



**Matthias MAEDER**

Senior Director Flight Operations Support  
Airbus Training India Pvt. Ltd.

# Performance Based Navigation: RNP and RNP AR Approaches

## 1. Introduction

Performance Based Navigation (PBN) is becoming more established in worldwide operations. It includes approaches called RNP APCH and RNP AR APCH, where RNP stands for Required Navigation Performance, APCH is simply an abbreviation for Approach and AR for Authorization Required.

RNP and RNP AR procedures allow crews to fly approaches using internal and very accurate navigation tools, instead of traditionally using external guidance aids. They also allow the replacement of visual and circling approaches by instrument approaches, thereby enhancing the safety of airline operations. They are non-precision approaches although they provide the crews with cues and

procedures similar to those used on precision approaches.

This article first describes how the performance of non-precision approaches has evolved over time; from the step down procedures to the Constant Descent Final Approach (CDFA) concept and finally how this evolution has led to RNP solutions and associated benefits.

All Airbus Fly-By-Wire (FBW) aircraft equipped with GPS are currently certified for RNP approaches, which will constitute the majority of cases. RNP AR capability will usually be necessary in marginal cases, where extra flexibility in approach design is needed. This will be illustrated by the following article in this magazine, dedicated to RNP AR operation.

## 2. Evolution of Non-Precision Approaches

Advances in technology have modified the way non-precision approaches can be flown:

- The first technological step involved the move from the traditional step down approaches (also known as “dive-and-drive” approaches) to the CDFA concept, and the use of FMS systems to compute, then guide on the lateral and vertical approach paths.
- The second step implied the change over to RNAV/RNP approaches, primarily thanks to the introduction of GPS to civil aviation.

## 2.1 Step Down Non-Precision Approaches

The non-precision nature of the approach is characterized by the poor embodiment of the vertical path of the final approach. At the Final Approach Fix (FAF), the crew might be provided only with an assigned altitude and a distance to the Missed Approach Point (MAP). Thus, the crew awareness of the aircraft position versus the intended vertical flight path of the final approach is quite low (fig. 1).

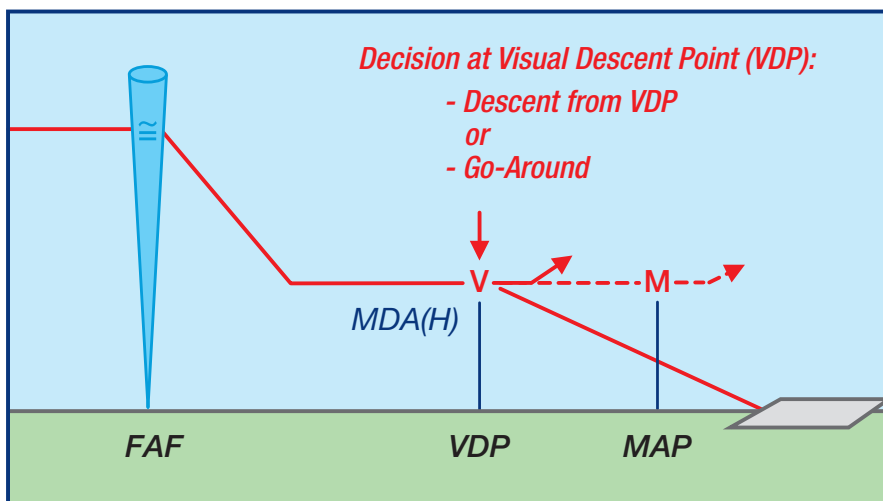
This traditional step-down approach technique has the following drawbacks:

- The aircraft never stabilizes during the final approach. The pitch attitude needs to be changed even at low altitudes, thus the thrust and pitch have to be continuously adjusted.

