GPS failure, what then?
Impact on en route and terminal air traffic in an RNP environment

Session 3: Airspace Built-in Safety

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• **ATS routes** (incl. SIDs/STARs) are backbone of the ATM System
• For separation/spacing, ATC wants aircraft operating on the route centreline.
• To remain on route centreline, need good aircraft navigation performance.
• $P - B - N$
‘Confidence’ in navigation performance is provided by PBN specifications: spell out crew and aircraft navigation performance needed to operate on a route.
The name of **RNAV** or **RNP** specifications for en route and terminal mostly indicates the lateral accuracy requirements 95% of the flight time. E.g. RNAV 1 (1nm either side of track 95% flight time).
How is the EN ROUTE and TERMINAL air traffic affected if there is an *area* outage of GPS? e.g. Unplanned outage due to jamming, space weather?
GPS area outage covering several FIRs?
Which viable alternative?

Before dual constellations available, need *alternative* positioning source to GPS with workable degradation to RNAV.

- ECAC has extensive DME coverage
- ECAC fleet well equipped with DME +/-IRU, but what of GPS only aircraft?
  - ATC reversion plan needed
    - Dimension/duration of GPS outage area?
    - Which specific aircraft cannot navigate?
      - How many such aircraft can ATC accommodate?
      - Radar vectoring solution?
    - Impact on capacity?
  - Prohibit entry into affected airspace of GPS only aircraft?
  - DME/DME coverage on RNP ATS routes, SIDs and STARs.
  - DME/DME navigation accuracy good for RNP 1 routes +/- FRT/RF
Principles of Reversion*

- Safe recovery of IFR/IMC aircraft
- Modify flight paths to avoid GPS outage area
- Continue dispatch of flights to deny economic target for intentional jammers
- Continue flight operations without significant workload for pilots/controllers

SESAR’s 2014 simulations will examine whether graceful/safe degradation to DME/DME navigation is possible .... And how to handle those aircraft that only have GPS

* Principles comparable to those of FAA in A-PNT Conops
The Safety Claim to be considered

- Air operation in RNP environment remains acceptably safe following GPS outage (Robustness aspect)
- Must analyse the safety Impact in such degraded mode

![Diagram]

- Normal operation
- GPS Outage
- Degraded Mode
- Safety level in normal operation
- Safety level in Degraded Mode

Acceptable level of safety

- Limit % of GPS-only A/C
- Decrease capacity
- Decrease complexity

Acceptable?

No

?????
Thank you
RNP Normal vs. RNP degraded mode

**NORMAL MODE**
- **FPL**
  - Indicate Sensors GPS/DME/IRU
- **Air crew HMI**
  - GPS status in PFD
- **Air crew procedures**
  - Notify ATC
  - Phraseology
- **ATM HMI (RDP)**
  - Sensors from ATC FPL Item 10 in extended Radar Label
- **ATC procedures**
  - Phraseology
  - Intervention

**DEGRADED MODE**
- **FPL**
  - Indicate Sensors GPS/DME/IRU
- **Air crew HMI**
  - GPS status in PFD
- **Air crew procedures**
  - Notify ATC
  - Phraseology
- **ATM HMI (RDP)**
  - Show GPS outage area
  - Show D/D coverage > FLX
  - In extended Label,
- **ATC procedures**
  - Phraseology
  - Control by exception
  - Remove non-DME aircraft
  - Capacity Regulation