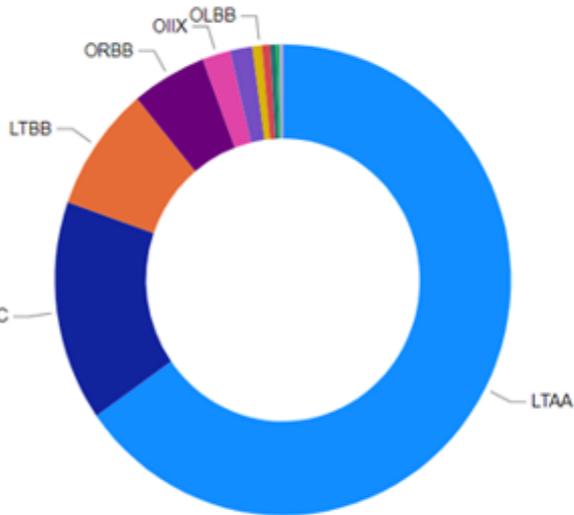


GPS Outages and Its Operational Impacts in Türkiye



GPS Signal Loss Event Count Per FIR

GPS Signal Loss Event Count By FIR





GPS Outages and Its Operational Impacts in Türkiye



Current Situation of Nav aids in Türkiye:

- Conventional Navigation aids in place have critical roles to overcome GPS outages and its effects. Therefore, we have modernised and well maintained our nav aids equipments, 75 VORs, 148 DMEs and 68 NDBs are in service in 58 airports and all over Türkiye.
- The flight inspections of these nav aids were conducted by our 2 aircrafts till now. However, in order to overcome flight inspection problems of our nav aids due to the dependency to GPS signals of flight test aircrafts, we have bought new flight inspection aircraft that does not depend on GPS signals for reference.



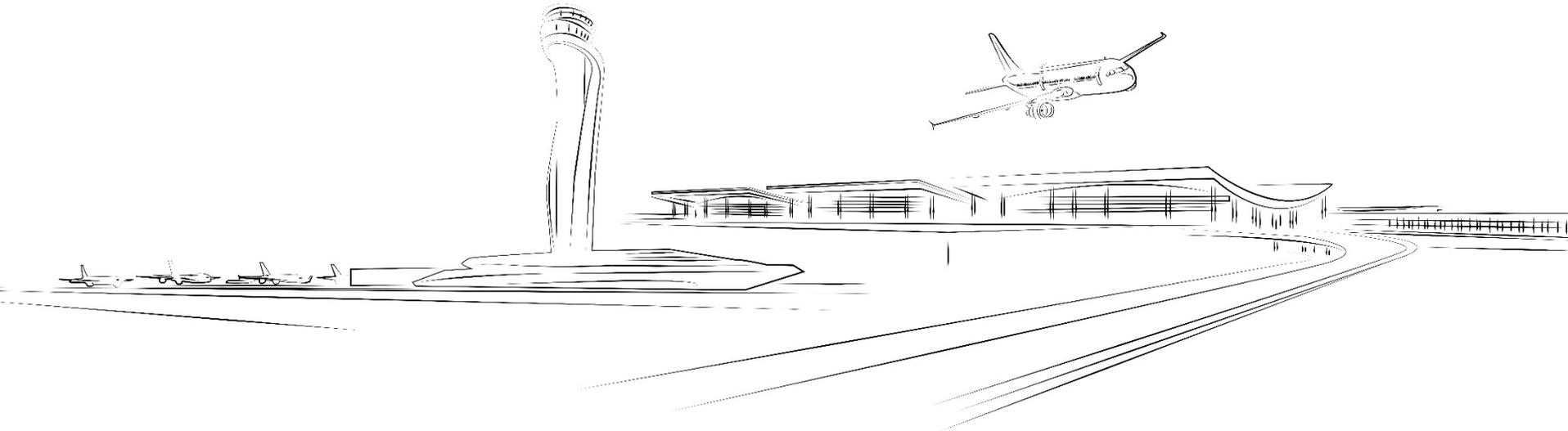
Our Flight Inspection Aircraft





Thank You

Questions?



ICAO EUR/MID Radio Navigation Symposium, Antalya, 6-8 February 2024