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# PBN SG 9
# GNSS reversion & contingency

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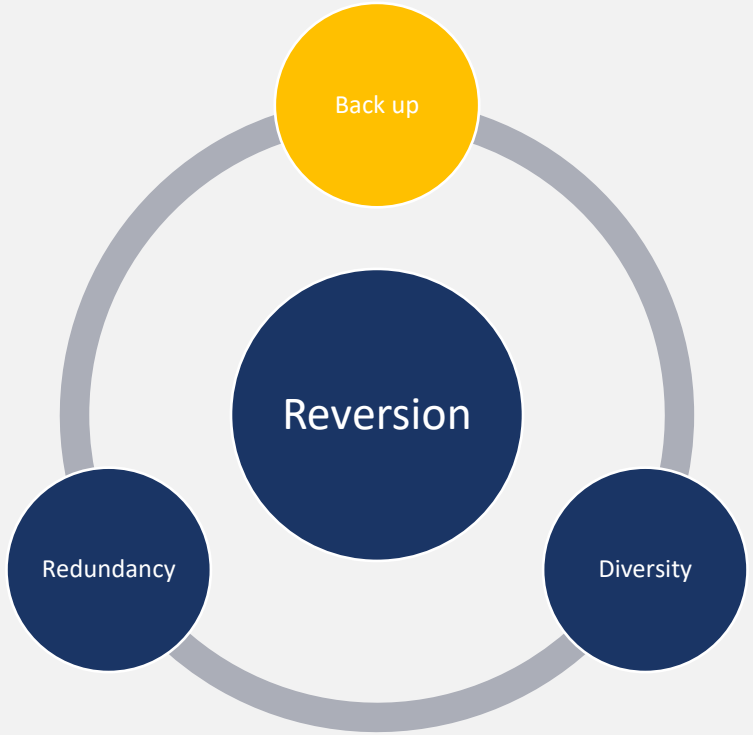
# What is GNSS Reversion / Contingency?

- **Reversion** refers to the need to “revert” from primary infrastructure (GNSS) to complementary means (e.g. DME) that contribute to the output of the NAV service in its nominal operation.

- **Contingency** operations refer to a situation when ATM operations can not continue “normally” (ATM performances might be affected: more staffing, less capacity, etc)

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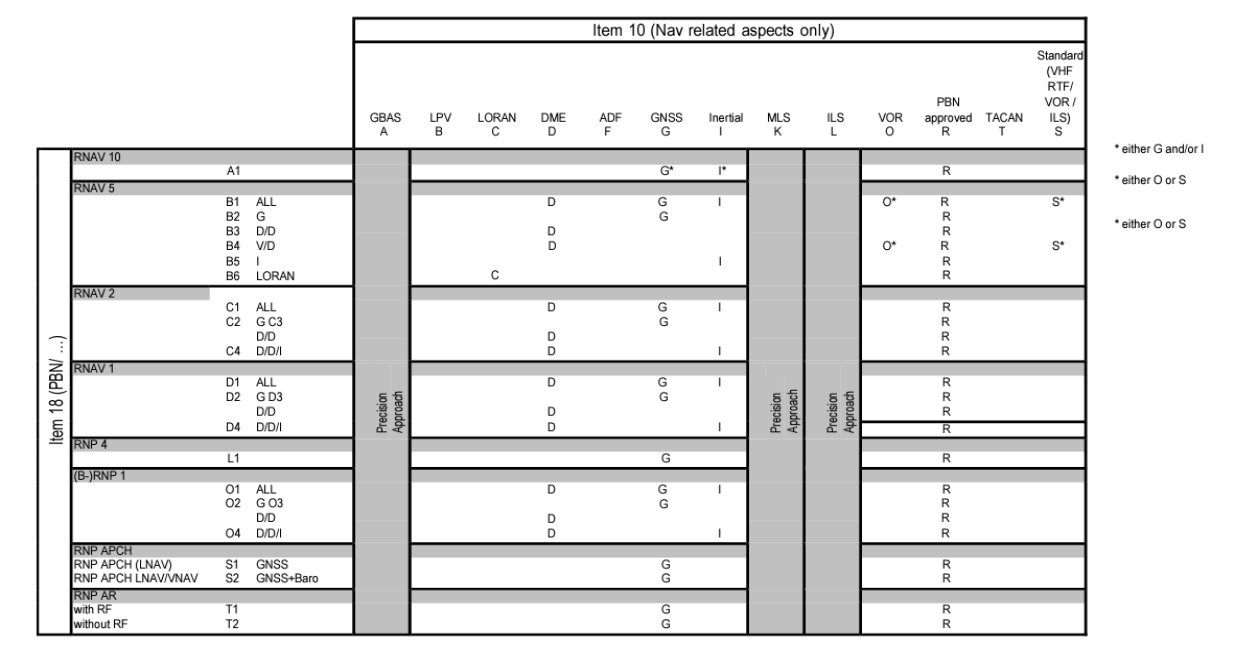
# Reversion scenarios in PBN



Item 10 (Nav related aspects only)

| Item 18 (PBN/ ...) | | | GBAS A | LPV B | LORAN C | DME D | ADF F | GNSS G | Inertial I | MLS K | ILS L | VOR O | PBN approved R | TACAN T | Standard (VHF RTF/ VOR / ILS) S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RNAV 10 | | | | | | | | | | | | | | | |
| | A1 | | | | | | | G* | I* | | | | R | | |
| RNAV 5 | | | | | | | | | | | | | | | |
| | B1 | ALL | | | | D | | G | I | | | O* | R | | S* |
| | B2 | G | | | | | | G | | | | | R | | |
| | B3 | D/D | | | | D | | | | | | | R | | |
| | B4 | V/D | | | | D | | | | | | O* | R | | S* |
| | B5 | I | | | | | | | I | | | | R | | |
| | B6 | LORAN | | | C | | | | | | | | R | | |
| RNAV 2 | | | | | | | | | | | | | | | |
| | C1 | ALL | | | | D | | G | I | | | | R | | |
| | C2 | G C3 | | | | | | G | | | | | R | | |
| | | D/D | | | | D | | | | | | | R | | |
| | C4 | D/D/I | | | | D | | | I | | | | R | | |
| RNAV 1 | | | | | | | | | | | | | | | |
| | D1 | ALL | | | | D | | G | I | | | | R | | |
| | D2 | G D3 | | | | | | G | | | | | R | | |
| | | D/D | | | | D | | | | | | | R | | |
| | D4 | D/D/I | | | | D | | | I | | | | R | | |
| RNP 4 | | | | | | | | | | | | | | | |
| | L1 | | | | | | | G | | | | | R | | |
| (B-)RNP 1 | | | | | | | | | | | | | | | |
| | O1 | ALL | | | | D | | G | I | | | | R | | |
| | O2 | G O3 | | | | | | G | | | | | R | | |
| | | D/D | | | | D | | | | | | | R | | |
| | O4 | D/D/I | | | | D | | | I | | | | R | | |
| RNP APCH | | | | | | | | | | | | | | | |
| RNP APCH (LNAV) | S1 | GNSS | | | | | | G | | | | | R | | |
| RNP APCH LNAV/VNAV | S2 | GNSS+Baro | | | | | | G | | | | | R | | |
| RNP AR | | | | | | | | | | | | | | | |
| with RF | T1 | | | | | | | G | | | | | R | | |
| without RF | T2 | | | | | | | G | | | | | R | | |

