GNSS RFI Mitigation: European Efforts & Proposals

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Overview

- GNSS RFI Mitigation Plan Development
  - Introduction & Principles
  - Implementation Support

- Threat Monitoring and Risk Assessment: Global and Regional Processes (Short Term)

- Long Term Strategic Objective

Note: Developed through SESAR

Introduction

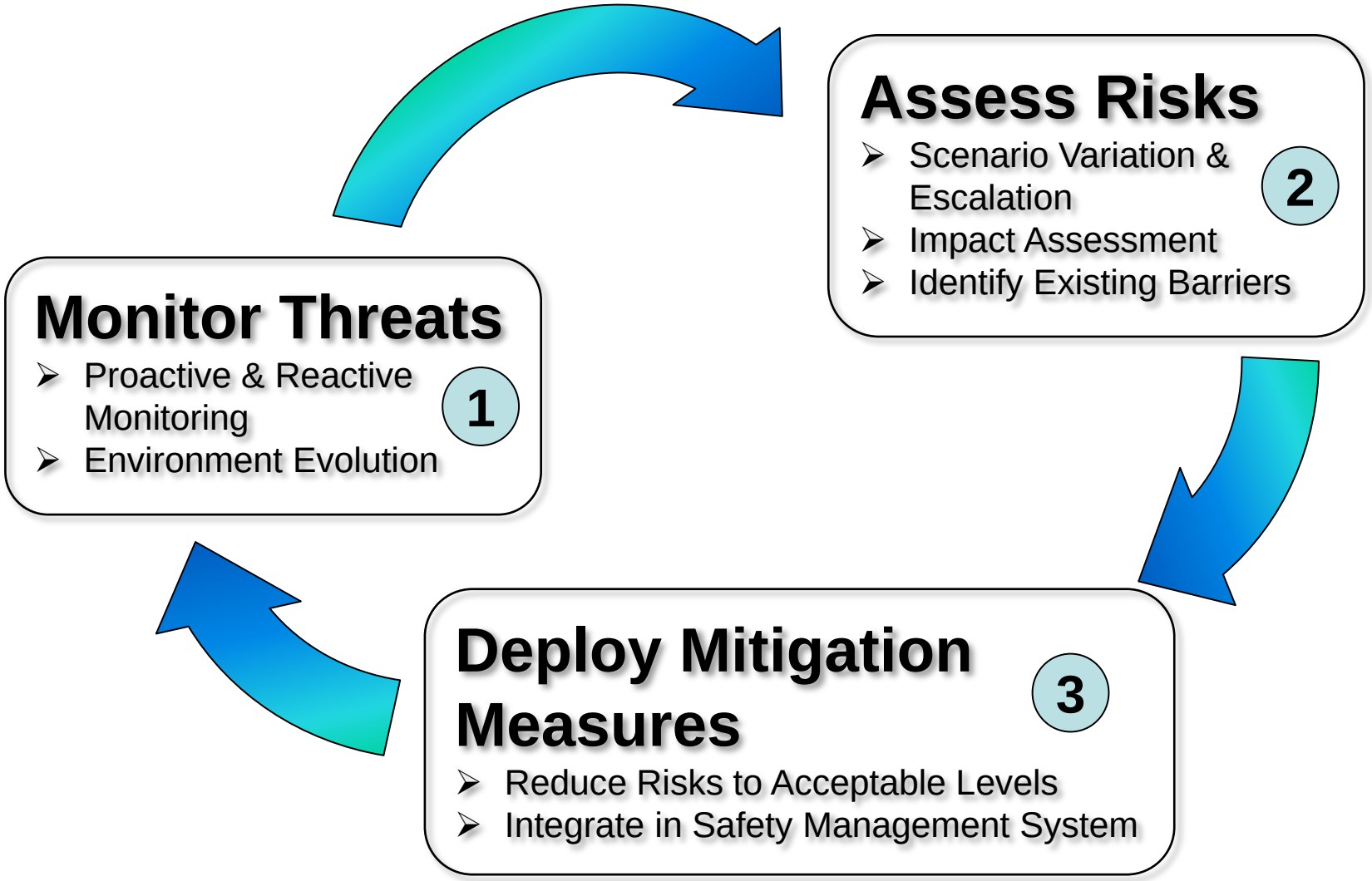
- GNSS RFI Mitigation Plan History & Context
  - Initiated by Spring 2013 Workshop at Eurocontrol Navigation Steering Group Meeting
  - Guidance developed through ICAO Navigation Systems Panel
  - In response to ICAO 12th Air Navigation Conference Job Card
  - Proposed for inclusion in GNSS Manual, ICAO DOC 9849
    - Dec 2015 Change Package
  - Beginning of document very technical (definitions and classification), but rest should be accessible to general audience

- Scope
  - Limited to threats requiring radio frequency propagation
  - Not dealing with corruption of position once it has left receiver

