

# GNSS RFI Mitigation: International Efforts to Protect Aviation

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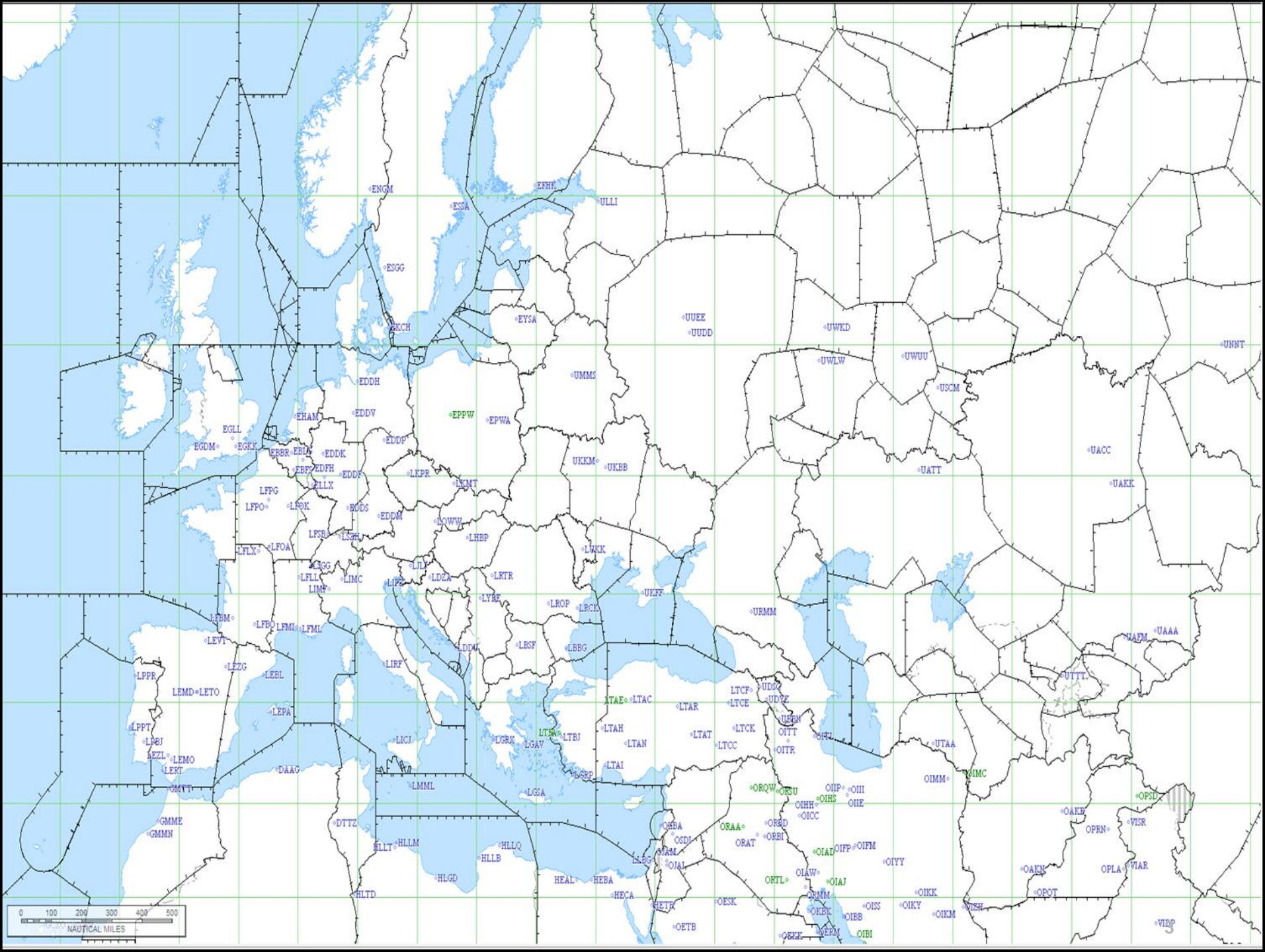
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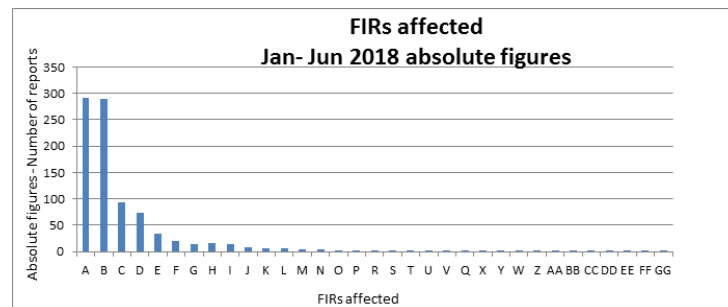
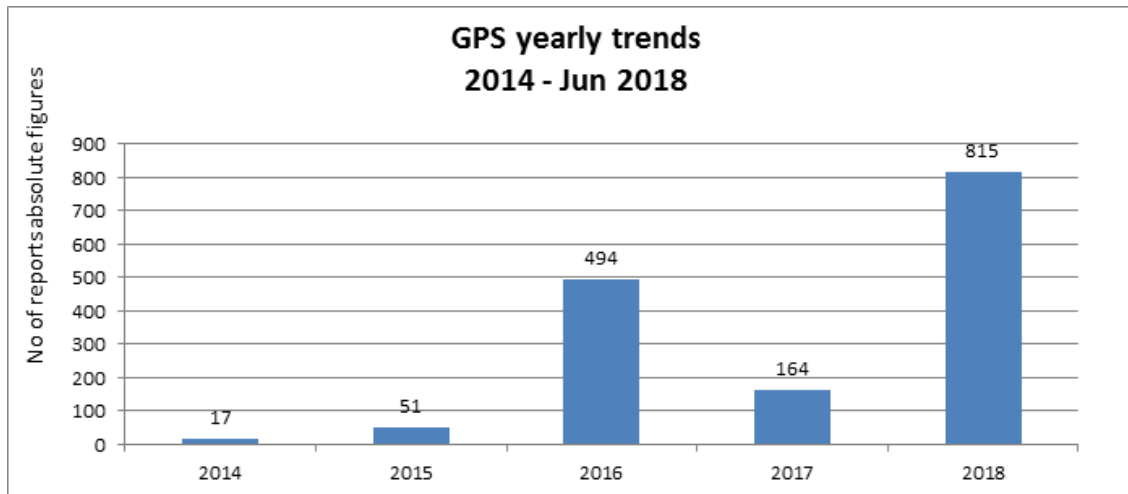
## Background and Objectives