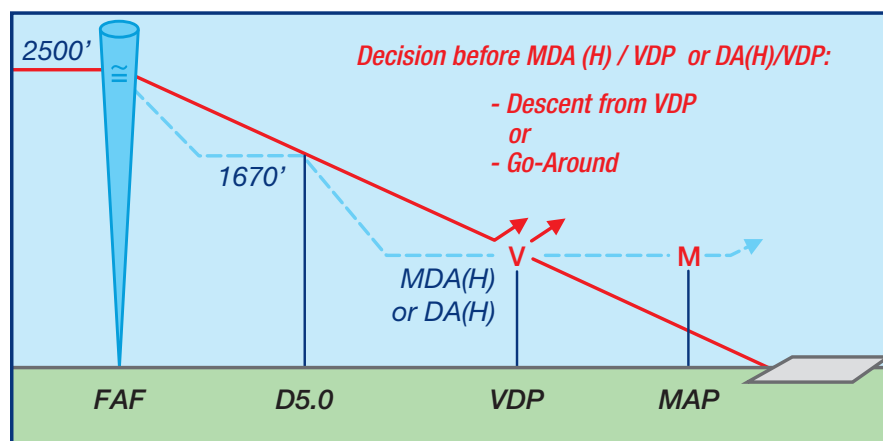
- The aircraft reaches MDA(H) in quasi-level flight either before or after the Visual Descent Point (VDP). Consequently, the acquisition of visual references is affected by the pitch attitude of the aircraft. This pitch is significantly greater than the nominal pitch attitude observed when the aircraft is established on an e.g.  $-3^\circ$  approach descent angle. This affects the perspective view of the runway.

- When acquiring visual references beyond the VDP, the pilot might be tempted to continue the final approach visually, which will result in a high descent rate during the visual segment of the approach.

- The monitoring/advising task in these approaches is also very high but remains a critical element of a successful approach.



**Figure 1**  
Traditional step down NPA



**Figure 2**  
NPA flown using the CDFA concept

## 2.2 Constant Angle Non-Precision Approaches (CDFA) concept

The CDFA concept addresses the key drawbacks of the step down procedure, mainly because the descent angle is constant throughout the final approach (fig. 2), allowing:

- A stabilized final approach: pitch attitude, speed, thrust and pitch trim remain constant. The monitoring of the vertical flight path during the approach is simple and continuous.

- A smooth transition from instrument to visual flying, as the aircraft is established on a descent angle (e.g.  $3^\circ$ ) and the crew keeps a constant perspective view of the runway.

- A safe approach up to the landing as the go-around decision is taken at the VDP, which is on the flight plan.

and therefore minimizes the risk of:

- Controlled Flight Into Terrain (CFIT)

- Landing short

- Runway Excursion due to landing long

The move from the step down to the CDFA concept was made possible thanks to Flight Management System (FMS) features, which are currently available on all Airbus aircraft by the use of TRK/V/S, TRK/FPA, FINAL APP or FLS modes, when applicable.

## 3. RNP AND RNP AR APPROACHES

The CDFA concept was further adapted by RNAV (aRea NAVigation) approaches, which are described by a series of point-to-point trajectories where each point may be defined either by a bearing / distance to reference ground navigation aids (VOR – DME) or by a geographic position defined as a latitude / longitude. An altitude constraint is assigned to each waypoint. Therefore, RNAV approaches define both a lateral and a vertical trajectory.

The ICAO Document n° 9613 – PBN Manual - describes the navigation specifications for RNAV and RNP.

This is achieved by adding the following systems to the aircraft:

- A Global Navigation Satellite System (GNSS), of which the US Global Positioning System (GPS) is currently the world's most utilized type.
- An On Board Performance Monitoring and Alerting system (OBPMA). The OBPMA is required to monitor the navigation system and will alert the crew in case of malfunction, e.g. GPS PRIMARY LOST and, therefore, allows the flight crew to determine whether the RNP system satisfies the navigation performance required.