Precision Approach

* either G and/or I

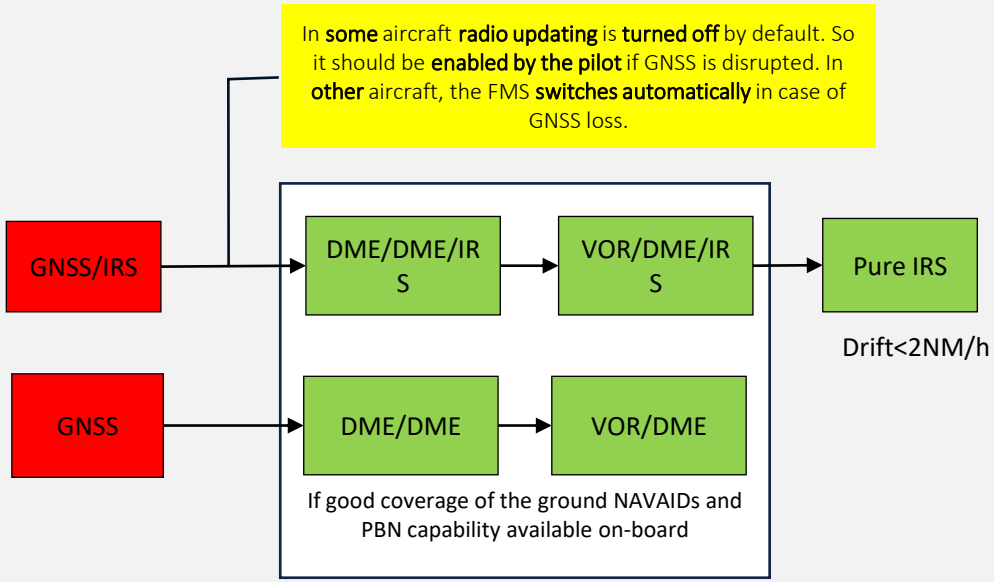
* either O or S

* either O or S

[ICAO Guidance_Item 10_18.pdf]

Guidance for the provision of NAV/COM/SUR information in the ICAO 2012 Flight Plan

## How avionics react to a GNSS loss




GNSS RFI guidance to operators: https://safetyfirst.airbus.com/gnss-interference/ , Flight Crew Operating Manual

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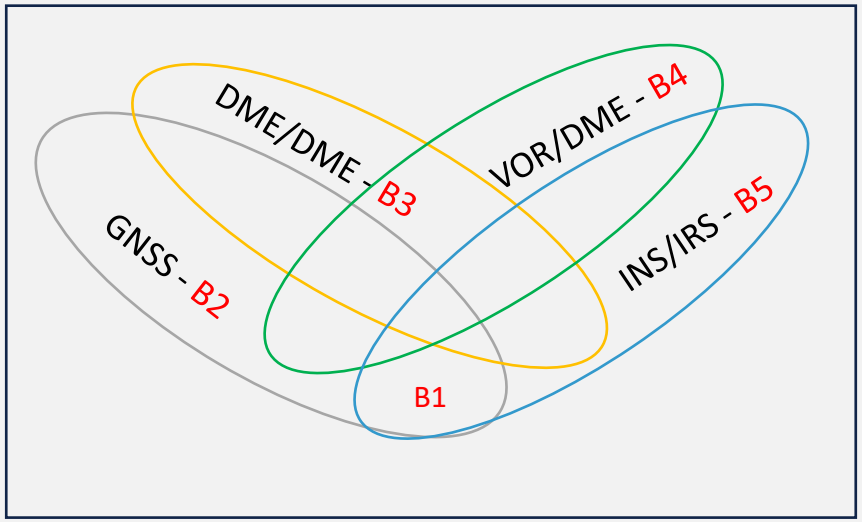
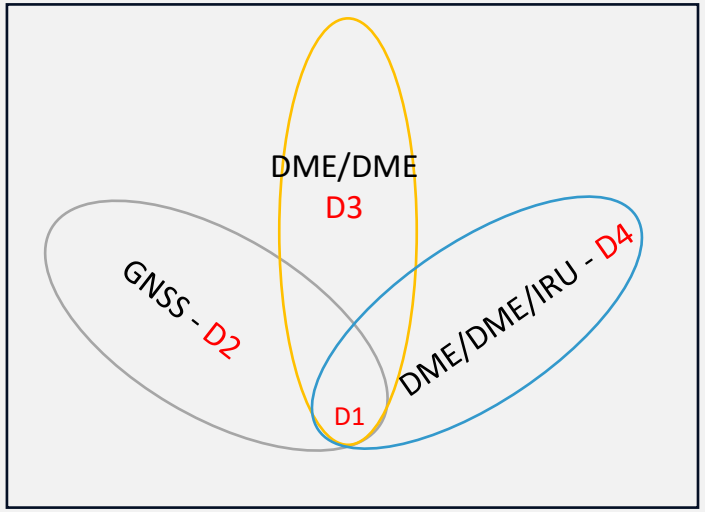
# Reversion scenarios

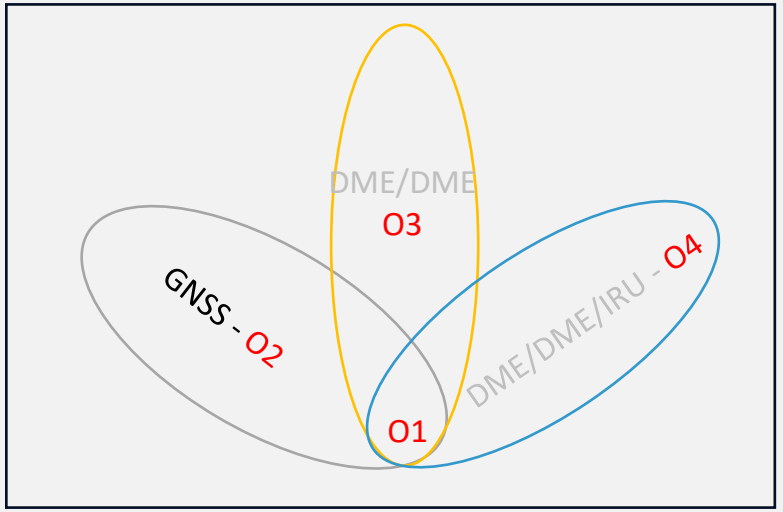



RNAV5




RNAV1

DME/DME use for RNP 1 subject to State approval, appropriate infrastructure & aircraft capability




