Supporting
European
Aviation

EUROCONTROL

GNSS RFI Mitigation

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Radio Navigation Workshop for NAM and SAM Regions

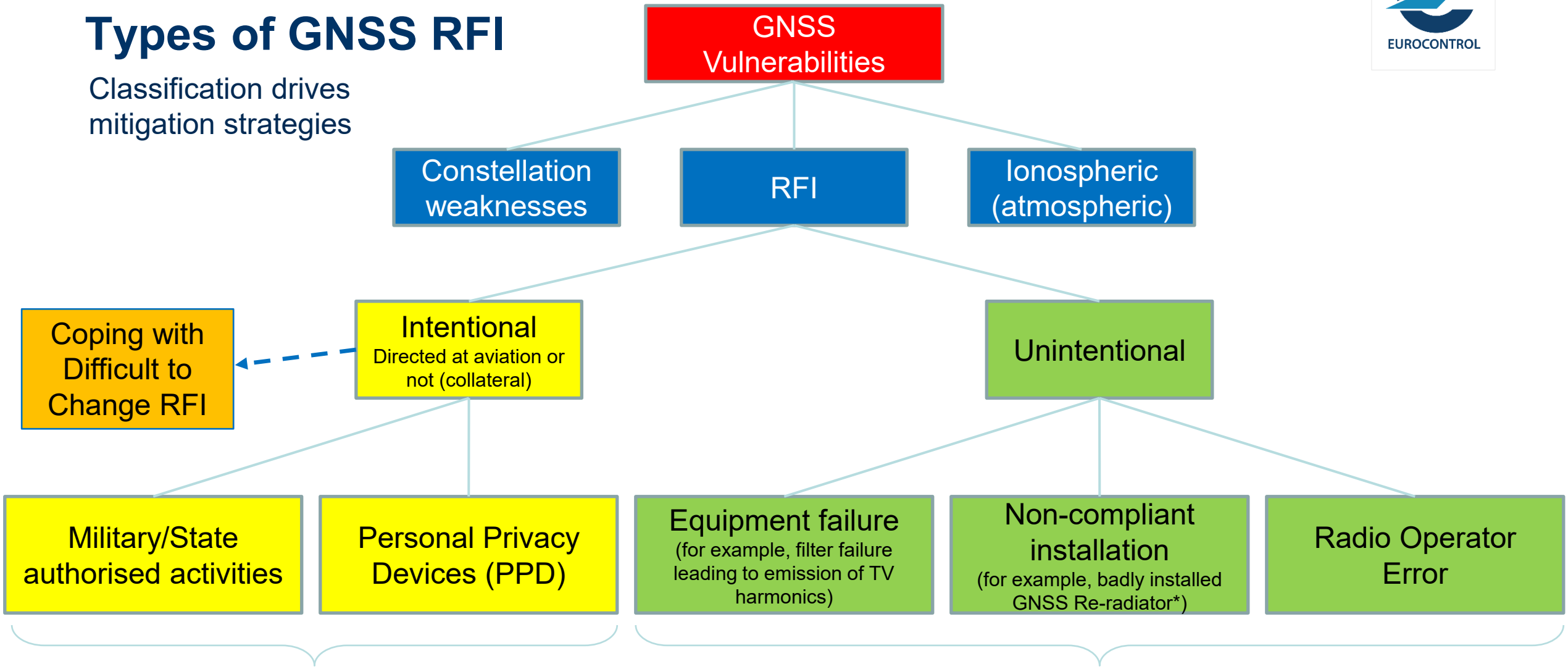
Mexico City, Mexico, 2-4 September 2025

FOUNDING MEMBER SESAR JOINT UNDERTAKING

NETWORK MANAGER

Types of GNSS RFI

Classification drives mitigation strategies



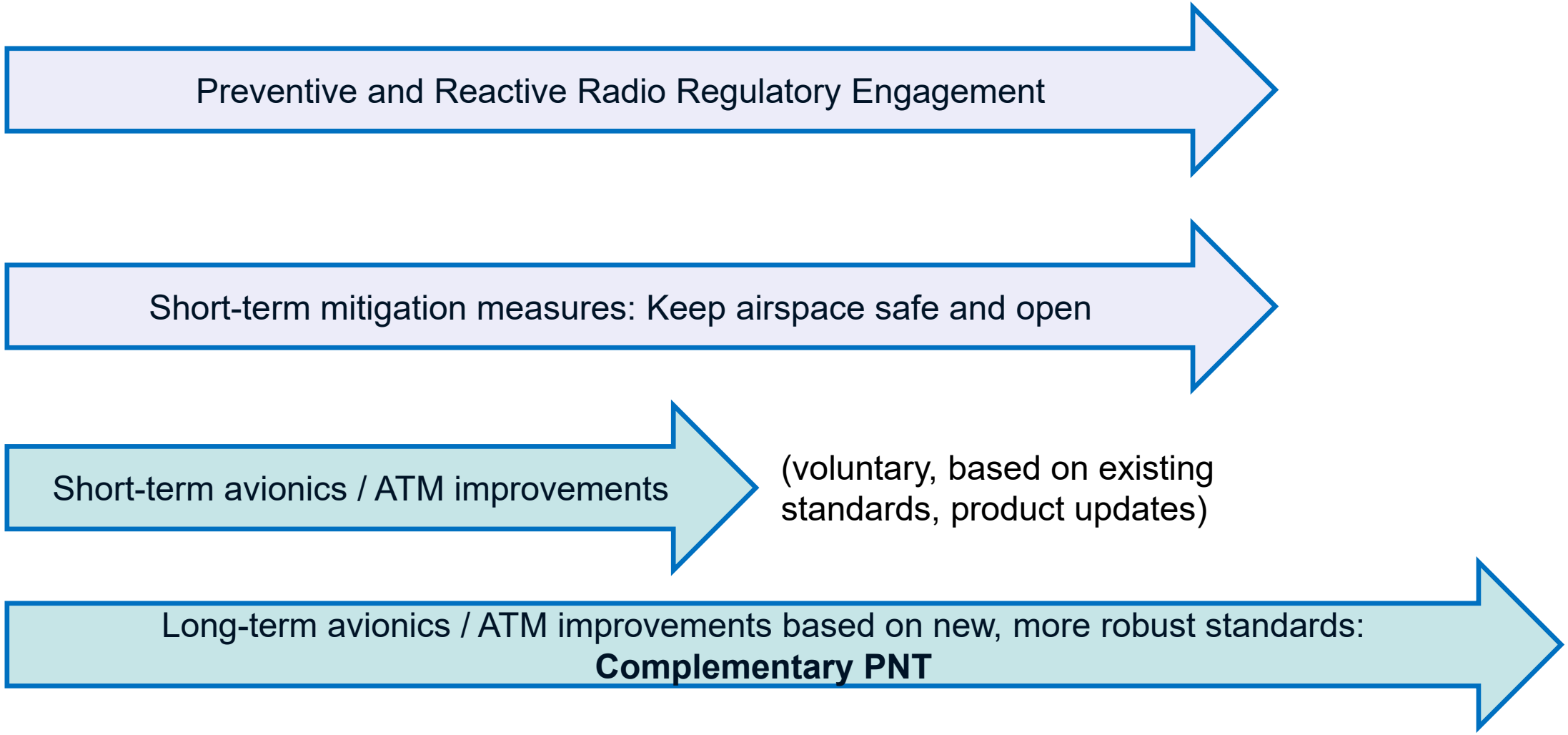
Interference whose purpose is to disrupt/mislead GNSS signal reception