### 3.1 RNP approaches

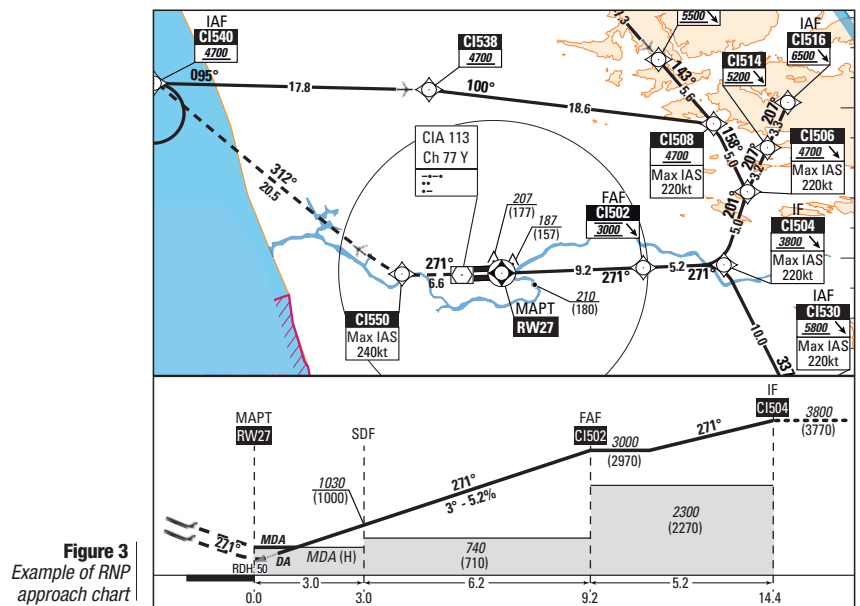
The first approaches using RNAV equipment have been developed before the definition of RNP. For this historical reason RNP approaches are commonly charted as RNAV (GNSS) or RNAV (GPS).

These RNP approaches are characterized by straight segments between the FAF and the runway (fig. 3).

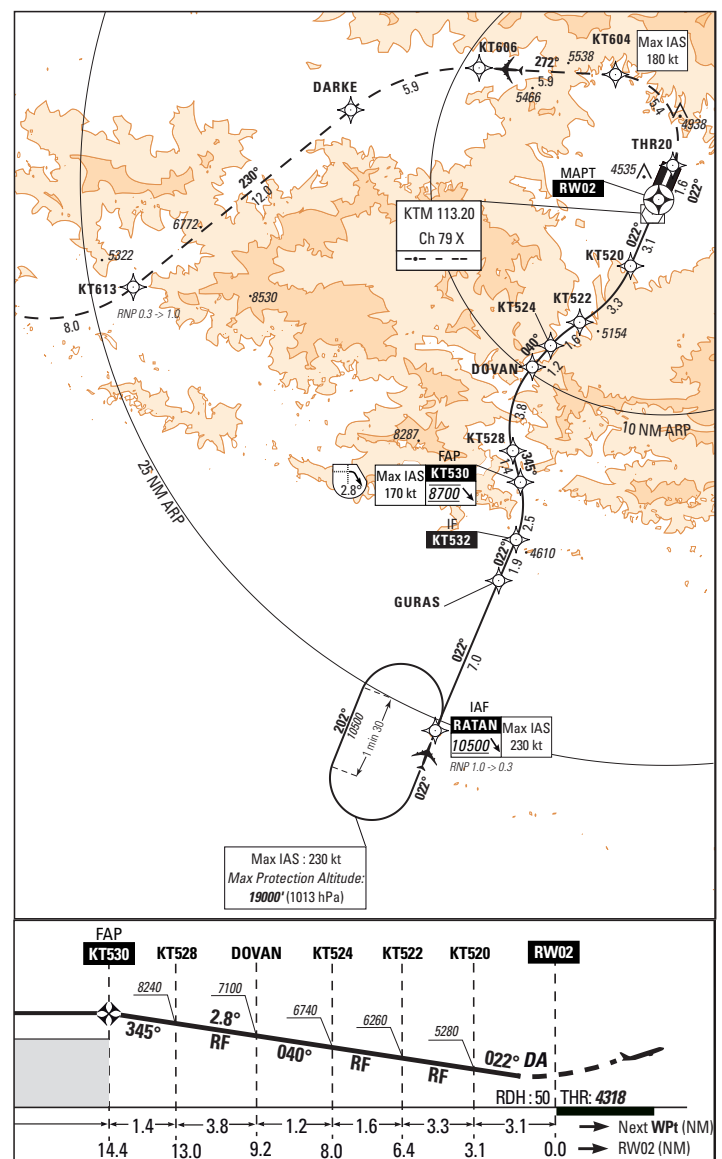
### 3.2 RNP AR Approaches

Compared to RNP approaches, where the segment between the FAF and the runway is straight, RNP with Authorization Required approaches might have “curved” final segments. These approaches are therefore colloquially called “curved approaches”. Furthermore, RNP AR approaches allow reduced obstacle clearance compared to RNP approaches (fig. 4). RNP AR\* approaches are charted as RNAV (RNP).