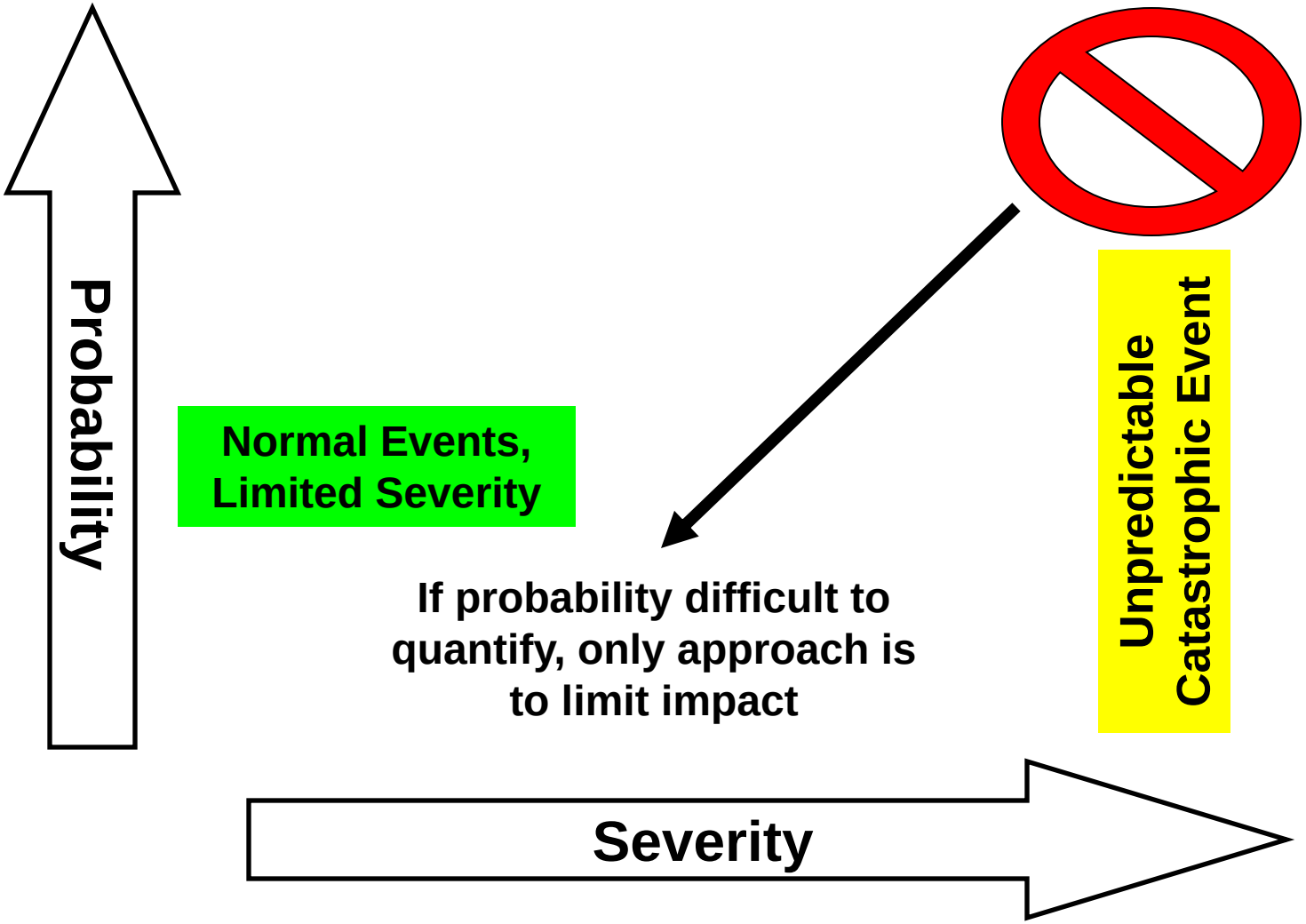
Moving from Vulnerability to Mitigation

- Objective of RFI Mitigation Plan
  - **Define set of activities for States to ensure that risks to aviation from GNSS RFI are sufficiently mitigated**
  - Checklists of set of activities to be considered
  - Much is already in place, State to decide depending on local environment
  - To enable reliance on GNSS and associated aviation benefits
- Focused on States
  - Spectrum a sovereign responsibility
  - Regulation and enforcement part of national oversight
  - Framework to encourage coordination and exchange of best practices
  - Current work focused on regional and global support