RNP1

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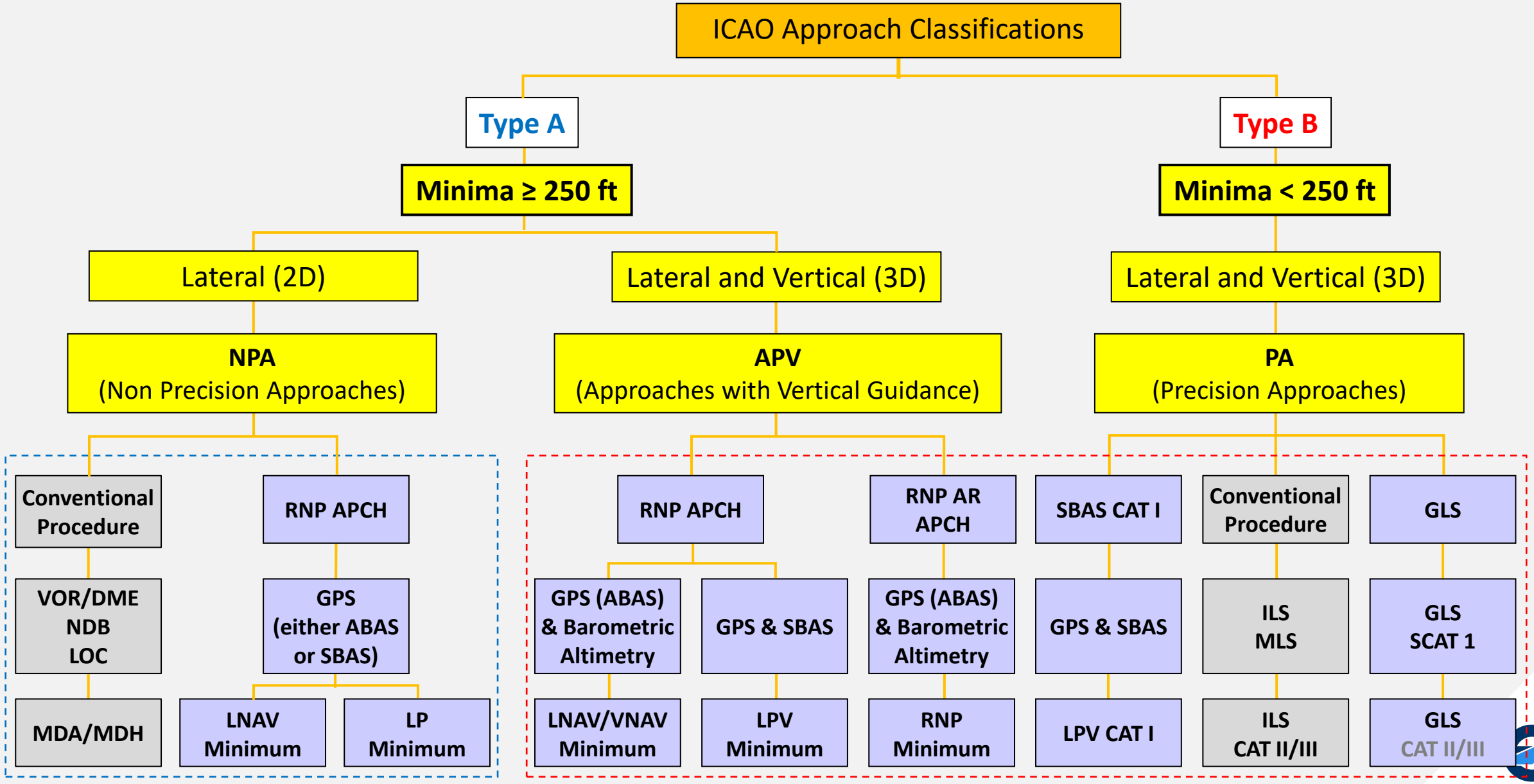