- GNSS RFI Mitigation Plan (for Aviation)
  - Briefed at CGSIC in 2015
  - Published in ICAO GNSS Manual Doc 9849 (3<sup>rd</sup> Edition, 2017)
  - Implemented system to collect pilot reports of GPS Outages: EVAIR
- Ongoing threat monitoring and risk assessment leads to effort to strengthen mitigation barriers
  - Objective of this presentation:
    - Explain challenges of international coordination in current RFI cases
    - Highlight associated technical challenges where further work by community is encouraged

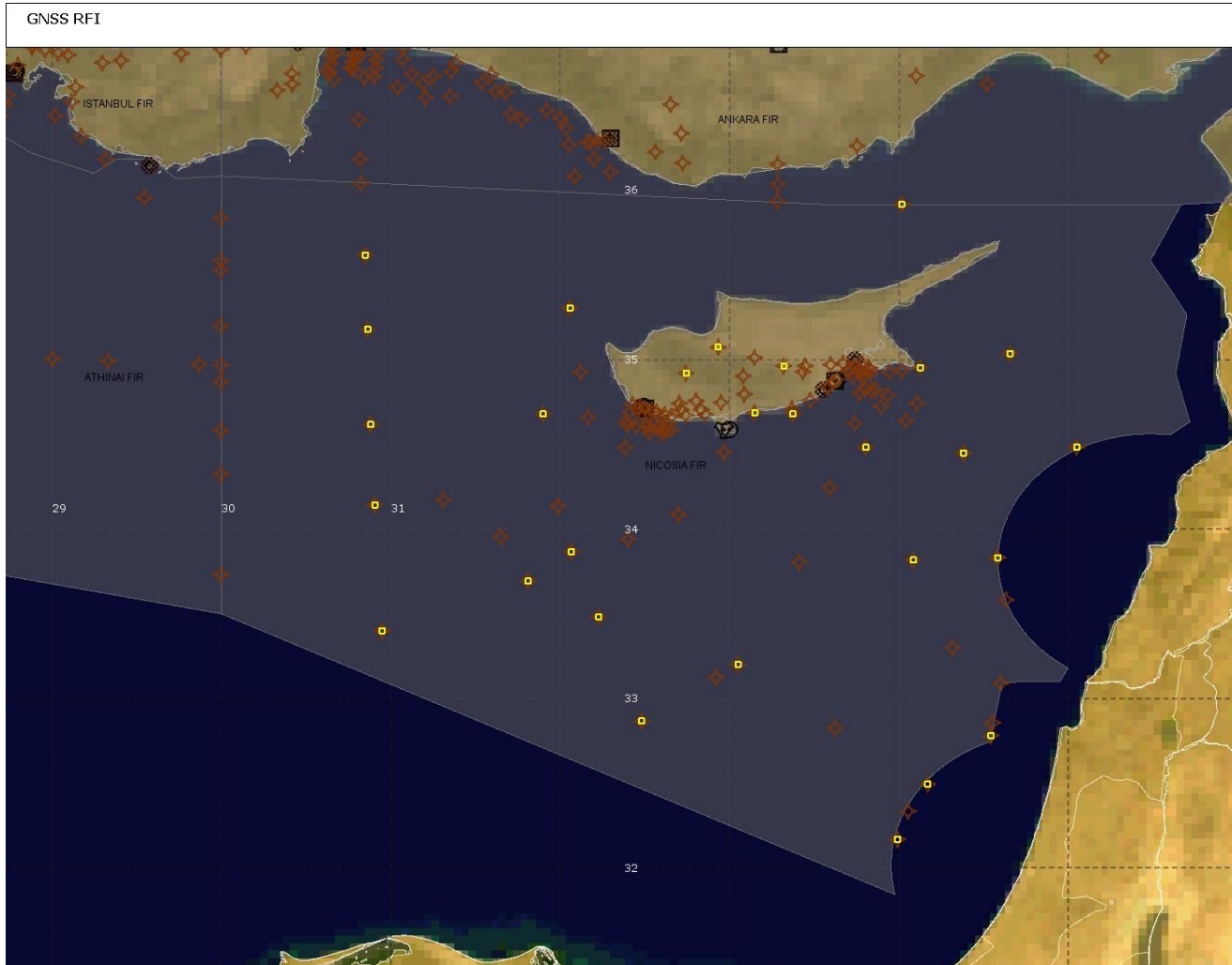


# EVAIR: EUROCONTROL Voluntary ATM Incident Reporting System

- Collects “GPS Outage” reports from participating aircraft operators in Europe and adjoining areas



# Nicosia Flight Information Region (FIR)



# Current GNSS RFI Case

- EUROCONTROL is supporting Cyprus
  - Over 180 pilot reports of GPS problems submitted to Cyprus Air Navigation Service Provider between mid March to AUG 2018
    - Cyprus Dept. of Electronic Communications confirmed in one measurement Syria as origin of two 10MHz wide jamming signals on L1 and L2 center frequencies
    - Confirmed by DSNF French Flight Inspection aircraft on approach to Beirut
- Other reports being sent to IATA (International Air Transport Association) and EVAIR system
  - Additional reports in Turkish and Israeli airspace and from Maritime sector
- Other reported RFI cases include VHF COM, SSR (ATC Radar), COSPAS SARSAT link
  - Other RFI sources remain possible!