Outreach, Law enforcement against unauthorized jammers
Coordination of GNSS RFI testing exercises

Spurious emissions not intending to disrupt/mislead GNSS signal reception

Spectrum protection
Respecting Standards and allocated frequencies

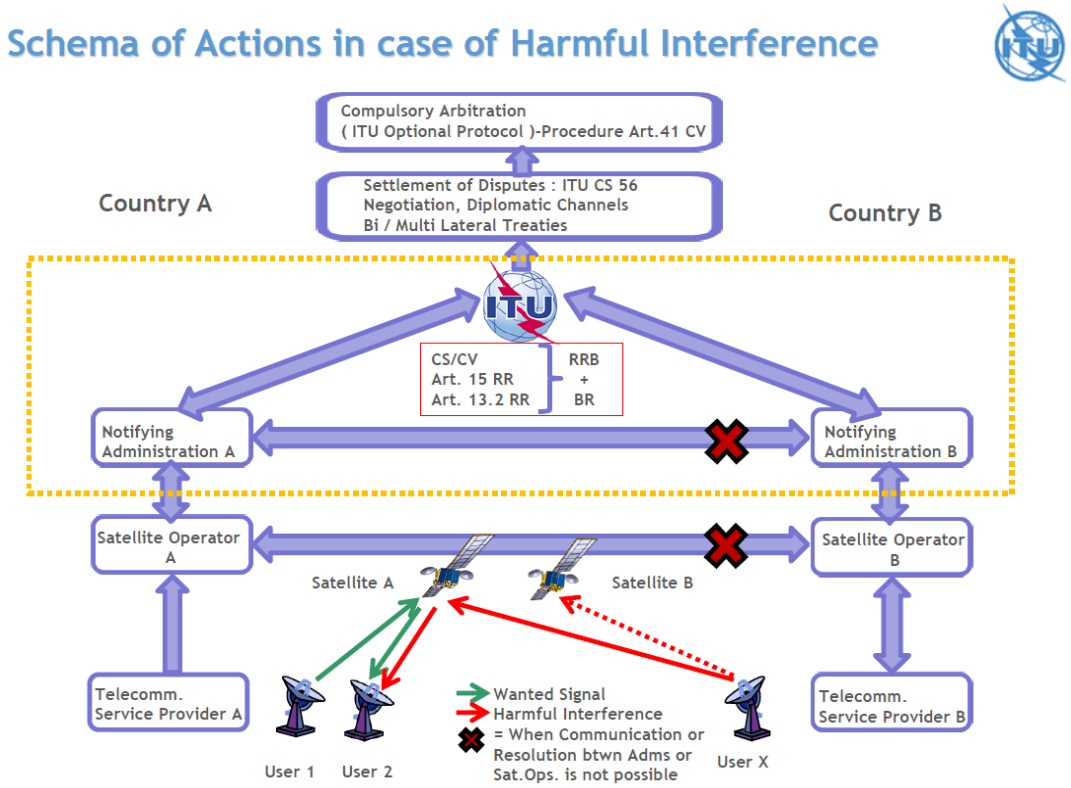
GNSS RFI Mitigation Activities



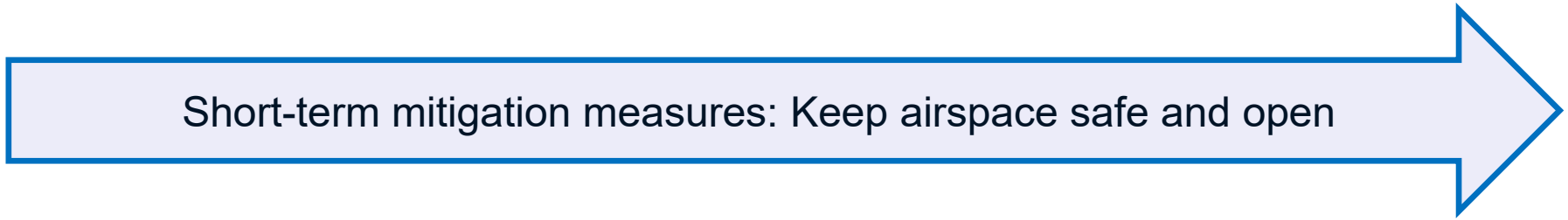
GNSS RFI Mitigation Activities

A “duty to complain” and use formal process

- ANConf/14 WP63 provides relevant references to ITU Radio Regulation (RR art 15)
  - What you see on the ground **is not** what you see in the air
    - ADS-B makes aircraft impact visible, **but is NOT an RF signal measurement!**
    - Need measurements of interference signals, ideally with source geolocation
    - *Build up flight inspection, other aerial work or UAS capabilities!*
    - Especially for persistent RFI sources operating 24/7
    - Need indisputable / impartial technical evidence
  - Once neighbouring State has not responded to bilateral letter, escalate to ITU Radiocom Bureau
- Further develop procedures between cooperative States (C-UAS, Military Exercises & Testing)