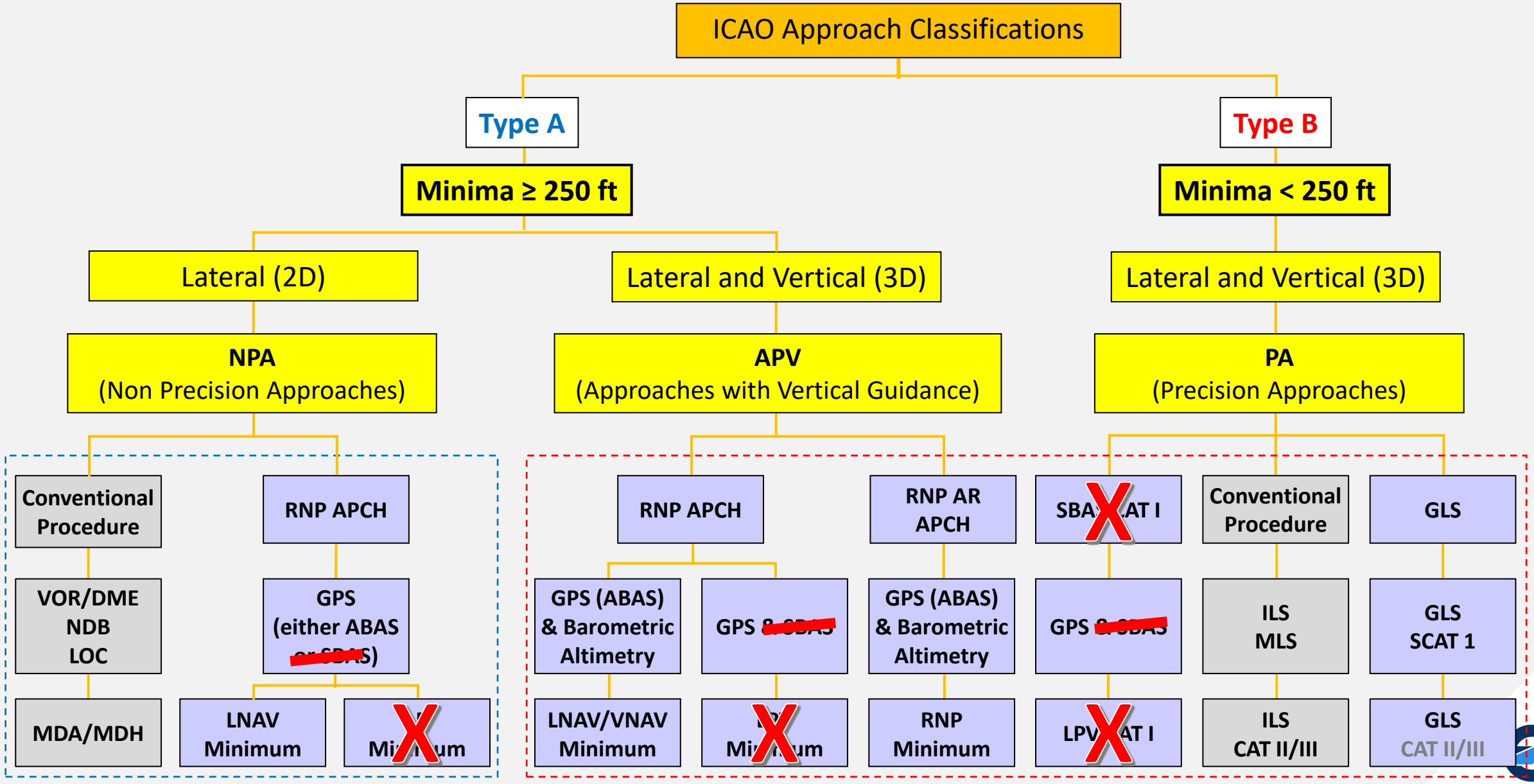
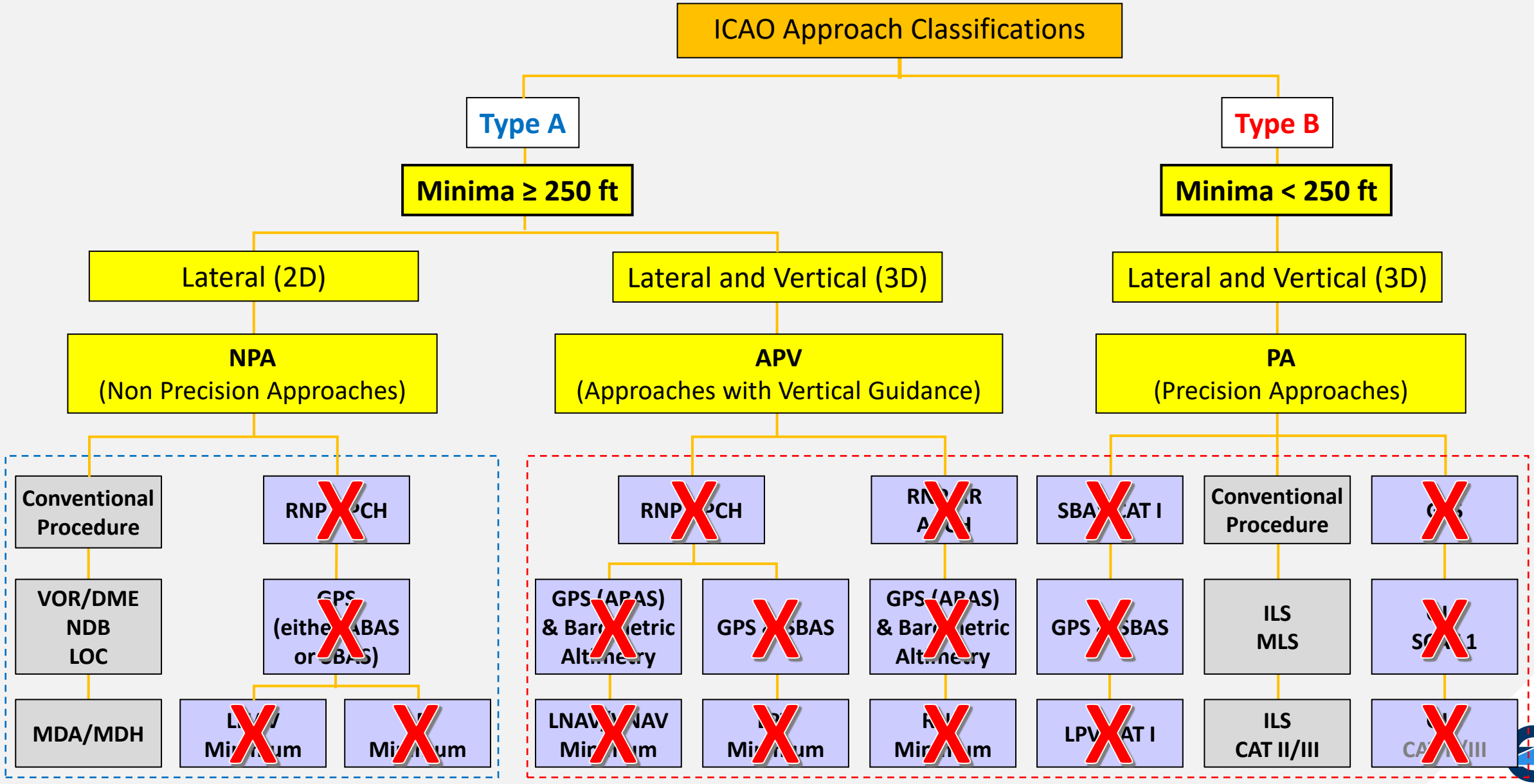
# Approach Options