# Operational Impact

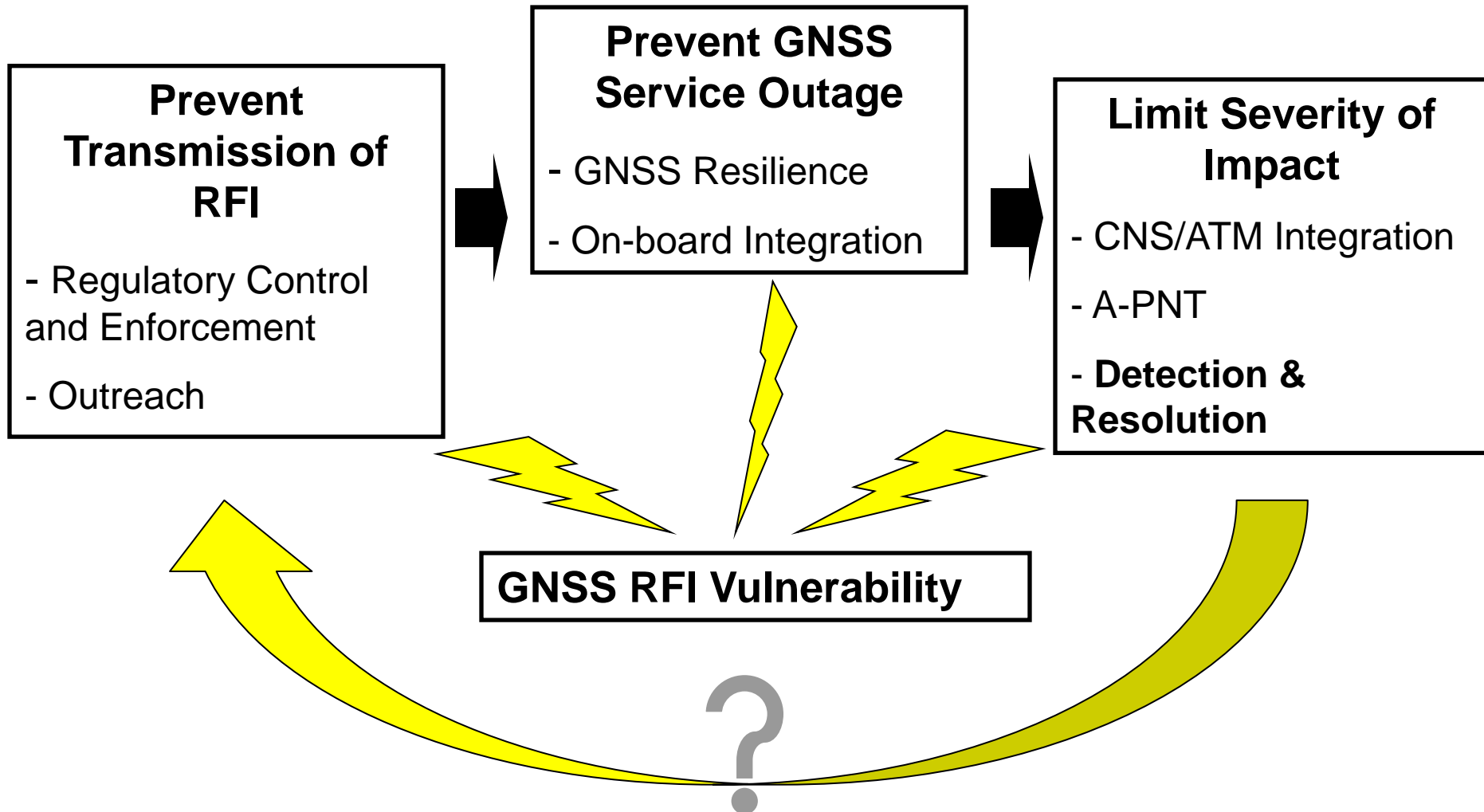
- In general, GNSS RFI to aircraft while en-route is mainly an operational nuisance
  - Integrated navigation capabilities including INS
  - Assumes that there is suitable coverage of terrestrial navigation aids, and SUR and COM capabilities
  - These capabilities are more limited in extended over-water regions
- Operational Mitigations by Air Traffic Control
  - May lead to increased staffing of ATC sectors to ensure that navigation assistance can be provided if requested
  - May lead to suspension of maintenance activities of CNS equipment
  - ***Any simultaneous impact on 2 or 3 of the COM, NAV and SUR elements can quickly become a serious safety risk***
  - *ATC would like to have clearer understanding of how GPS loss impacts aircraft systems! (growth tendency)*

# RFI from Neighbouring State confirmed: What now?

- International Telecommunications Agency, ITU
  - Radio regulations have international treaty status
    - Infringement procedure & procedure in case of harmful interference
- **15.21 § 13** *If an administration has information of an infringement of the Constitution, the Convention or the Radio Regulations ... committed by a station under its jurisdiction, the administration shall ascertain the facts and take the necessary actions.*
- **15.28 § 20** *Recognizing that transmissions on distress and safety frequencies and frequencies used for the safety and regularity of flight ... require absolute international protection and that the elimination of harmful interference to such transmissions is imperative, administrations undertake to act immediately when their attention is drawn to any such harmful interference.*
- Cyprus Radio Regulator initiated infringement procedure, ITU sent letter to neighbouring States – in March / April...



# Implementing Mitigation Barriers



# Why bother with international agreements... ?

- Additional MoC between ITU and ICAO for aviation cases
  - Used in the past for Incheon FIR
  - Typical arguments and tricks...
- EUROCONTROL Network Manager, Radio Frequency Function
  - Reporting process for EU & EUROCONTROL Member States
  - Works better due to common political and legal basis
- Even if interfering party is not cooperative, need to maintain a response
  - Not complaining is not responsible
  - Even in other, domestic cases, often no prosecution
    - But often RFI stops once there is a complaint, even if nobody admits...