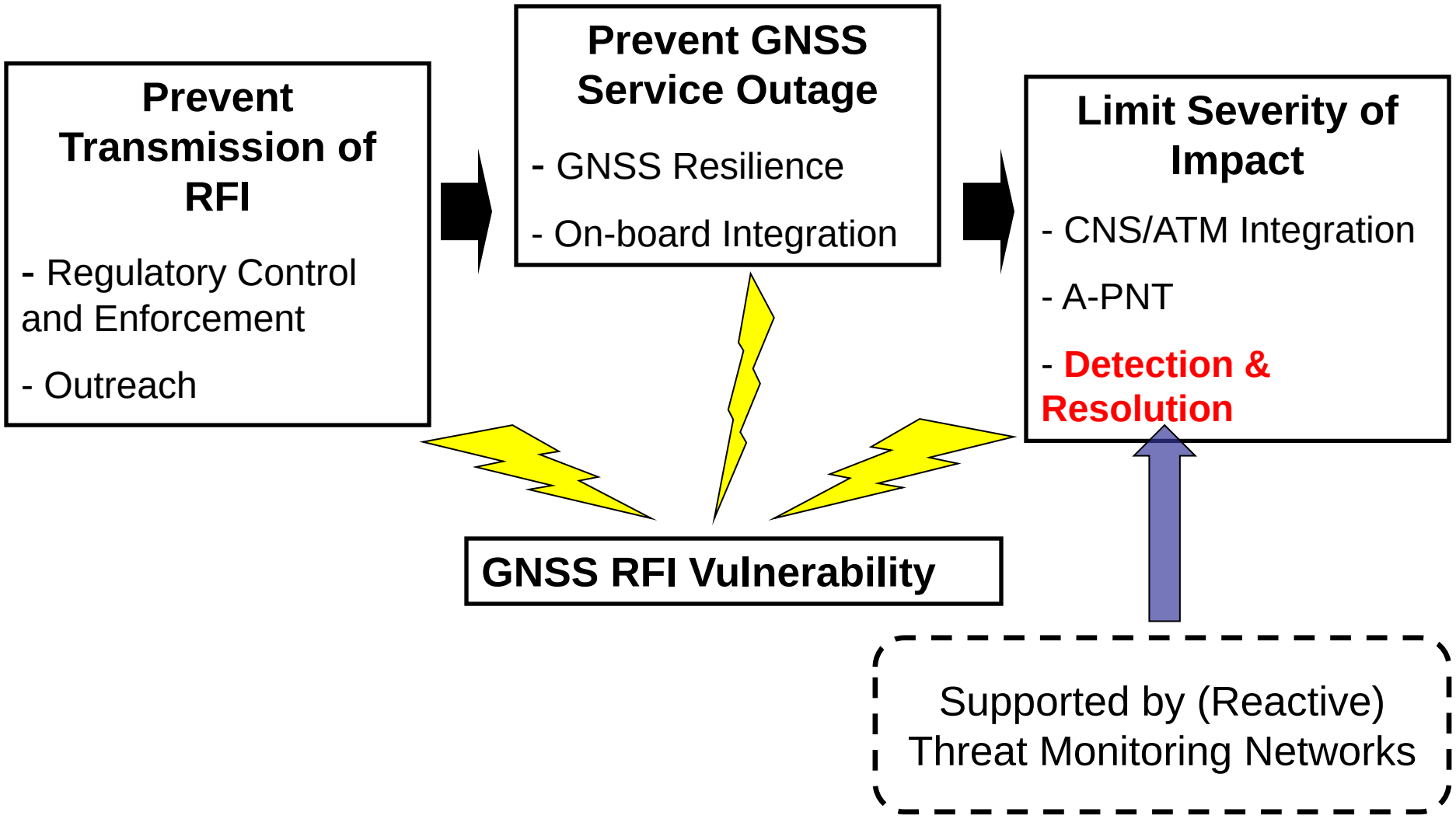
Mitigation Plan Framework



Risk Trade Space



Implementing Mitigation Barriers

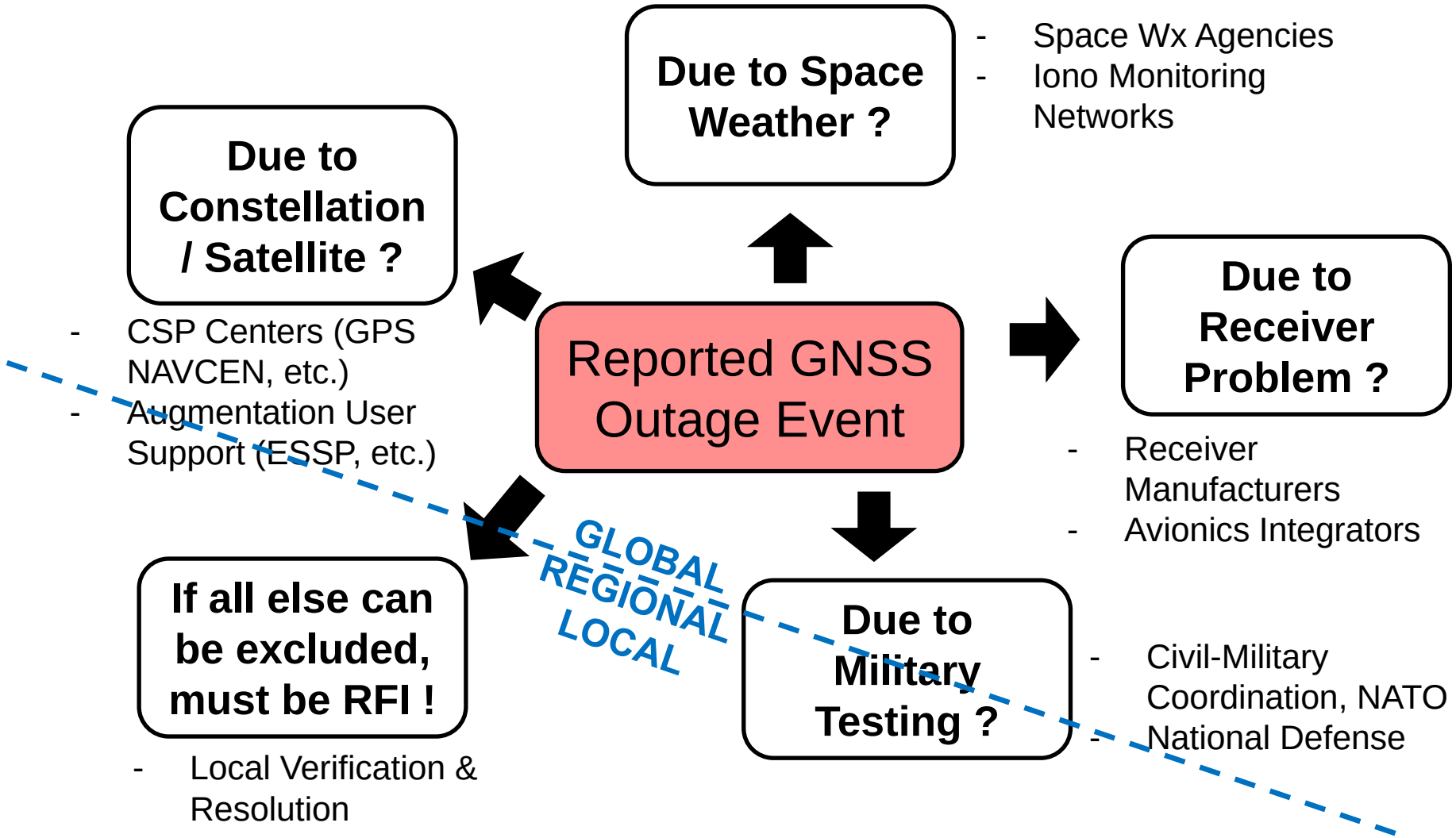


Starting Challenges

- Observability: Difficult to get data on incidents
  - Existing Spectrum Groups receive few reports
  - NOTAM search produced few results
- Event Confirmation:
  - Difficult to conclude that GNSS outage is result of RFI
- Event Scope
  - Difficult to quantify geographical extent, duration and impact

- **Best to monitor at the impact source: aircraft receiver**
  - Currently, only pilot can observe receiver outage
  - Subsequent reporting requires support at regional and global level
  - Ground networks useful complement, but limited use
    - Apart from visibility issues, lacks essential risk assessment link: what is the impact at the aircraft?

Identification of Probable Cause Through Elimination



GPS OUT Reporting Streams Today

GNSS Multi-Modal

Aviation one User among many

Aviation Specific

GNSS Out One Issue among many

First Step: Align Aviation Coordination

GPS NAVCEN

IATA

Second Step: Interfaces with GNSS System Providers

AO

- Airline OPS Center
- FOQA Monitoring?
- PIREP: Local AIS

ESSP

Eurocontrol Network Manager

Local ANSP ?

- AIS to Technical Services
- Technical Services activate subsequent process?