GNSS RFI Mitigation Activities



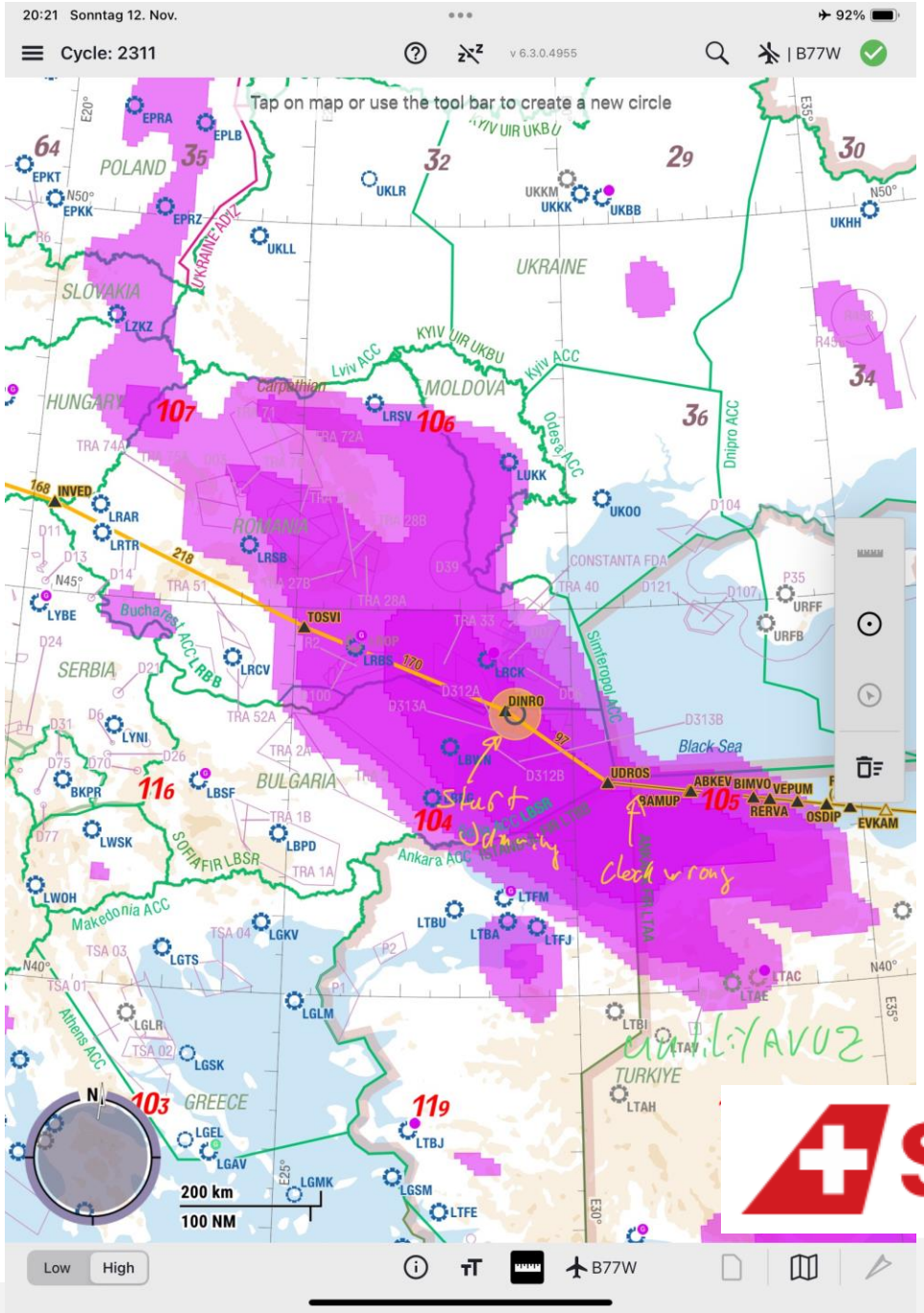
Request from Pilots: Give me the “GPS Weather” on my EFB!

- **GNSS RFI Layer in Lido mPilot**

Limited to “Yesterday’s GPS Weather”

Allows pilots to deselect GPS prior to entering degraded GNSS environment to protect navigation system performance

And to reactivate GPS and associated systems once outside known zone of RFI



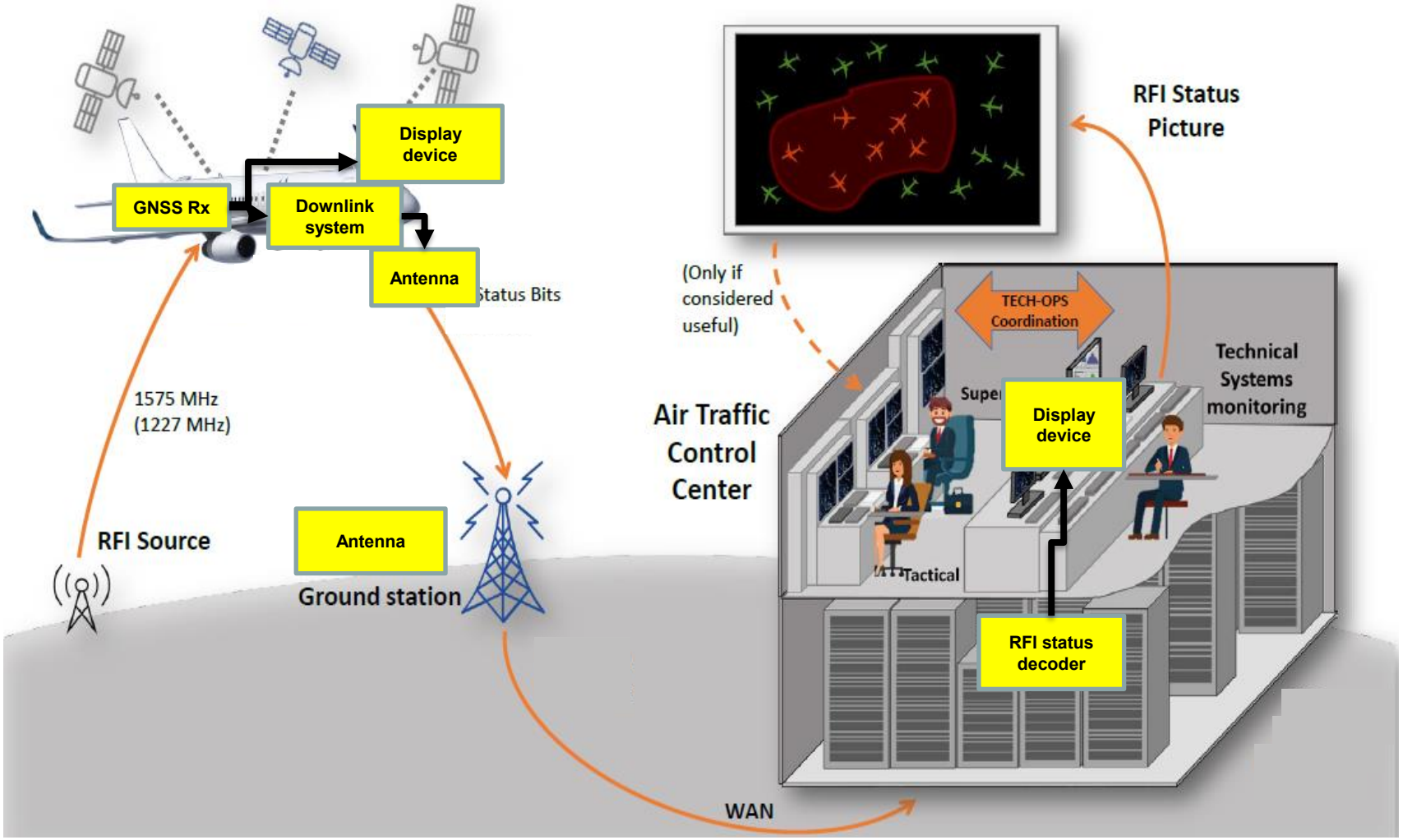
Visualizing GNSS RFI to ensure ATC Support