# Technical Observations

- Measuring GNSS RFI on ground over large distance can be very difficult
  - Masked by earth curvature while aircraft at altitude remain exposed
  - Source localization requires sufficient baseline for interferometric approach
- Remains useful to have access to aircraft with suitable measurement capabilities
  - Pilot report not sufficient to confirm RFI
  - When using ADS-B data, useful to be able to distinguish between RFI on 1575 MHz vs. RFI on 1090 MHz
  - Multiple independent measurements can help in making political pressure

# Challenges for RFI Source Elimination

- In current example, no evidence exists other than Syria as a source of the RFI (active zone of conflict)
  - But cannot exclude that multiple sources exist
  - Difficult to measure and locate on ground an RFI source far away and impacting aircraft at altitude
- If RFI source would be over international open waters, it will be extremely difficult for impacted State to identify source and start escalation procedure
  - State radio regulator has no legal authority
  - Even if able to identify State of Registry of maritime vessel or aircraft, unlikely to lead to a resolution if of a military nature
    - *However, also note that in many cases, military gets blamed prematurely*
  - Due to drone warfare, can expect such cases to increase

# Aviation Principles and Consequences

- ICAO legal framework provides basis to assign unique responsibility of an ANSP in airspace over international open waters
  - ANSP must be able to assume that ITU regulations are being respected to provide CNS services
- Currently, process exists to close airspace to civil aircraft operations over declared zones of conflict
  - Aviation currently learning that outside of that zone, cases of RFI to all CNS systems are becoming more frequent and need to be managed
  - Impact range for GNSS RFI can be very significant
  - RFI in extended over-water regions can be especially difficult
  - Aviation will work on improving associated reporting and coordination processes, coordination with UN-ICG ongoing

