RNP RNAV Approach with Airbus
Contents

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- Types of RNAV approaches
- RNP RNAV with RNP<0.3
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The Advantages of RNAV Approaches

- Approach on runway axis
- Final descent at a constant Flight Path Angle
- Stabilized approach leading 50 ft above runway threshold
- Accuracy of navigation
The Advantages of RNAV Approaches

• All Airbus with an FMS and GPS are capable to fly such RNAV Approaches

• Since mid-80’s Airbus promotes a constant slope NPA rather than step-down ("dive and drive") procedures

• All Airbus with FMS 2 can fly in addition RF legs
Types of RNAV Approaches

- RNAV (GPS) “Sensor related”
- RNP RNAV “Performance related”
  - DH as low as 250 ft AGL with APP NAV/FINAL (LNAV/VNAV) guidance

A lot of destinations could benefit from the implementation of Instrument Approach Procedures published under ICAO PANS OPS (or TERPS) criteria. A large part of the Airbus world fleets can fly these Instrument Approach Procedures.
Sensor related : RNAV Approaches

Typical “public” RNAV Approach PANS OPS

Sensor related : RNAV Approaches

Typical “public” RNAV Approach PANS OPS
The Required Navigation Performance concept was initially documented by ICAO

- RNP RNAV Procedures - ICAO PANS OPS
  - RNP 0.3,
  - Straight final segment

On many destinations, opportunities exist in Approach and Missed Approach

- For Lower RNP values
- For Curved Approaches / Missed Approaches
International standardisation - Current Situation and Perspectives

Different possibilities:

- **UNITED STATES/FAA**
  - Federal Aviation Administration (FAA) approach is based on a “case by case” method, based on National operational approval organisations (SAAAR process: Special Aircrew and Aircraft Authorization Required)
  - **FAA SAAAR Notice 8000.287** exists for **Private SAAAR**: the most demanding.
  - FAA objective: to adapt this Notice to **Public RNP SAAAR** procedures
  - Public criteria for **procedure design** included in **FAA Order 8260.RNP SAAAR**
  - Aircraft evaluation and Operator approval requirements being published in **Advisory Circular - AC 90-RNP SAAAR**: more standardized, less flexible

**AIRBUS** is compliant with the most demanding regulation available.
International standardisation - Current Situation and Perspectives

- **ICAO**
  - Europe rely on existing **ICAO** RNP RNAV Procedure for Air Navigation Services operations (PANS OPS) available for Straight In / RNP 0.3
  - Today, no RNP<0.3 criteria published for procedure design
  - Current criteria are based on national certification criteria, need for world-wide harmonization:
    - Europe supports ICAO RNP SORSG meetings

- **Objective:** to standardize a new approach type for RNP < 0.3

- **EASA**
  - European Aviation Safety Agency (**EASA**) approach aims standardisation across European countries and harmonization with FAA
  - **AMC20-XZ** in progress
    - Includes aircraft and operational criteria
    - Equivalent to the FAA AC
    - Objective is the harmonisation of RNP SAAAR
Airbus RNP<0.3 project status

- Airbus global RNP project aims at achieving RNP 0.10 certification with the EASA and the FAA
  - Initially with a specific set of equipment
  - Ultimately with any Airbus suppliers’ latest generation equipment

- RNP 0.15 achieved S1 2005 on A320 family (except A321) with ANZ configuration
  - FMS2 Honeywell, Honeywell ADIRU High Step1, MMR Collins

- RNP 0.10 targeted on all SA family before end ’05 with ANZ configuration

- First RNP<0.3 certification for the Long Range Aircraft family is planned S1 2006
  - A330:
    - Honeywell FMS2, Honeywell ADIRU (HIGH step1), all MMR
RNP<0.3 Certification

**OPERATIONAL ASSUMPTIONS**

- AP ON in FINAL APP mode
- Two systems to start the approach
- GPS PRIMARY available
- HIGH ACCURACY
- TF and RF F-PLN legs only
- WGS 84 geodesic system

**FTE withstands:**

- Winds up to 60kt all directions
- Wide range of IAS, Altitude, Weight, CG,.....
- Radius of turn as low as 0.8 NM
Performance demonstrated:

Navigation System Error (NSE_XTK 95%) = 0.03
Flight Technical Error (FTE 95%) = 0.07
Total System Error (TSE 95%) = 0.08

TSE = √(NSE² + FTE²)

Better than the target (RNP 0.1)

Pilot interface to monitor the FTE:
• Lateral Deviation on PFD
• XTK error on ND with improved resolution

FTE [Flight Technical Error], also called XTE [Cross Track Error] or LAT DEV [Lateral Deviation]
Airbus A/C provides Real time monitoring of current Navigation performance:

- Position Estimation: “GPS PRIMARY” and accuracy monitoring (EPE versus RNP)

- FTE: Pilot interface to monitor the Path Steering Error

(Upgrade of LCD Display software necessary)
“GPS PRIMARY” (white) message on ND

MCDU PROG Page

GPS PRIMARY

EPE: Estimated Position Error
[The EPE is a conservative value of the NSE computed by the FMGS]