Using ADS-B low PIC today, working on standardized function in DFMC

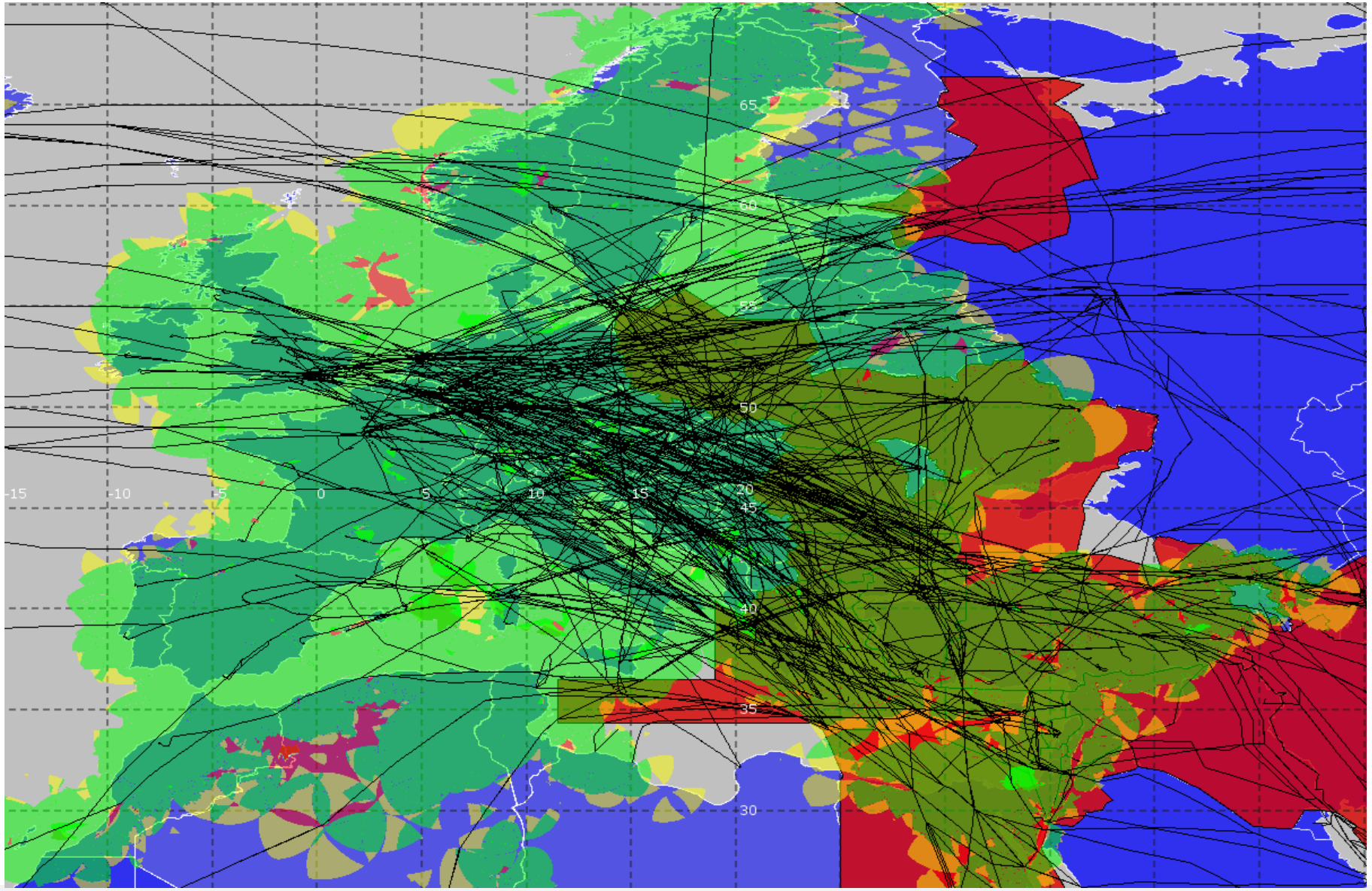
Steps

1. GNSS Receiver **detects RFI** and **reports** it to the **ground**
2. Ground stations **process RFI status** and allow generating **an integrated RFI status** picture for multiple aircraft
3. TECH services coordinate with OPS on impacted areas and launch **operational mitigation measures**
4. Report to the **radio regulator**