No aggregate vision of events ➔ Incomplete threat picture

Resolution depends on awareness of many individuals

Implemented: GNSS in EVAIR

- EVAIR = Eurocontrol Voluntary ATM Incident Reporting

  www.eurocontrol.int/services/evair

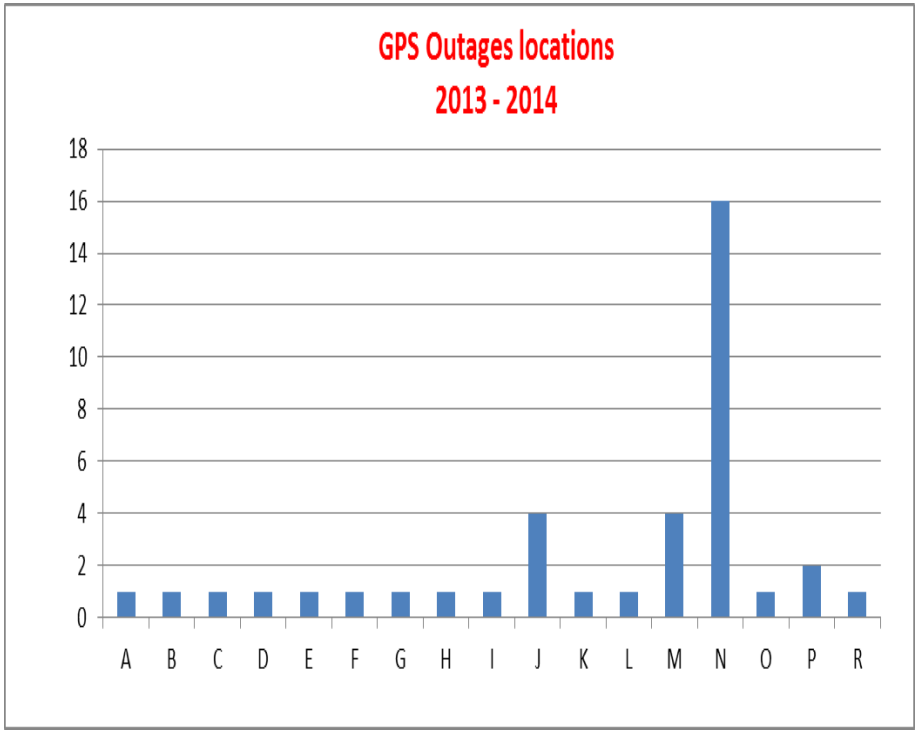
  - Established Safety Process (Confidentiality, Anonymity)
  - 250 Participating Aircraft Operators
  - Coverage: Europe, Middle East, Northern Africa
  - Close cooperation with IATA
  - Part of Network Manager Functions

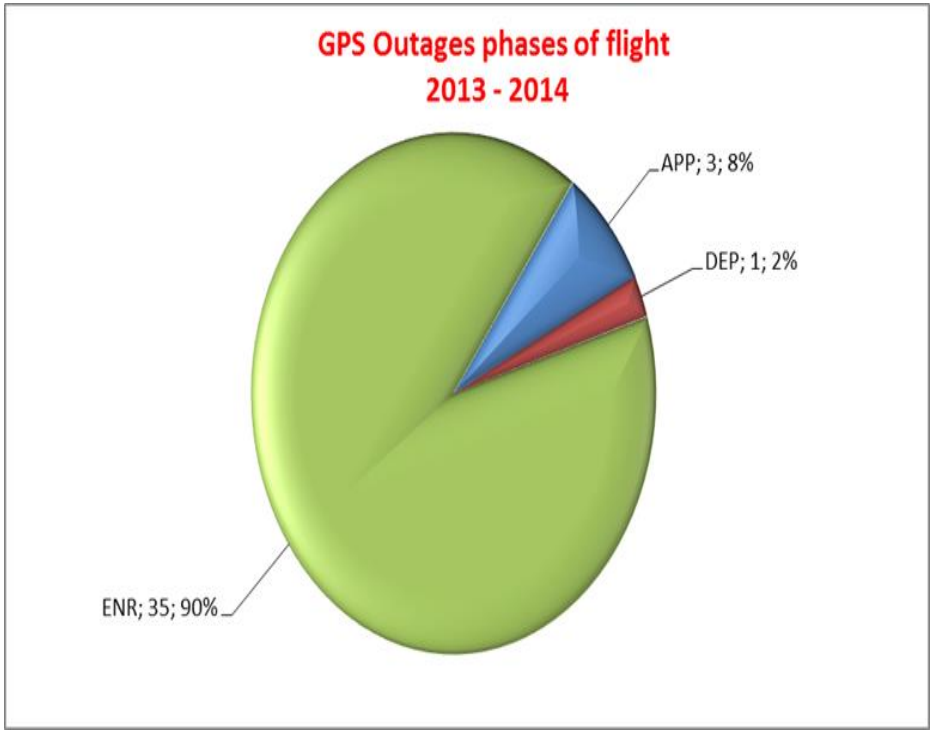
- Info Bulletin / Request sent beginning 2015
  - Initial wave of reports received covering 2013/2014
  - Additional reports coming in every few weeks
  - GNSS Outage one issue among many
  - Simple to set up because it is an existing process / framework
  - Working on further awareness materials

GPS Issues: EVAIR Findings

(Status May 2015)

- **First reports received in 2013**
- **# of reports in the DB - 42**
- **# of AOs (Aircraft Operator) reporting GPS outages so far - 11**
- **# of locations identified – 17**
- **En-route flight phase most affected**