# Loss of EGNOS



# Loss of GPS


ICAO Approach Classifications
Type A
Type B
Minima ≥ 250 ft
Minima < 250 ft
Lateral (2D)
Lateral and Vertical (3D)
Lateral and Vertical (3D)
NPA
(Non Precision Approaches)
APV
(Approaches with Vertical Guidance)
PA
(Precision Approaches)
Conventional Procedure
VOR/DME
NDB
LOC
MDA/MDH
ILS
MLS
ILS
CAT II/III
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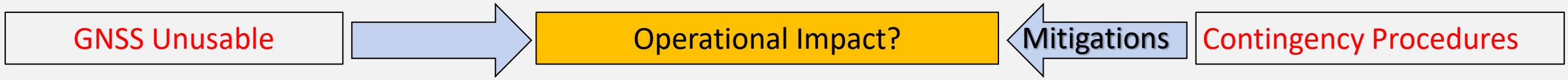
# GNSS contingency strategy

Strategy for the continued safe management of air traffic in the event of a GNSS outage, preventing nominal operations.

Loss or Disruption of GNSS signals – Continued operations in a degraded environment (pbnportal.eu)




How is the outage identified?

Who is informed?

What is the impact?

- Loss of RNP APCH
- AC with only GPS require assistance
- Capacity implications?

**May include:**

a. Missed Approach (Extraction)

b. Radar Vectoring

c. Conventional procedures

d. Diversion



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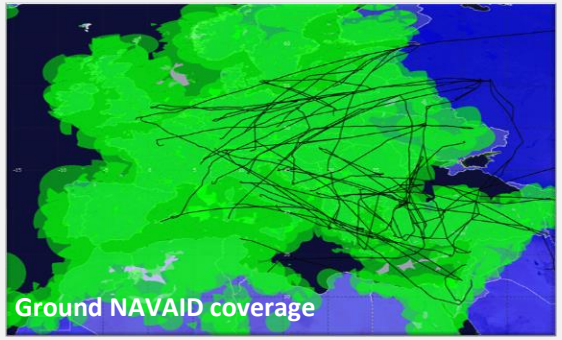
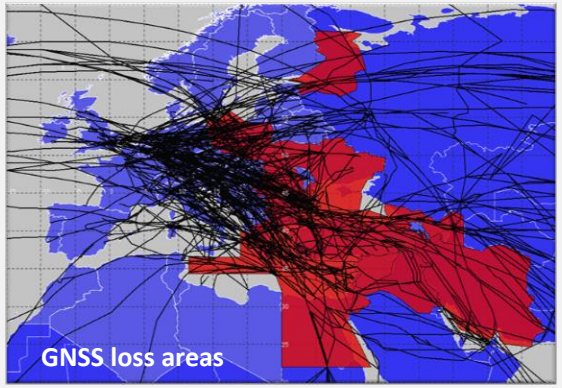
# GNSS contingency

**Are flights able to continue navigation without degradation of their performances in case of GNSS loss?**








Impact assessment aims to mitigate issues before they become real safety problems

- C-PNT available
- Impact on operations

**Availability of a NAV back up allowing the same level of performances**

**Flights able to bridge the gaps**

**Is there a potential need for ATC assistance, requiring the availability of extra resources/application of other measures?**

**Flights needing ATC assistance**

**Radar vectoring achievable (SUR)**

**Tolerable increase of ATC workload**

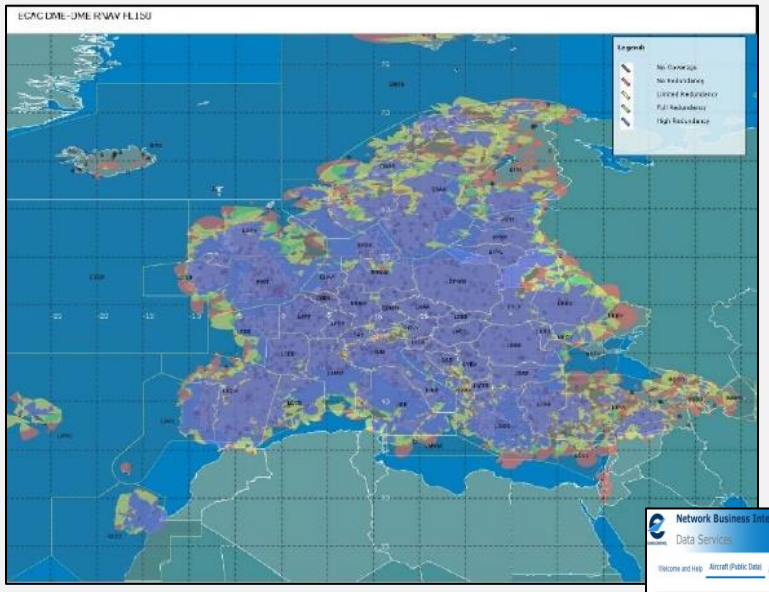
**Minor impact on OPS**

**High ATC workload increase**

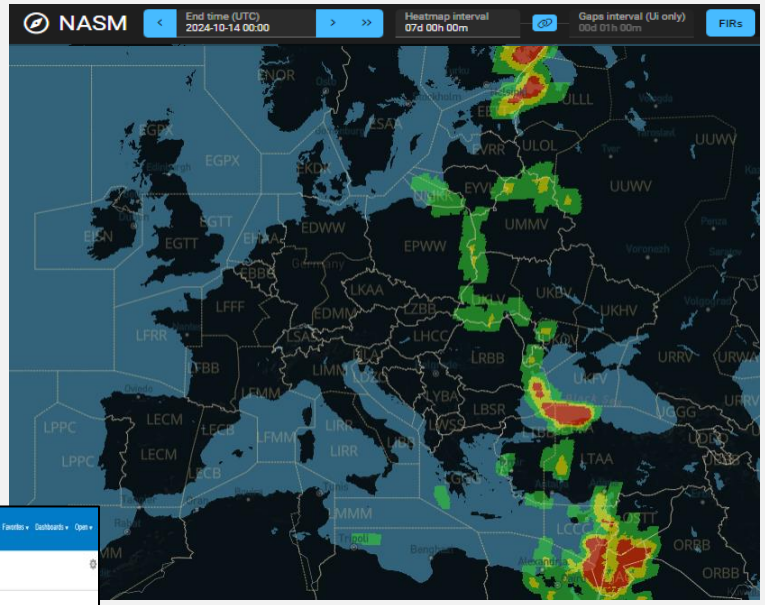
**ATFCM measures (ATC rerouting, ATC staffing, capacity reduction)**

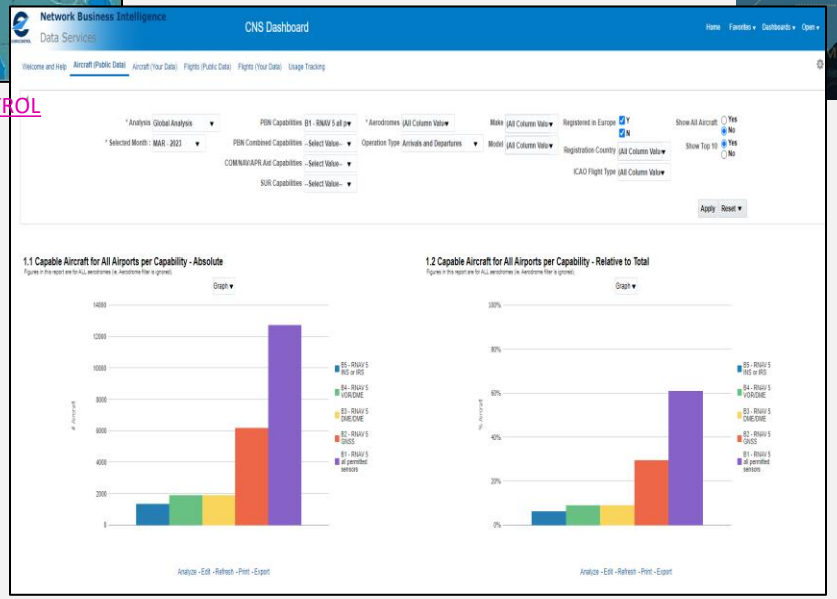
**Flight plan rejection criteria**

# Fleet capability and NAV infra monitoring



Distance measuring equipment tracer (DEMETER) | EUROCONTROL




https://www.eurocontrol.int/dashboard/communication-navigation-and-surveillance-dashboard