Concept of Operations under development in collaboration with most impacted ATC



EUROCONTROL Airspace Risk Assessment



Dark RED: FIR affected by GNSS RFI

Black: Flights crossing affected FIRs

Green: Alternative DME/DME RNAV Coverage Available

Yellow/orange: DME/DME RNAV Coverage Available but no redundancy

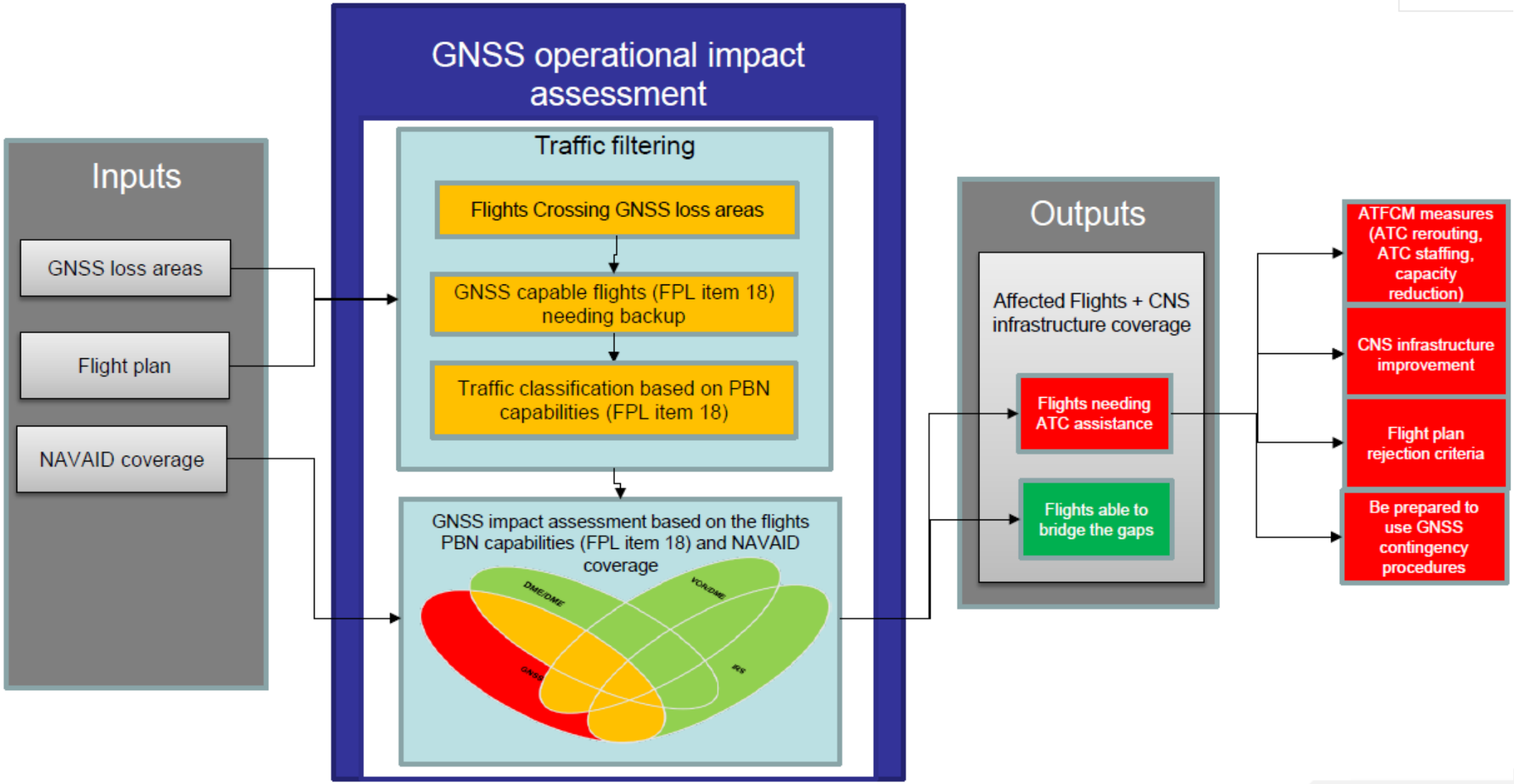
Light red: No DME/DME RNAV Coverage

Operational Management of GNSS RFI

OPS Logic:

Depending on ATC Sector, one or two aircraft needing special support is acceptable

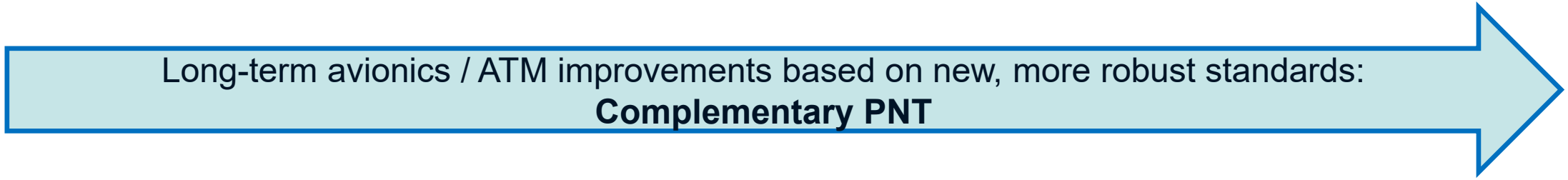
If this level is crossed, capacity measures become necessary



Short-term GNSS RFI Mitigation Measures

- Improve reporting and operational procedures (especially Ground Prox)
- Safety Collaboration between ANSP & Operators (ANConf/14 WP61)
  - Ensure aircraft operators knows what ANSP provides to support contingency
  - Ensure aircraft are equipped to use the provided contingency services
- Provide a Resilient Operational Network (RON)
  - DME/DME based SID/STAR and ENR support whenever possible
- Ensure ILS remains available as needed
  - Ensure ILS intercept is possible without GPS (RNAV waypoints for IAF, MAPt)
- Provide a Minimum Operational Network (MON)
  - VOR/DME for non DME/DME equipped airspace users to enable safe landing
- Ensure CNS/ATM infrastructure is robust against compromised GNSS time

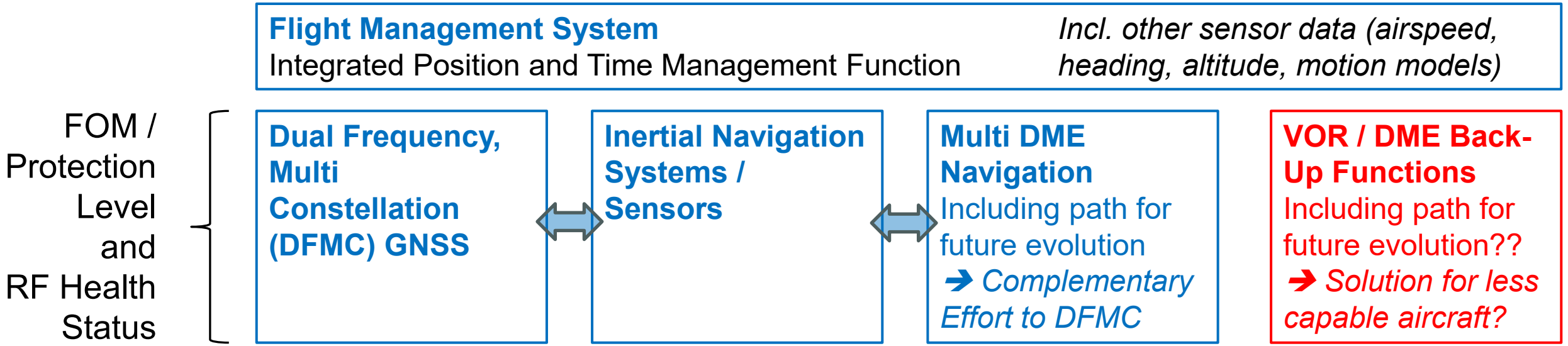
GNSS RFI Mitigation Activities



Moving towards Complementary Resilient Navigation

(ICAO Assembly Resolution 41-8C)

- Need “all sensors” interoperable integrity
  - More than multi-sensor: cross-check sensors for anomaly detection
  - Propagate robust position and time to all systems including ADS-B
  - Develop robust timing and time synchronization
- Similar principles can apply to SUR position integration
  - Compare ADS-B to SSR / MLAT position



Moving towards Complementary Resilient Navigation

(ICAO Assembly Resolution 41-8C)

- Rejuvenate DME: Move from DME/DME to Multi-DME Navigation (including INS)
  - Develop DME network balancing criteria, i.e. know how many DME we really need
  - Standards ground-work ongoing:
    - EUROCAE WG-107 DME Infrastructure supporting PBN
    - RTCA SC227 / EUROCAE WG85 Navigation Standards
    - ICAO FLTOPS PBN Manual / Navigation Specifications

Need to discuss necessary balance of space / air / terrestrial capabilities!