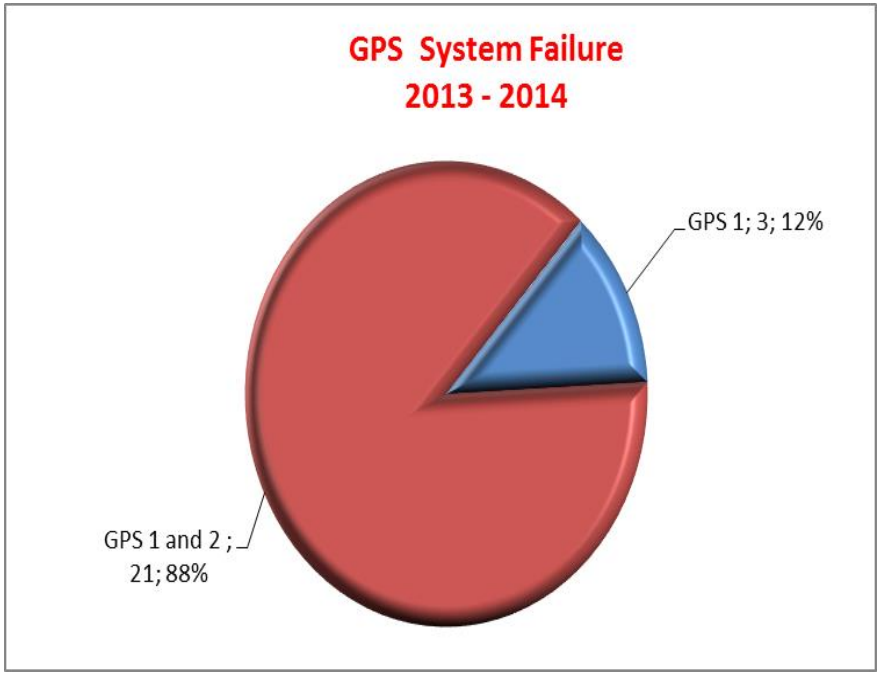


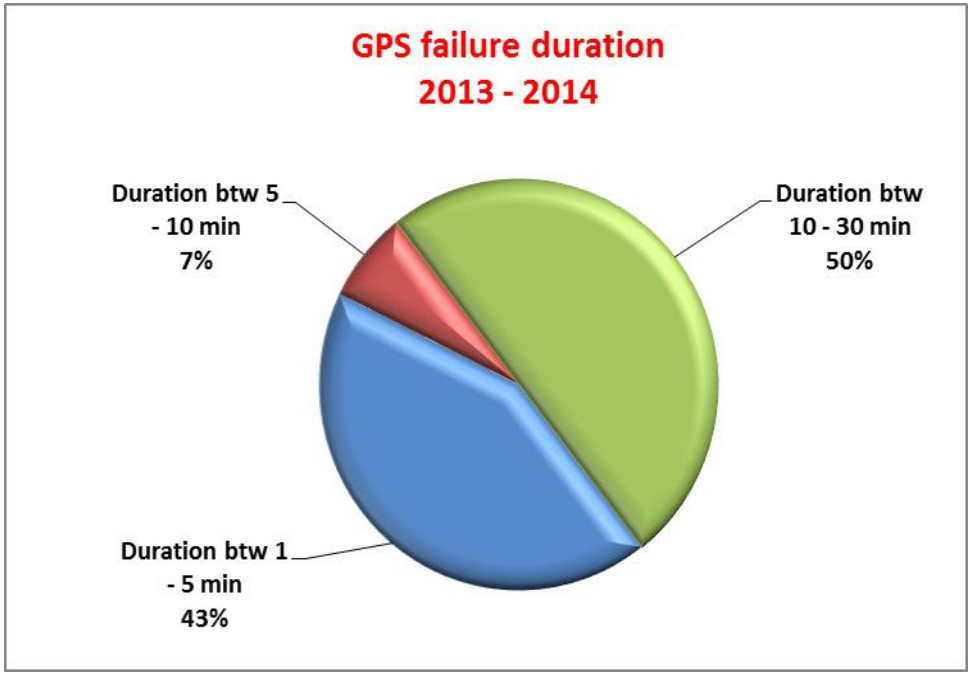


GPS Issues: EVAIR Findings

Type of reported GPS issues 2013 – 2014

- Loss of GPS Signal
- GPS Outage
- GPS Jamming
- Total Loss of GPS
- GPS 1 and 2 Lost
- GPS 1 Lost