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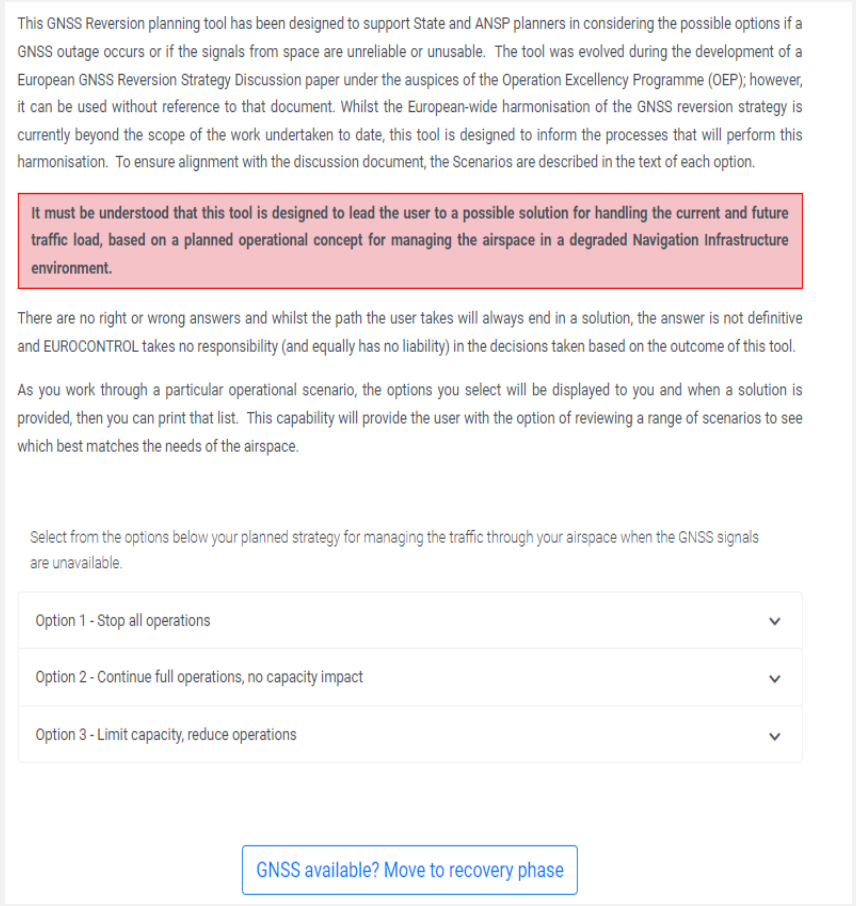
# Contingency plan: ANS

| | S1: Tap Full Off  | S2: Tap Full On  | S3: Tap Partially Closed  |
|---|---|---|---|
| **Objective**: | To land all aircraft in the affected airspace as soon as possible. | To maintain full operations no matter the size of the affected airspace, duration and type of GNSS failure. | To reduce capacity to maintain a safe throughput of traffic through the affected airspace. |
| **Capacity**: | Zero traffic flow in the affected airspace while GNSS core constellation is unusable. | Capacity is not “impacted” in a degraded environment. Traffic managed either as normal PBN operations or conventionally. | Planned ATFCM measures applied to restrict the flow entering the affected area will impact capacity. Traffic managed either as normal PBN operations or conventionally. |
| **ATC**: | May allow the aircraft to continue to destination or require a/c to land at the next suitable aerodrome. | Has the option to cancel planned flights for unsupported operations. | Need to know which PBN procedures are lost. Will use flight plan information to assess and restrict aircraft of lower capabilities from entering the affected airspace. |
| **Further operations:** | Not permitted. | Permitted. | Partially permitted subject to FPL. |

# Contingency plan: Aircraft

| | S1: Tap Full Off  | S2: Tap Full On  | S3: Tap Partially Closed  |
|---|---|---|---|
| **Multi-sensor Aircraft:** | If infrastructure permits, maintain on cleared flight path to destination. | As S1 | As S1 |
| **GNSS only a/c** are managed by radar vectoring (subject to ATC capacity) and: | Diverted to next suitable aerodrome to land. | Either re-cleared to continue to destination or instructed to land at next suitable aerodrome. | Either re-cleared to continue to destination or diverted to land at next suitable aerodrome, if destination is within the affected area. |
| **Approach phase**:<br>Continue visually to land, if VMC, or fly missed approach and then execute a conventional NPA or PA. | Subject to available and serviceable conventional Navaids and published procedures. | Precision approaches will be ensured by a planned ILS MON. | As S2 |

# GNSS contingency planning tool



This GNSS Reversion planning tool has been designed to support State and ANSP planners in considering the possible options if a GNSS outage occurs or if the signals from space are unreliable or unusable. The tool was evolved during the development of a European GNSS Reversion Strategy Discussion paper under the auspices of the Operation Excellency Programme (OEP); however, it can be used without reference to that document. Whilst the European-wide harmonisation of the GNSS reversion strategy is currently beyond the scope of the work undertaken to date, this tool is designed to inform the processes that will perform this harmonisation. To ensure alignment with the discussion document, the Scenarios are described in the text of each option.

**It must be understood that this tool is designed to lead the user to a possible solution for handling the current and future traffic load, based on a planned operational concept for managing the airspace in a degraded Navigation Infrastructure environment.**

There are no right or wrong answers and whilst the path the user takes will always end in a solution, the answer is not definitive and EUROCONTROL takes no responsibility (and equally has no liability) in the decisions taken based on the outcome of this tool.

As you work through a particular operational scenario, the options you select will be displayed to you and when a solution is provided, then you can print that list. This capability will provide the user with the option of reviewing a range of scenarios to see which best matches the needs of the airspace.