- Push for equipment upgrade alongside DFMC GNSS Upgrade
  - Ongoing initiatives: RTCA SC159 / EUROCAE WG62, ED-259B DFMC GNSS Receiver MOPS
    - New requirement for GNSS to recover after encountering RFI
    - RFI detection and reporting output on L1/E1 and L5/E5 (Validation ongoing / ADS-B downlink requested)
    - Authentication: SBAS and Galileo OSNMA
    - Spoofing ad-hoc considering further improvements
    - Maintain redundant GNSS modes in A-RAIM
  - EU Space Programs: RFI detection using LEO
  - ITAR changes: enabling use of advanced antenna systems (CRPA)

EUROCAE WG107:
DME Supporting PBN Positioning

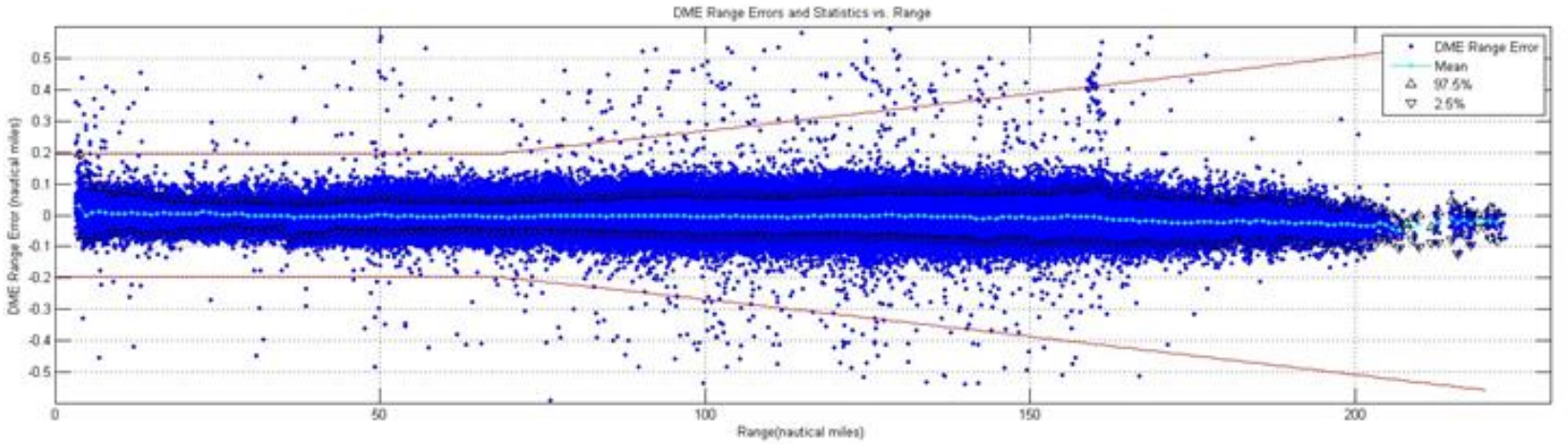
- Giving credit to DME equipment performance improvements since the minimum standards were written in the 1990's

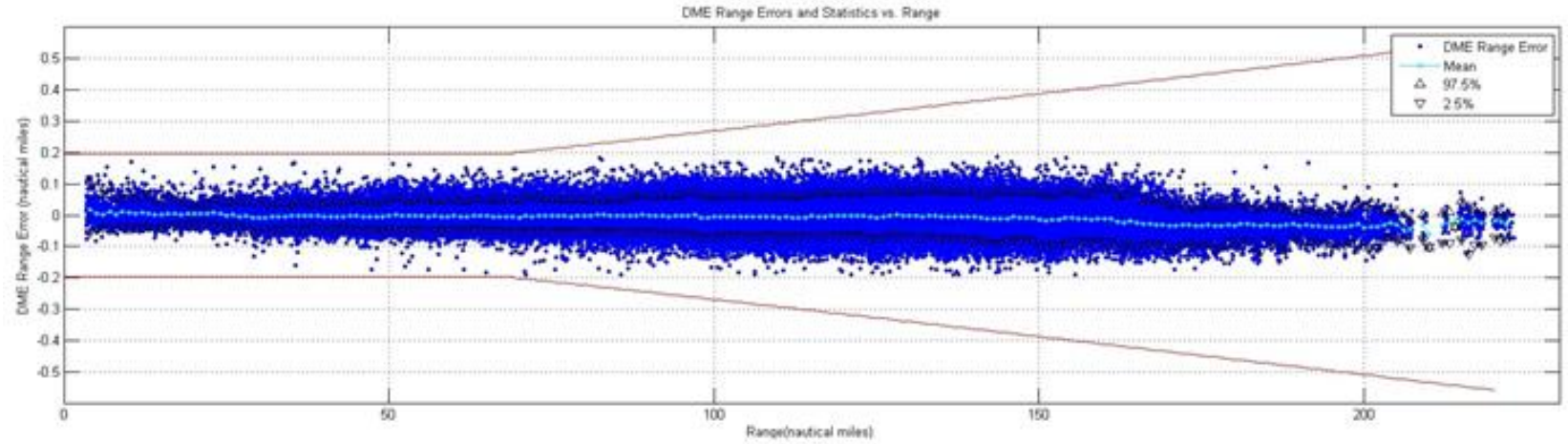
- Update of ED57, DME Transponder MOPS (Minimum Operational Performance Standard)
- New MASPS for DME supporting RNP (Minimum Aviation System Performance Standard)

- To be compatible with RNP/RNAV MASPS, DO 236D / ED-75E
- To be compatible with ICAO PBN Manual Doc 9613
- To provide one acceptable basis for State Authorization of optional use of DME in PBN
- To support move from DME/DME to Multi DME Navigation (all in view)