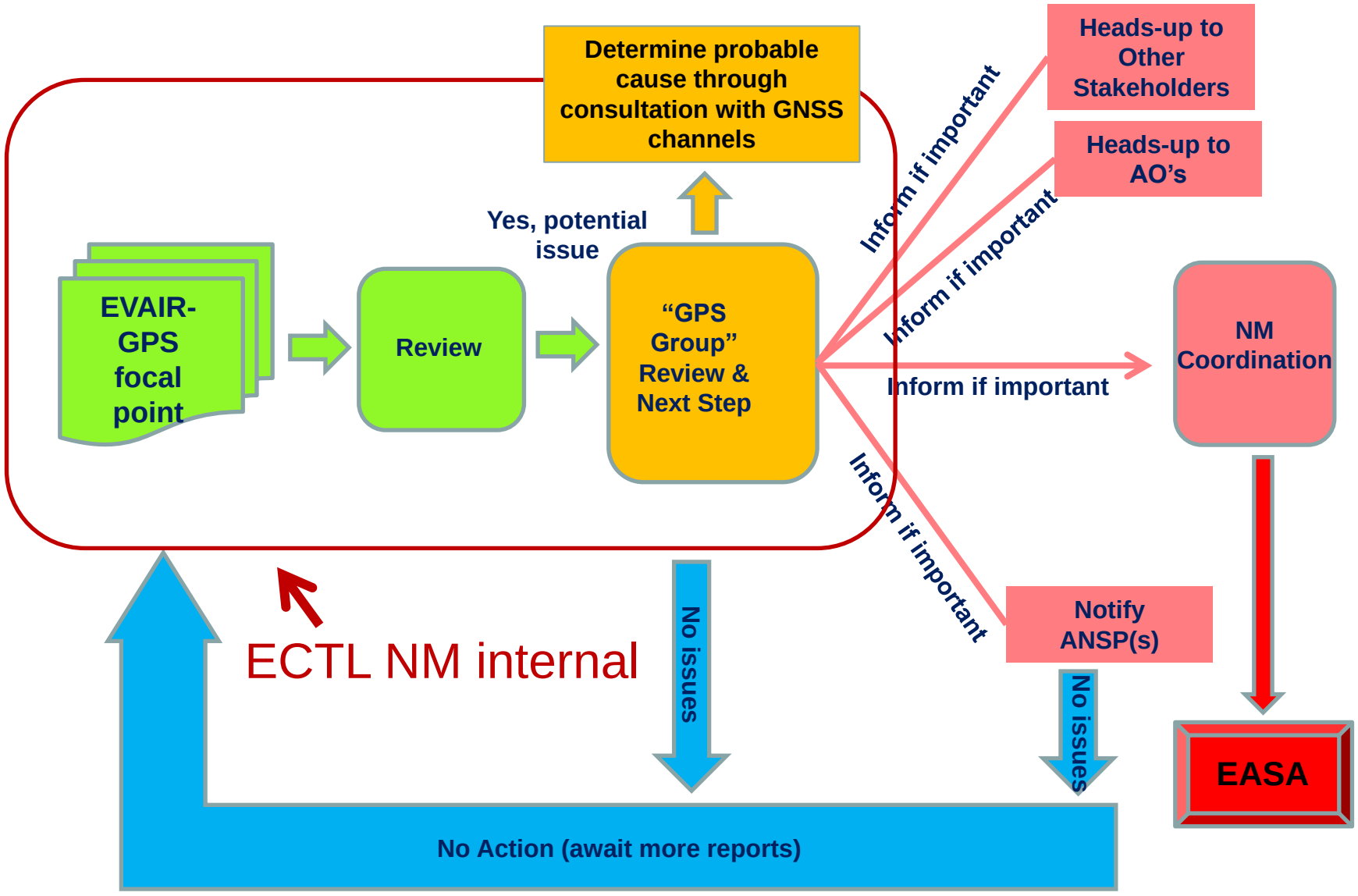
GNSS in EVAIR: Threat Monitoring

- Return to normal operations & impact on both receivers on few aircraft point to RFI with high probability
  - **Proves that RFI Outages are REAL but also limited in operational impact currently**

- Time-limited, single events do not warrant action
  - **Supports strategic objective of threat monitoring**
  - Enables setting boundaries on event probability and severity
  - Provides detection if environment changes