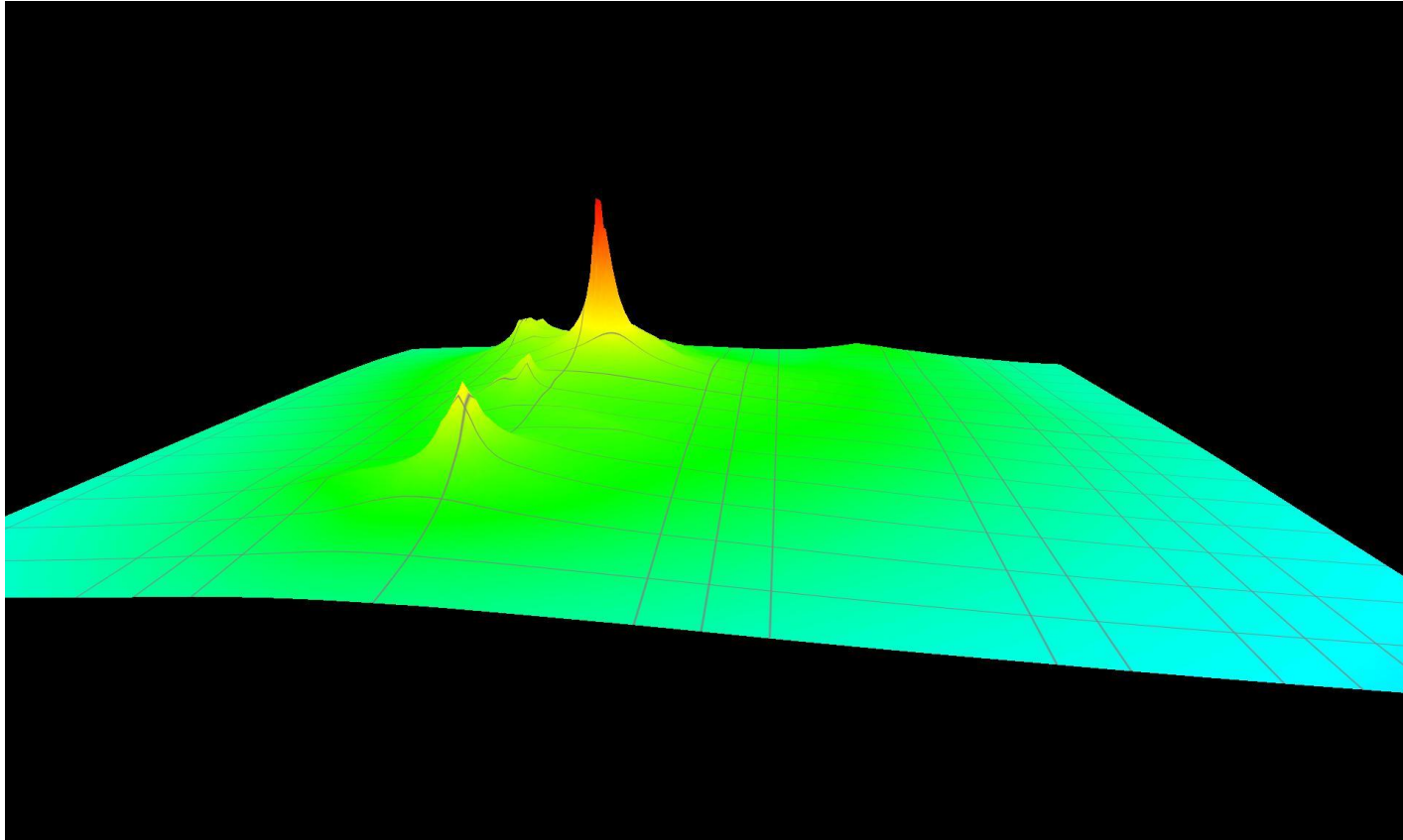
# Requests to GNSS Government Community

- Make States aware that:
  - All airspace where aircraft operate is assigned to a unique ANSP which must provide interference-free CNS services
  - RFI sources inside zones of conflict can impact civil air traffic far outside of such zones with possible safety impact
  - RFI sources in or over international open water can be extremely difficult for aviation to resolve
- Invite States to evaluate if their civil-military coordination arrangements are appropriate to:
  - Ensure that anyone exercising electronic warfare capabilities outside of declared zones of conflict will fully coordinate with the responsible ANSP, including over international open water