DME Signal in Space Performance / In-Flight Data

Slant Range Accuracy up to 200NM





Data from several European State DME's at around FL200

Full raw dataset: 797,505points

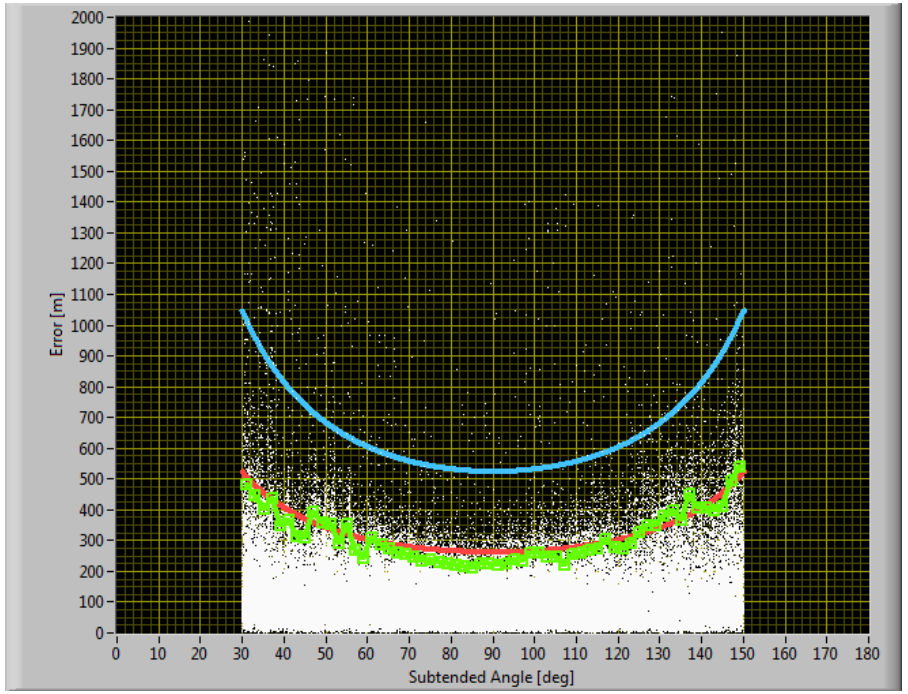
20 sec filter dataset: 413,808 points

Data aggregated for all stations

Results similar for a more recent, low altitude data set

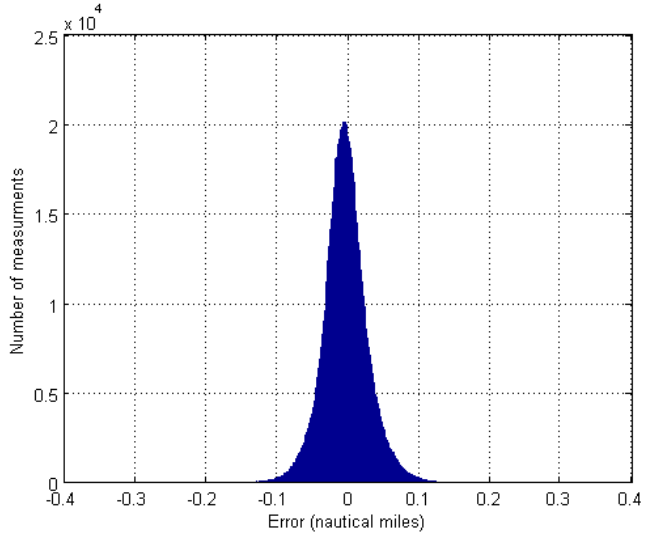
DME Signal in Space Performance / In-Flight Data

Slant Range Accuracy

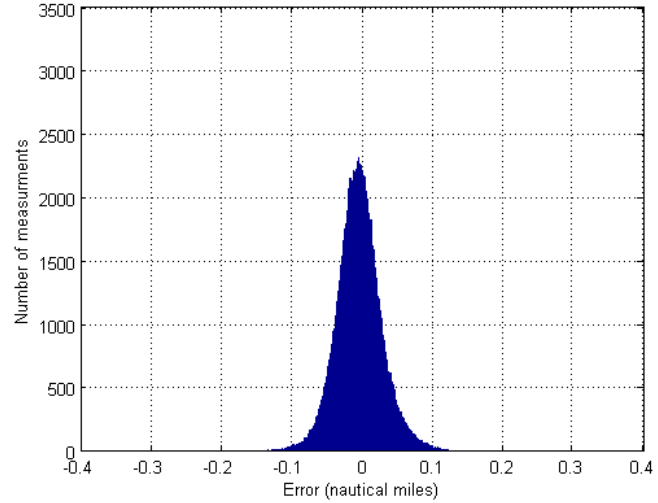


- Measured accuracy twice better than standards
  - Range error : $2\sigma < 0.1$NM
  - DME/DME NSE: $2\sigma < 0.3$ NM

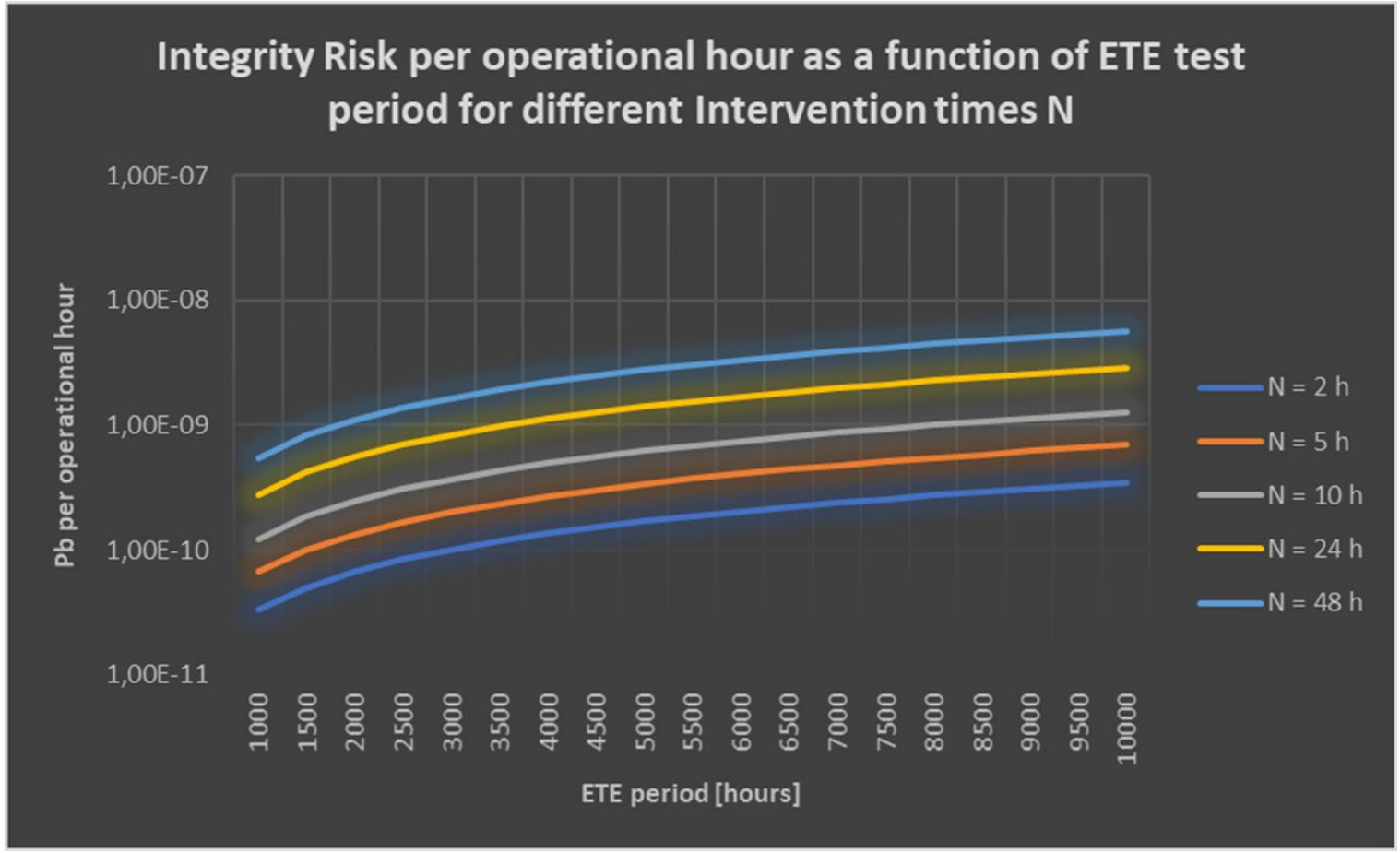
- Without 20 s filter applied:
  - Mean = -0.0038 NM (-7.04m)
  - Standard deviation = 0.0333 NM (61m)