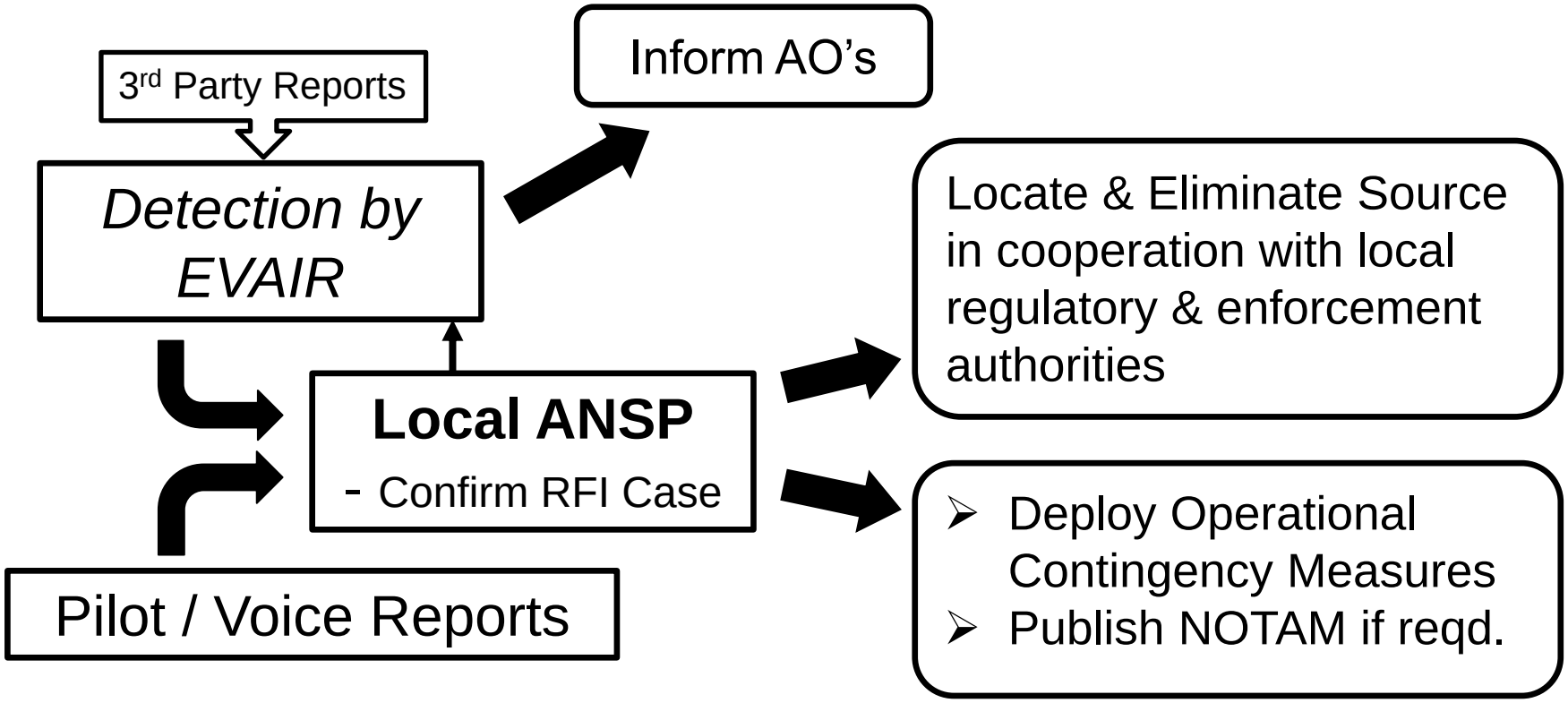
- Maintain central repository and statistics of GNSS Outage events
  - Consultation of GNSS service and space weather monitoring reports provides further refinement
  - May also benefit from data from local ground receivers
  - Clarify interfaces for aviation-relevant reporting

EVAIR: GPS Issues Information Flow



EVAIR: Trigger for Detection & Mitigation

- Significant accumulation of events in specific area leads to detection and triggers mitigation action
- Ensuring timely resolution reduces vulnerability / exposure



Interfaces with GNSS System Operators (GSO)

- Currently, mainly GPS NAVCEN and ESSP
  - Multi-constellation: GLONASS, Galileo, Beidou Service Centers
  - Regional SBAS User Support Centers (GBAS with local ANSP)

- **Case 1: Strategic Long Term Threat Monitoring**
  - Info from GSO to Aviation: Ensure comprehensive view of all aviation-relevant cases

- **Case 2: Tactical Mitigation: Actual Significant Outage Event**
  - Request from Aviation to GSO: Support in identifying probable cause
  - Benefit from established links (receiver issues, ionosphere, RFI testing)

Medium Term Improvements

- Not really Pilot's job to determine cause of GPS outage or to report signal in space issues
  - In the age of SWIM, reporting should be automated
  - GPS Outage Simulation: ATCO & Planners want to know geographic extent, start and end of outage (Budapest simulation outcome)

- Reporting through ADS-B Figure of Merit
  - Part of ongoing SESAR investigations
  - Feasibility demonstration: Australia (Sydney case)
  - Need to build experience in how to integrate information

- Some guessing remains with respect to probable cause
  - Especially for wide-area outage where resolution should be fast
  - Implement RFI detection standard feature in all receivers ?

Long Term RFI Mitigation Improvements

- A lot can be done with current capabilities at reasonable cost
  - EVAIR is available now
  - Mostly a matter of setting up interfaces and data integration
  - ADS-B FoM Monitoring excellent example of CNS synergy use without introducing additional complexity
  - Still want to reduce guesswork in future equipment
- Next Generation MC GNSS Avionics
  - ICAO NSP requested implementation of reasonable mitigation capabilities from RTCA / EUROCAE
  - Detection capability seen as a feasible minimum:
    - Permit aircraft to switch to “A-PNT capability”
  - Information must reach ANSP
    - Quick Access Recorder, Flight Operations Quality Monitoring
    - Future: SUR Downlink Aircraft Parameters (DAP) ??

Proposed Actions for CGSIC Consideration

1. **Support Aviation GNSS RFI Mitigation Plan**
   - Aviation-relevant threat monitoring & event resolution
   - May be suitable for other transport modes & user segments also
2. **Support Setup & Alignment of Global Interfaces**
   - Encourage EVAIR example to be used in other regions
   - Requires channels which can handle sensitive information
   - Multi-constellation GNSS will increase complexity & need for global exchange
3. **Support strategic long term objective: Closed-loop service provision for space based infrastructure**
   - Detect signal-in-space issues at receiver without requiring pilot intervention
   - Provide means to make information available to ANSP & radio authorities with goal to reduce intervention times
   - Investigate best options to support future implementation