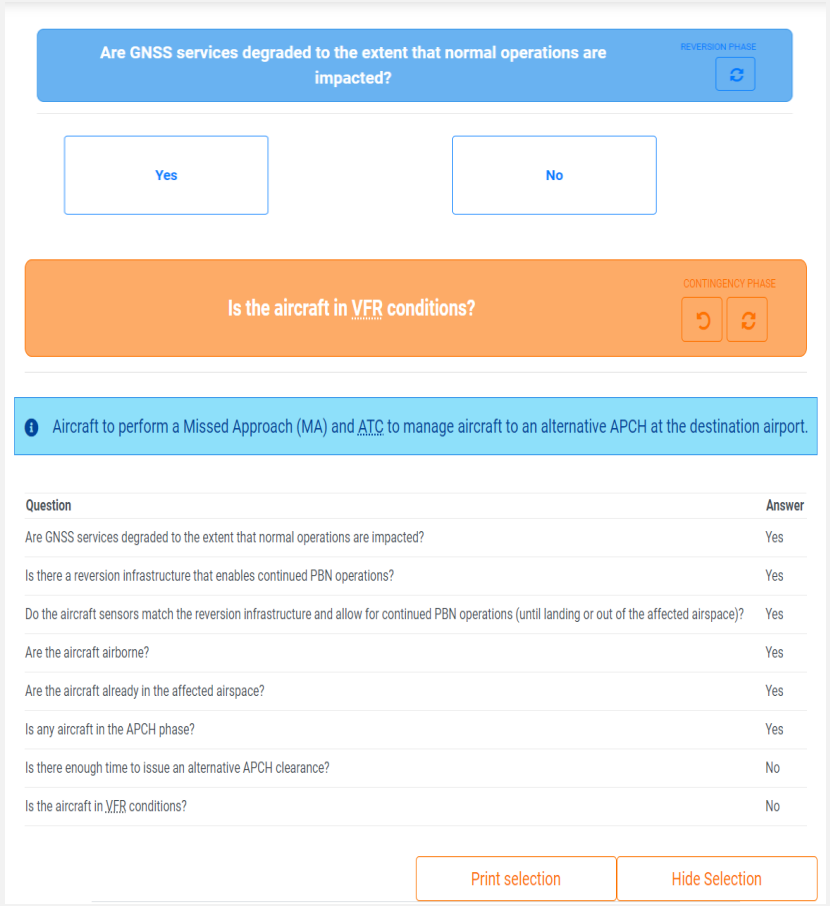
Select from the options below your planned strategy for managing the traffic through your airspace when the GNSS signals are unavailable.

Option 1 - Stop all operations

Option 2 - Continue full operations, no capacity impact

Option 3 - Limit capacity, reduce operations

GNSS available? Move to recovery phase



Are GNSS services degraded to the extent that normal operations are impacted?

REVERSION PHASE

Yes

No

Is the aircraft in VFR conditions?

CONTINGENCY PHASE

Aircraft to perform a Missed Approach (MA) and ATC to manage aircraft to an alternative APCH at the destination airport.

| Question | Answer |
|---|---|
| Are GNSS services degraded to the extent that normal operations are impacted? | Yes |
| Is there a reversion infrastructure that enables continued PBN operations? | Yes |
| Do the aircraft sensors match the reversion infrastructure and allow for continued PBN operations (until landing or out of the affected airspace)? | Yes |
| Are the aircraft airborne? | Yes |
| Are the aircraft already in the affected airspace? | Yes |
| Is any aircraft in the APCH phase? | Yes |
| Is there enough time to issue an alternative APCH clearance? | No |
| Is the aircraft in VFR conditions? | No |

