Performance Based Navigation & Ground Based Augmentation System
Agenda

- Approach Types and Classification
- GBAS
- PBN supporting the Approach
- RNP to xLS
Evolution of Approaches

**Lateral**
- Conventional
- RNP APCH

**Vertical**
- CDFA

**Sensors**
- VOR/DME/NDB Localizer
- GPS
- GPS + Baro
- GPS + SBAS
- ILS/MLS
- GPS + GBAS

**NPA**
Non Precision Approaches

**APV**
Approaches with Vertical Guidance

**PA**
Precision Approaches

**APV Baro**

**APV SBAS**

**Conventional**

**GBAS Approach**
Approach Types Today

VOR/NDB NPA

RNP APCH LNAV

FAF

RNP APCH Baro

RNP APCH SBAS

MDA/MDH

MDA/MDH

DA/DH

DA/DH

DA/DH

DA/DH

MDA/MDH

ILS/MLS/GLS

Lateral path defined by Procedure Designer. Avionics provide lateral guidance aircrew manage the vertical profile.

Lateral and vertical path defined by Procedure Designer. Avionics provide guidance in both planes.
New Approach classifications

- Approach operations are classified according to the lowest designed operating minima (DH):
  - **Type A**: Instrument approach operation 250’ or above
  - **Type B**: Instrument approach operation below 250’

- Methods of flying the approach operation.
  - 2D - lateral guidance only
  - 3D - lateral guidance and vertical guidance
# ICAO Approach Classifications

## ICAO Approach Classification

<table>
<thead>
<tr>
<th>Domain</th>
<th>Document</th>
<th>Classification (based minima)</th>
<th>Type A (Minima)</th>
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<td>CAT II (less than 200’ &amp; 100’ or higher)</td>
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* NPA procedures require a derived DA/H

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**ICAO Approach Classifications**

**Classifications**

- **CAT I**: (less than 250’ & 200’ or higher)
- **CAT II**: (less than 200’ & 100’ or higher)
- **CAT III**: (less than 100’)

**Minima**

- **MDA/H**: MDA/H
- **DA/H**: DA/H

**System**

- **PANS-OPS Vol. II**
  - **NPA**: NDB, Lctr, LOC, VOR, Azimuth, GNSS
  - **APV**: GNSS/Baro/SBAS
  - **PA**: ILS, MLS, SBAS Cat I, GBAS

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**Method**

- **2D**
- **3D**
Agenda

- Approach Types and Classification
- GBAS
- PBN supporting the Approach
- RNP to xLS
GLS

- **Ground Components:**
  - Receiver Antennae
  - Processing Unit
  - Approach database
  - VHF Datalink

- **GBAS transmits:**
  - Local corrections for all SVs in view
  - Integrity information
  - Final Approach Segment (FAS)

- **Aircraft:**
  - Must only use monitored SVs
  - MMR creates Final Approach Path and provides guidance
Agenda

- Approach Types and Classification
- GBAS
- PBN supporting the Approach
- RNP to xLS
Components of PBN

Applications:

- RNAV
- RNP

Navigation Application

Navigation Specification

NAVAID Infrastructure

Use of the Navigation Specification and Navigation Infrastructure together

- Ground-based NAVAIDS
- Space-based NAVAIDS

X = Navigation Accuracy in NM 95% of flight time

On-board Performance Monitoring and Alerting
### PBN supporting the Approach

#### FLIGHT PHASE

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#### Additional Functionalities (Required or Optional)

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<th>RF</th>
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</table>

- PCP and PBN IR
- Specific requirements for RF & VNAV

Performance Based Navigation & Ground Based Augmentation System
RNP to xLS

A-RNP
RNP 1 + RF
RNP APCH + RF
RNP AR APCH
RNP 0.3 + RF

≥ 5NM

≥ 7NM

Performance Based Navigation & Ground Based Augmentation System
Agenda

- Approach Types and Classification
- GBAS
- PBN supporting the Approach
- RNP to xLS
ILS, LPV, GLS Characteristics

- **ILS:**
  - Signal limited to a sector, provides a fixed path and therefore not an area navigation system
  - Outside the sector ILS can not be used for airborne location or guidance

- **SBAS:**
  - Regional augmentation
  - Supports LPV
  - FAS in aircraft’s NavDB

- **GLS:**
  - Local augmentation
  - Currently supports CAT I
  - FAS transmitted by ground station

SBAS & GBAS signals not limited to a single sector and therefore can be theoretically used for position estimation and flight guidance in a large area.

In practice, there may be limitations with LPV and GLS deviations normally presented to the flight crew as an ILS look-alike depending on the avionic solution.
RNP Transition to LPV

• RNP-LPV procedures developed within SESAR P05.06.03 project (APV):
  o ENKB - KRISTIANSUND/Kvernberget - Norway
  o LEPA - Palma de Mallorca - Spain
  o EGDD - Bristol – UK
  o LIMF - Torino - Italy

• These RNP-LPV procedures:
  o Are designed with similar geometries compared to RNP-GLS procedure: Advanced-RNP to LPV, in CDO
  o Will be validated within 9.9 / 9.10 project (advanced LPV / RNP-xLS) by flight tests on ATR aircraft, with similar avionics problematic
RNP Transition to GLS

• The transition from RNP to GLS addressed in SESAR P06.08.05

• The RNP with transition to GLS procedures should allow:
  • Optimization of operational flight safety:
    ✓ More reproducible and predictable trajectories.
  • Reduction of operating costs
    ✓ Reduction of fuel consumption and flight time.
    ✓ More flexible trajectories.
    ✓ Flight procedure minima reduction and airport accessibility improvement.
  • Reduction of the environmental impact.

• The main Key Performance Areas (KPA) detected: Safety, Capacity, Efficiency, Environment and Human Performance as Transversal Area.
RNP to GLS Concept – SESAR P6.8.5

Option for CDO
From Top of Descent using vertical barometric positioning

RNP Transition
Initial and Intermediate approach
A-RNP or RNP APCH
curved segments coded as RF

GLS Portion
Straight in GLS CAT I
Final Approach Segment

Missed Approach
A-RNP or RNP APCH missed approach -
option to include RF in accordance with ICAO Doc 9613 (Ed 4)

The scenario selected for the procedure development is Palermo airport (Italy)
RNP transition to GLS considerations

- Lateral Transition
  - Linear to angular guidance – capturing of FAS

- Vertical Transition
  - Barometric to Geometric transition

- Crew procedures
  - Arming modes once aligned on Final Approach – impact of last RF leg?

- Flyability
  - FAS length impact on GLS guidance laws
  - Aircraft must be stabilised at 3NM/1000’ – acceptable for system but is it acceptable to flight crew?
  - Straight segment prior to FAP required? Could safe transition to GLS segment be achieved turning onto FAP?
  - Performance of descending/sloping RF turns need to be assessed
Summary

Performance Based Navigation & Ground Based Augmentation System

FAF/FAP
CAT I
CAT II/III
Final Approach
Final Approach Capture
Above CAT I
CAT I
CAT II/III

STAR (RNAV 1 or RNP 1)

RNP APCH
Includes:
- LNAV
- LNAV/VNAV
- LP
- LPV

RNP AR APCH

ILS
GBAS/GPS
(LPV 200)

GBAS/Multiple constellations

CDO