- With 20 s filter applied:
  - Mean = -0.005001NM (-9.26 m)
  - Standard deviation = 0,0322 NM (59m)

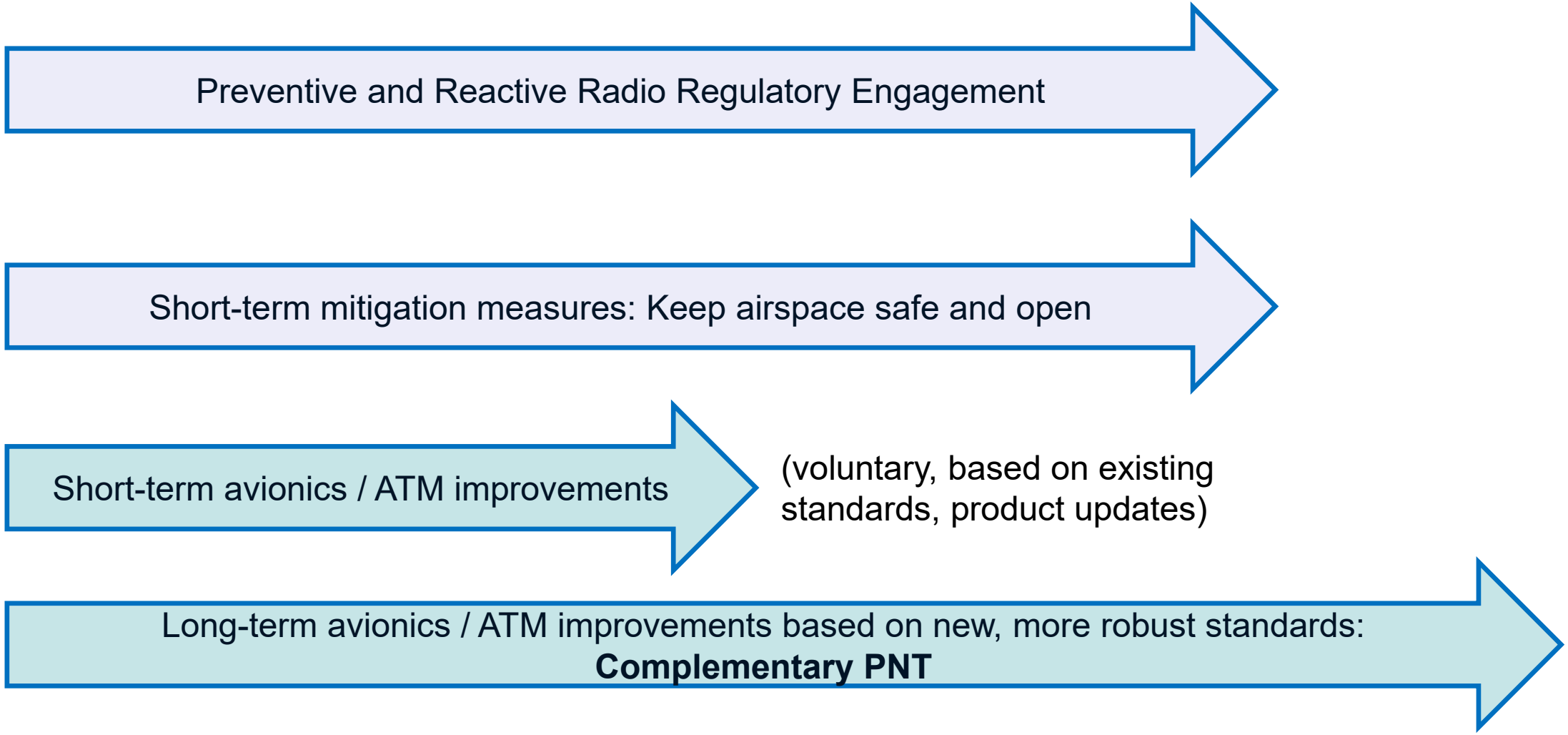


DME Ground Transponder Integrity



Current generation DME installed in Europe typically meet 1-10^{-7}/h Integrity!

GNSS RFI Mitigation Activities



CLOSING THOUGHTS

- A lot of GNSS RFI remains in areas which do not have an obvious link to any zone of conflict
- ITU Constitution provides sovereign right to States to deny any radio service for security purposes
  - Rights come with obligations: Limit power and impact to minimum necessary!
  - Right does not extend to neighbouring State
  - Intergovernmental coordination between Telecom (Spectrum Regulator), Aviation and Defense necessary
- Experience has shown that States get active on GNSS RFI once they have events
  - Nobody can say by now that they have not been warned
  - Even occasional events (Denver & Dallas in the US) can have significant cost
  - “An ounce of prevention is worth a pound of cure”

Further References EUROCONTROL / EASA

- GNSS RFI reporting: https://www.eurocontrol.int/service/eurocontrol-voluntary-atm-incident-reporting
- GNSS contingency procedures: https://www.eurocontrol.int/publication/european-gnss-contingency-reversion-handbook-pbn-operations
- EUROCONTROL Guideline on GNSS Interference Testing (enables coordination for those willing to coordinate) https://www.eurocontrol.int/publication/eurocontrol-guidelines-process-civil-military-gnss-interference-testing
- PBN Portal https://pbnportal.eu/epbn/home/home.html and GNSS Threat Assessment Tool https://pbnportal.eu/epbn/main/PBN-Tools/GNSS-Threat.html
- GNSS RFI Training Course https://learningzone.eurocontrol.int/ilp/pages/course-description.jsf?courseId=20758176&catalogId=896269&isTemplate=true

- EASA SIB https://ad.easa.europa.eu/ad/2022-02R3

Further References ICAO / ITU

- ICAO GNSS Manual Doc 9849 (being updated)
- ICAO Assembly Resolution 41-8C
- ICAO EUR/MID Workshop February 2024 leading to
  - **ICAO State Letter 2024/054, Aviation safety concerns regarding interference to GNSS**
- ICAO Air Navigation Conference 14 (incl. European WP 61 and 63)
  - **Recommendation 2.2/2 – Addressing GNSS interference and contingency planning**

- ITU WRC23: Resolution 676 on RNSS (GNSS L1/E1 and L5/E5)
- ITU Circular Letter CR/488, 8 July 2022

Further reading & watching (somewhat outdated)

- Technical Webinar on GNSS RFI: https://www.eurocontrol.int/event/eurocontrol-stakeholder-forum-gnss
- GNSS RFI risk assessment: EUROCONTROL Think Paper #9 https://www.eurocontrol.int/publication/eurocontrol-think-paper-9-radio-frequency-interference-satellite-navigation-active
- Aviation and Spoofing? https://insidegnss.com/gnss-spoofing-and-aviation-an-evolving-relationship/