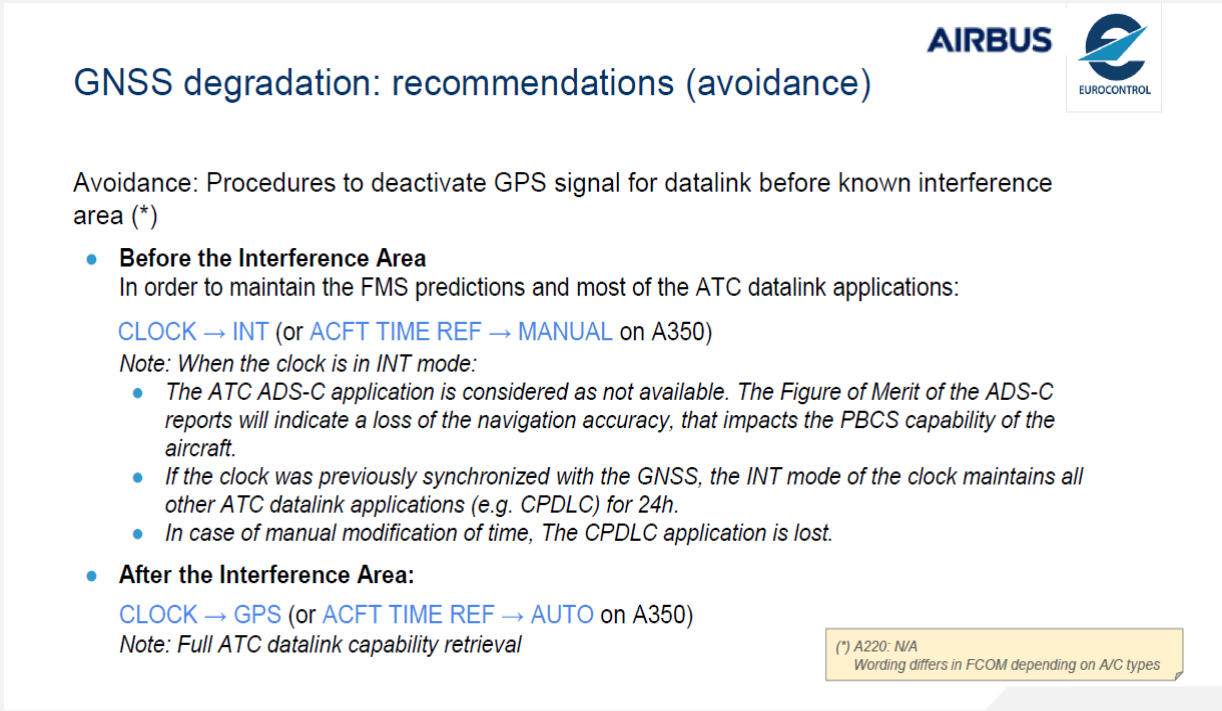
Print selection

Hide Selection

https://pbnportal.eu/epbn/main/PBN-Tools/GNSS-Outage-Strategic-Decisions.html

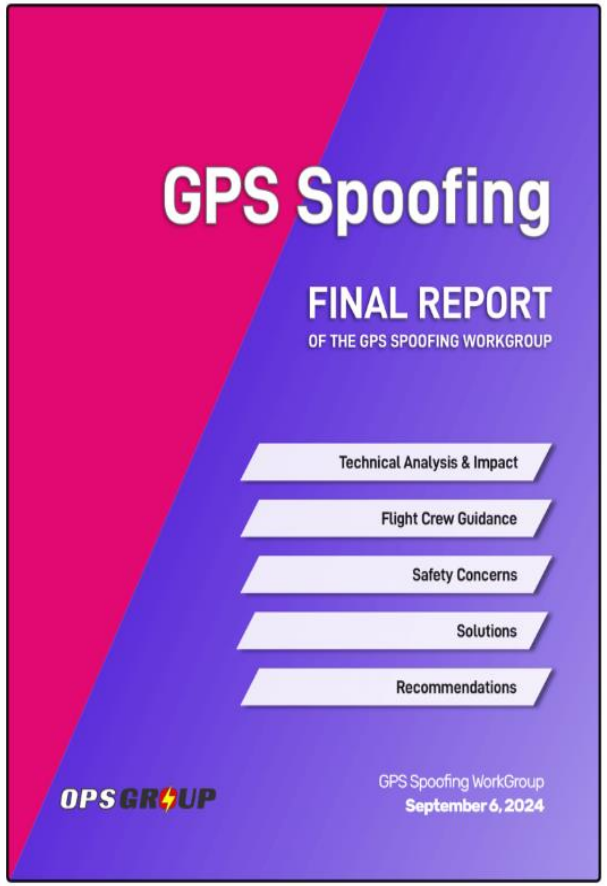
# Possible ATM Issues - Dependent Surveillance & Communication

| Impact of GPS loss | Operational Impact and mitigation |
|---|---|
| Dependent sensors ADS-C | Procedural control in ADS-C surveillance only areas (e.g. oceanic or remote areas) |
| Dependent sensors ADS-B | Multi sensor tracking including Independent Surveillance sources.<br>Procedural control without surveillance in ADS-B surveillance only areas |
| Multilateration sensors | Back-up timing sources can enable continued operation. Multi sensor tracking |
| Radar sensors | Back-up timing sources can enable continued operation. Multi sensor tracking |



# Crew guidance

https://ops.group/blog/gps-spoofing-final-report/







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# Summary


**Incident Management**

## Strategic/Pre-tactical

- Evaluate the available **GNSS backups** (DME/DME, IRS, …)
- **Define** the **contingency procedures** applicable for each case
- Verify if suitable **GNSS-independent SUR and COM** systems are fully operational to **provide assistance to pilots** when needed.
- Identify **PoC** (NFM) to be contacted if **RFI** is **detected**

## Tactical

- **Contingency procedures** (e.g. radar vectoring, procedural control, reroute flights, capacity reduction, introduce flight rejection criteria…)
- **NOTAM** issue to alert airspace users (Input: GNSS RFI reports/monitoring), Location of the events, Possible impacted systems
- **Report** to the radio regulator to provide the grounds for interventions by the police of the spectrum and stop the source if possible

## Post-Ops

- Improve **responsiveness** to such incidents (Reporting, Monitoring, Operational management, Stopping the source)
- Refine contingency procedures
- Evaluate the **suitability** current CNS **infrastructure** compared to declared fleet capabilities

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# Further reading & watching

- Loss or Disruption of GNSS signals – Continued operations in a degraded environment (pbnportal.eu)
- GNSS contingency procedures: https://www.eurocontrol.int/publication/european-gnss-contingency-reversion-handbook-pbn-operations
- GNSS contingency : https://pbnportal.eu/epbn/main/PBN-Tools/GNSS-Outage-Strategic-Decisions.html
- GNSS RFI risk assessment: EUROCONTROL Think Paper #9 https://www.eurocontrol.int/publication/eurocontrol-think-paper-9-radio-frequency-interference-satellite-navigation-active
- Crew guidance: https://ops.group/blog/gps-spoofing-final-report/
- GNSS RFI Mitigation Plan: GNSS Manual, ICAO Doc 9849
- Training: https://learningzone.eurocontrol.int/ilp/pages/course-description.jsf?courseId=20758176&catalogId=896269&isTemplate=true


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# Thank you!

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CONSORTIUM COORDINATOR sesar DEPLOYMENT MANAGER
FOUNDING MEMBER sesar JOINT UNDERTAKING
NETWORK MANAGER

# PBN impact on NAVAID infrastructure planning

- GNSS can be a common point of failure to CNS. This is important when considering airborne and ATM contingency operations as well as infrastructure optimization.
- PBN implementation will require infrastructure planners to consider:

a) the infrastructure requirements for normal operations (a function of the airspace concept objectives);

b) the infrastructure required for contingency operations (a function of the objective of the contingency operations (such as safety only, required levels of service, compliance with regulatory requirements); and

c) how CNS supports both normal and contingency PBN operations (trade-offs between C-N-S can be made).

- the duration of the outage period should be determined.

# Contingency arrangements/Procedures

- Air traffic services authorities shall develop and promulgate contingency plans for implementation in the event of disruption, or potential disruption, of air traffic services and related supporting services in the airspace for which they are responsible for the provision of such services. Such contingency plans shall be developed with the assistance of ICAO as necessary, in close coordination with the air traffic services authorities responsible for the provision of services in adjacent portions of airspace and with airspace users concerned. *Annex 11 – Air Traffic Services Chapter 2, Section 2.31*

- The various circumstances surrounding each contingency situation preclude the establishment of exact detailed procedures to be followed*.* *PANS-ATM Chapter 15 Section 15.6*

- Doc 9854 – Global Air Traffic Management Operational Concept Highlights the necessity of contingency planning as part of a seamless and globally interoperable air traffic management system to address system interruptions and ensure service continuity.

# Recommendations

Considering the foregoing, ANSPs are strongly encouraged to undertake an awareness campaign on GNSS contingency. Furthermore, ANSPs are encouraged to develop Reversion Scenarios and associated Contingency Procedures in the event of GNSS being unusable.

*The following Draft Conclusion is proposed:*

*Draft Conclusion 9/X: GNSS reversion & contingency*

*That States:*

*a) are strongly encouraged to raise awareness on GNSS contingency planning to enhance preparedness and operational resilience;*

*b) are urged to develop reversion scenarios and associated contingency procedures to maintain safe and efficient operations in the event of GNSS being unusable.*

# Actions by the Meeting

The meeting is invited to:

- take note of the information provided and engage in discussions on any relevant matters, as deemed appropriate; and
- endorse the proposed draft Conclusion