  - Consider sharing information about GNSS RFI sources and impact areas when available to help maintain the safety of air traffic

# EUROCONTROL Support to RFI Mitigation

1. Monitor for operationally significant events using EVAIR
2. If multiple events accumulate, contact State / ANSP concerned and start investigation of ADS-B track data to determine nature of event and support State in RFI source localization
3. Building on experience with real events, propose improvements to equipment functions to increase robustness (and reaction capabilities) to RFI

# Current Work: 3D Probability Contours

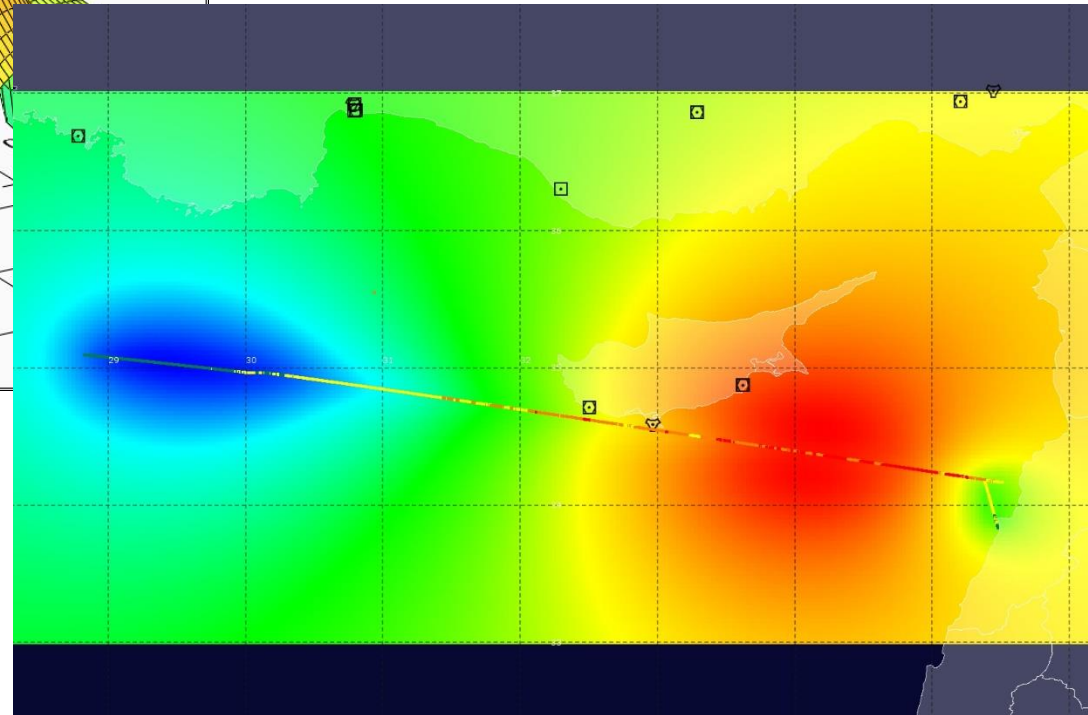
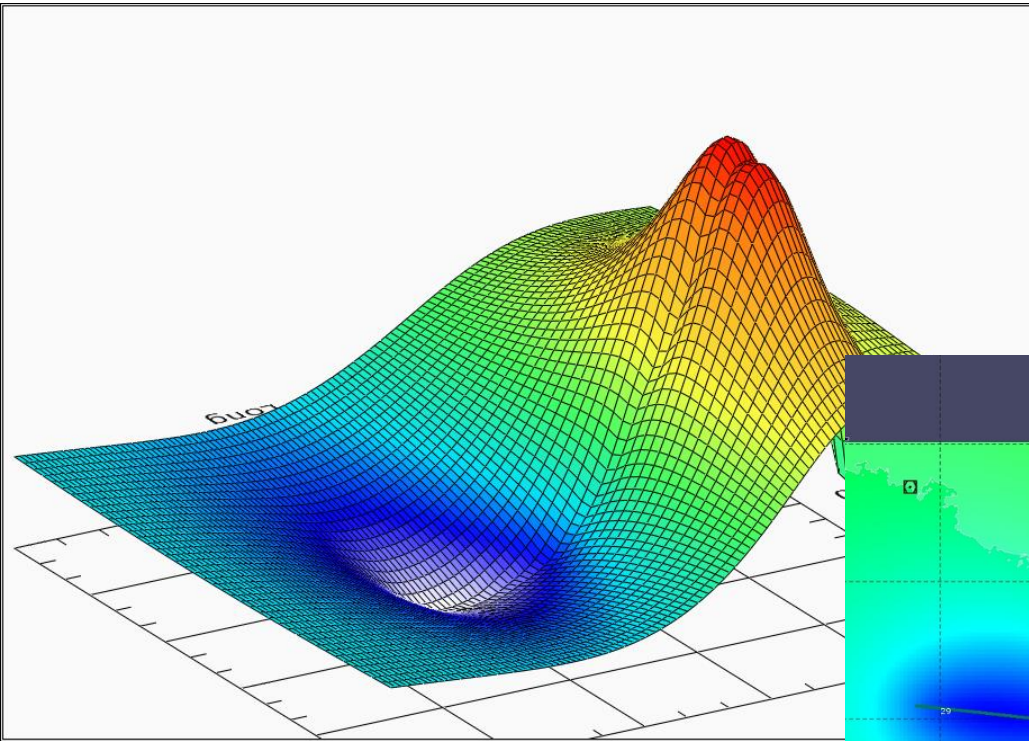