RNP: Required Navigation Performance

“GPS PRIMARY” (white) message in MCDU scratchpad

ACCURACY assessment: HIGH needed;
[ LOW when EPE> required RNP ]
Position Estimation monitoring - WARNINGS

- "GPS PRIMARY LOST" on ND (not pilot clearable)
- "GPS PRIMARY LOST" message in MCDU scratchpad
- Aural triple click during a non-precision approach
Path Steering Error monitoring (mandated for RNP<0.3)

New Lateral Deviation Indication:
- L/DEV displayed on PFD
- Available
  - in approach with same display logic as V/DEV:
    - FINAL APP (armed or engaged) or FM Approach phase
  - during Go-Around

• Scale: 1 dot = 0.1 NM
• Same symbology as the V/DEV

Lateral deviation box representing the computed flight plan

Graduation every 0.1NM
Path Steering Error monitoring (mandated for RNP<0.3)

XTK Error:
• Resolution to the hundredth of NM
• Below 0.2 NM of XTKE and below Transition Altitude
Operational Approval

- Generic Approval for RNP 0.3 RNAV (PANS OPS)
  - Navigation Database Integrity
  - Crew Procedures
    - FCOM SOP
  - Dispatch Requirements
  - Crew Training
    - Briefing on RNP RNAV
    - Navigation system knowledge (learned during Type Rating)
    - Use of RNAV navigation system (learned during Type Rating)
      - Training on FINAL APP mode
  - Documentation update
RNP SAAAR benefits:

- Reduce minima in mountainous area
- Provides a stabilized automated way to fly what was a hand-flown curved path final
- More efficient and Predictable Air Traffic Management:
  - De-conflicting adjacent airports
  - Better access to simultaneous parallel runway or converging runway approaches
- Optimize noise abatement procedures in sensitive areas

RNP SAAAR constraints:

- Operational evaluation of each instrument procedure
- Special flight crew training
- Specific operational approval
- Today, National Authorities need to adopt FAA SAAAR criteria or develop their own regulation: Need for harmonization
RNP SAAAR implementation Project

AIRBUS
RNAV-RNP< 0.3
Certification
with
EASA/ FAA

AIRLINE
Operational Approval
with the support of Airbus and the Procedure Designer

Approach Procedure Designer

• Aircraft performance
• Fly-ability checks
• Flight crew procedures
• Crew training
• Documentation

• Approach design
• Approach charts
• Nav. Database coding
• Nav. Database integrity
• Procedure maintenance
RNP RNAV Operational benefits – Improving safety

JetBlue - New York JFK - A320

“Provides a stabilized automated way to fly what was a hand-flown curved path final with reference to lead-in lights and other visual cues.”
Evaluation of minima reduction at Lhasa with RNP RNAV procedures: RNP 0.3

- RNP RNAV RWY09
- DA preliminary evaluation:
  - Visual (wide circling in the parallel valley)
    - Current DA = 16404’ (5000m)
    - Current DH = 4701’ (1433m)
  - RNP 0.30
    - DA = 12605’ (3842m)
    - DH = 900’ (274m)
Evaluation of minima reduction at Lhasa with RNP RNAV procedures

- RNP RNAV RWY27
- DA preliminary evaluation:
  - Current
  DA = 13779’ (4200m)
  DH = 2076’ (633m)
  - RNP 0.30
  DA = 12618’ (3846m)
  DH = 927’ (282m)
RNP RNAV Operational benefits – Reducing minima

ANZ RNP RNAV RWY05 approach at Queenstown – A320

Minima reduced from 3500ft AGL to 270ft with RNP 0.15
PROCEDURE ASSESSMENT

Fly-ability check in the simulator

- Check that FM assumptions are taken into account in the design of the proposed instrument procedures:
  - Check that FTE (Flight Technical Error) performance is in line with certification objectives,
  - Perform tests under various wind conditions
  - Determine airspeed and wind limitations if required
  - Evaluate EGPWS behavior
- Modify the design of the approach procedures
- Define specific crew procedures in addition to SOP for RNAV
- Define mitigation means (EGPWS)
Determination of specific crew procedures

- Based on certification data, Airworthiness Compliance Document, approach designer data and simulator tests, definition of:
  - Additional procedure steps to the SOP for RNAV approach
  - Navigation monitoring procedures
  - GA procedure
  - Relevant contingency procedures in case of:
    - Engine failure
    - Navigation performance degradation
    - Loss of AP
  - Dispatch requirements
    - Weather minima at alternate airport
    - Minimum Equipment List
Design Specific Flight Crew Procedures

- APPR SPD 160 CONF 2
- L/G DOWN CONF 3
- F SPD
- CONF FULL Vapp
- GA
- ACC
- FINAL APP
- Note: QN250 is co-located with NV VOR

9800'
Operational Documentation Update

● Airbus documentation:
  ‣ Flight Manual
  ‣ RNP 0.X Airworthiness compliance document (SAAAR capability)
  ‣ FCOM

● Airbus supports the airline in the development of:
  ‣ Crew briefing on RNP 0.X RNAV, SAAAR operations and navigation system capability,
  ‣ Draft of specific RNP RNAV procedures to update the airline’s Operations Manual
  ‣ Performance take off charts
Aircraft Airworthiness Approval

- RNP 0.X Airworthiness compliance document (SAAAR capability)
  - Aims to be used by Operators to support operational approval
  - Provides all relevant information for safe operation of RNP 0.X

SAAAR:
- Summarizes:
  - Airworthiness Assessment ➔ JAR 25 Certified Navigation Capability
  - Assumptions & Limitations that should be considered in the operational evaluation
  - Assumptions & Limitations that should be considered for the instrument approach procedure design
Crew training

• Ground training basic knowledge:
  ▶ RNAV (FMGS) system known since Type Rating
  ▶ Briefing on RNP RNAV and SAAAR procedures
  ▶ Briefing on special destination procedures and limitations

• Simulator training
  ▶ Fly approaches including GA
  ▶ Fly departures AEO and OEI
  ▶ Review contingencies procedures
  ▶ Review navigation monitoring

• Flying first approach under supervision
Operational demonstration to the Authorities

- The objectives are to demonstrate:
  - The navigation system capability,
  - The adequacy of approach procedure design,
  - The adequacy of the airline’s crew procedures and training

- The demonstration should include:
  - Simulator sessions in airline environment
  - Demonstration flight in VMC

✓ retrofit of the aircraft could be needed depending on required RNP and desired configuration (LAT DEV, EGPWS using GPS position)
✓ Specific DMU programming needed for flight analysis
Operational approval

- The airline will apply for operational approval
- Airbus will assist the airline in preparing its application for operational approval and will support the airline to meet the Authorities’ requirements in the area of:
  - Demonstration of the certified aircraft capability
    - FM
    - RNP 0.X Airworthiness compliance document (SAAAR capability)
  - Substantiation of specific crew procedures
  - Minimum equipment list
- The airline should also expect to address other topics such as:
  - Approach and SID’s design justification (with procedure designer)
  - Navigation database integrity checks
  - Mitigation means (EGPWS,..)
  - Revisions of Operations Manuals
  - Crew training
Airbus deliverables

- Crew procedures for desired airport
- RNP 0.X Airworthiness compliance document (SAAAR capability)
- MEL for RNP approach operations
- RNP approach procedures – a briefing for pilots
- Service Bulletins (if required)
SAFETY in Mountainous operation

**Mountainous operation**

- Proactive safety: Performance based navigation: **RNP**
- Reactive safety: emphasizes the AIRBUS Fly-By-Wire concept:
  
  - **Full Flight Envelope Protections**
    - Stall Protection (Alpha Floor Protection)
    - Over speed Protection
    - Protection against Unusual Attitudes (Pitch / Bank)
  
  - Instinctive reactions in extreme flight situations possible
    - Wind shear recovery maneuver
    - CFIT escape maneuver (EGPWS)
HOW DOES AIRBUS ENHANCE SAFETY?
FBW - CFIT escape trajectory summary

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**Initial Conditions:**
- Non protected: Gw - Cg unknown
- Landing config: V/S = -1500 ft/min
- Protected aircraft: MLW - aft Cg - Vref+5
- Non protected: Gw - Cg unknown

“TERRAIN - PULL-UP”
HOW DOES AIRBUS ENHANCE SAFETY?

- Full profit of Performance based navigation (RNP):
  - The NPAs and RNAV approaches can be flown the way pilots are used to fly everyday,
  - Final descent at a constant Flight Path Angle
  - Improved flight crew standardization and Reduction in training needs
  - Less circling approaches
  - Provision of containment throughout the operation with associated cockpit alerts
RNP RNAV: Conclusion

✓ Airbus firmly believes in the operational benefits of RNP RNAV implementation and has incorporated RNP 0.3 capability as standard on all GPS equipped aircraft
  ‣ offer the option of RNP 0.15 on A320 family (exc. A321, coming soon)
  ‣ is pursuing a robust schedule of pilot RNP projects to achieve RNP 0.10 on Single Aisle family and Long Range aircraft.
✓ RNP is fully taken into consideration in the Airbus RNP Roadmap:
  ✓ aircraft configurations
  ✓ Regulatory framework
✓ Airbus is already involved in RNP SAAAR projects with several Airlines
CONCLUSION (Ctd)

✓ Airbus aircraft are or will be compliant with RNP RNAV regulations (existing and under development)

✓ Airbus is involved in the regulations definitions, with both the FAA and the EASA

✓ Airbus will anticipate the future developments of RNP RNAV Operations to optimize the Airbus aircraft capabilities

✓ Airbus recommends EGPWS using GPS referenced position and Lateral Deviation indication (although not mandatory for RNP 0.3)
A 380 AIRBORNE!

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