Probability density “heat map” example generated by real case of ADS-B track gaps due to RFI  
(Method developed by Valeriu Vitan, EUROCONTROL)



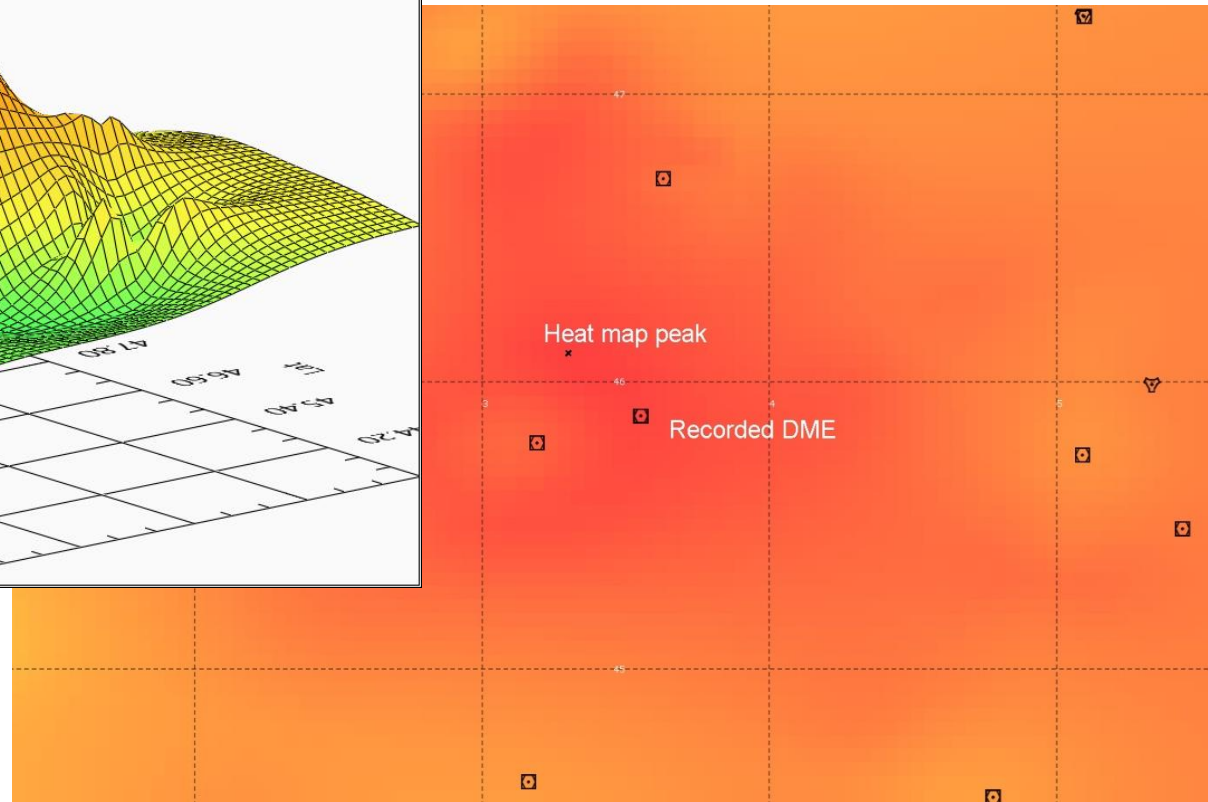
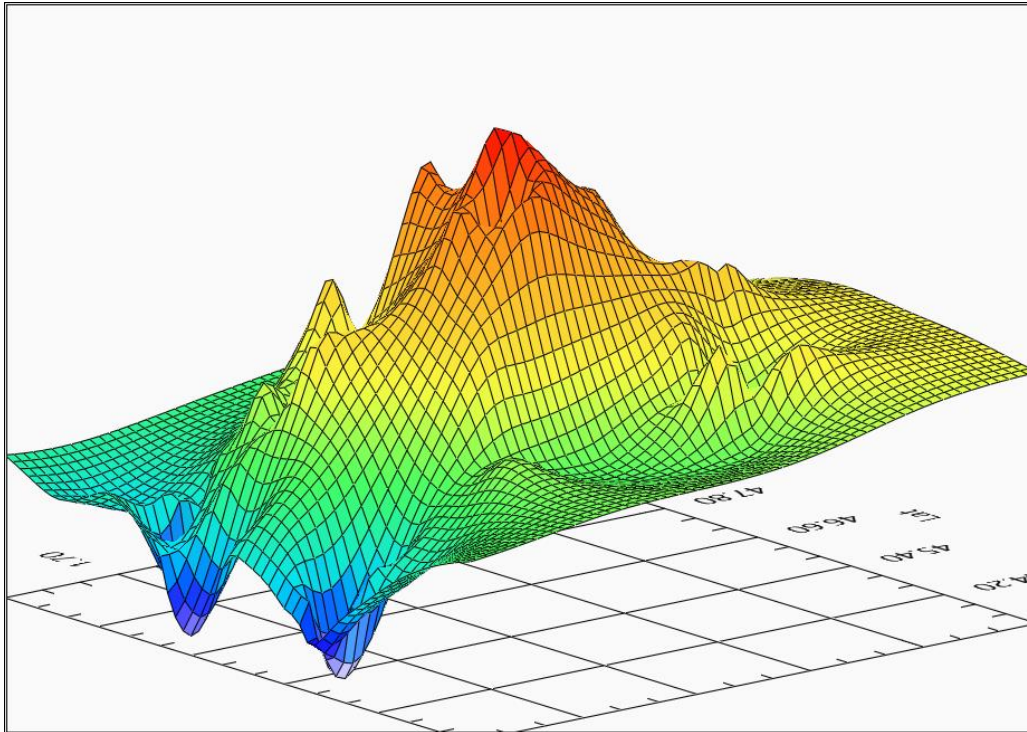
# Current Work: 3D Probability Contours

Probability density “heat map” generated by real case of in flight RFI measurements



Data provided courtesy of DSNA/DTI Flight Inspection (with C/N0 levels)

# Current Work: 3D Probability Contours



Probability density “heat map” example generated by real case of DME peak level recordings (validation)

# Envisaged Improvements

- ATC could use a near real time picture of which aircraft are affected by RFI (location and duration)
  - Not for tactical controller but for planning and coordination functions
  - Initial work using current ADS-B track gaps
- Future avionics: provide GNSS receiver RFI status and downlink information to ATC using specific bits in ADS-B messages
  - Obtain directly actionable RFI report
  - Coordination ongoing through EU/US WG-C, ICAO NSP, RTCA and EUROCAE
  - We encourage further work on airborne RFI source localization using GNSS observables and PDOA approaches

# Conclusions

- Objective of GNSS RFI Mitigation activities is to ensure that threats to GNSS-based services continues to pose no unacceptable risks to aviation operations
  - Continued vigilance required, especially near zones of conflict
  - EUROCONTROL continues to act on behalf of aviation in support of its member States
- Many short term initiatives are possible and effective
  - Requires multi-sector cooperation, lots of interfaces
- Current threat assessment suggests that long-term improvements, including specifically designed equipment functions, are necessary
  - Work ongoing for next generation DFMC standards
  - Technical contributions in this area are encouraged

# Questions?

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