\* FAA terminology: RNP SAAAR (Special Aircrew and Aircraft Authorisation Required)



**Figure 3**  
*Example of RNP approach chart*

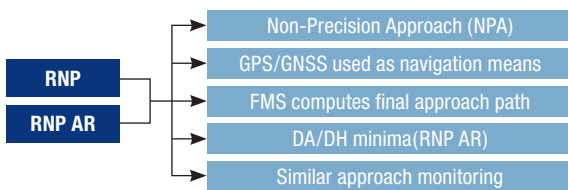


**Figure 4**  
*Example of RNP  
AR approach chart.*

	RNP Operation	RNP AR Operation
RNP Value 0.3	✓	✓
RNP Value < 0.3 (down to 0.1)		✓
Straight segment between FAP and RWY	✓	✓
Curve between FAP and RWY		✓
Minima DA/DH could be as low as 250 ft	✓*	✓
Departure and/or missed approach RNP Value < 1		✓

\* MDA/MDH might be given as well (LNAV only Minima).

**Figure 5**  
Respective characteristics of RNP and RNP AR approaches



**Figure 6**  
Summary of some key elements for RNP and RNP AR approaches

### 3.2.1 RNP AR Implementation Requirements

The specific nature of RNP AR operations call for the following additional requirements compared to RNP operations:

#### ► Aircraft Certification

Some RNP AR operations will require specific aircraft configurations. RNP certification have been granted to most Airbus types (A320 Family, A330 and A345/6). The aircraft capability appears in the AFM. For in service aircraft, application of a dedicated Service Bulletin is required.

#### ► Flight Operational Safety Assessment (FOSA)

RNP AR operations generally require a FOSA. The assessment should give proper attention to the inter-dependence of the elements of procedure design, aircraft capability, crew procedures and operating environment.

RNP AR procedures must be designed and tested in accordance with the design specificities and performance of the concerned aircraft.

#### ► Training Programs

Airlines have to develop training programs dedicated to their RNP AR operations.

#### ► Operational Approval

RNP AR application packages include a full set of operational documentation, procedures and training programs, which need to be approved by the local Authority.

## 4. SAFETY BENEFITS

### 4.1 RNP Approaches

#### ► Replacement of visual and circling approaches

RNP allows IFR procedures to be designed in environments, where previously no instrument approach could be envisaged. RNP approaches are particularly suited for (but not limited to) approaches in challenging areas (e.g. mountainous areas) and as a replacement for most existing circling approaches.

Compared to visual and circling approaches, the trajectory of the RNP approach is predictable. This enhances the preparation and briefing of the approach. Moreover, it facilitates the situational awareness and decision making. Flying these approaches fully managed in a lateral and vertical sense and in speed control makes energy management easy throughout the approach.

RNP approaches also ensure a simpler entry into a planned Go Around trajectory profile should one be required. This has always been a somewhat “difficult” aspect of circling approaches.

#### ► Lower weather minima

Lower minima allow a better transition to the visual segment when

aligned with the runway, thereby reducing the probability of having to go-around.

#### ► Less communication needs

The pilot workload is reduced as there is less need for communication.

#### ► Assessment of Terrain Avoidance Warning System (TAWS) warnings

The required procedure validation for RNP approaches will assess the absence of TAWS warnings.

### 4.2 RNP AR Approaches in addition to RNP Approaches

#### ► Improved flexibility

RNP AR approaches are expected to cover those cases where the procedure design limitations of RNP approaches do not allow to replace visual and circle to land procedures.

#### ► Implementation of safety criteria

The completion of a FOSA will ensure that for each specific set of operating conditions, aircraft and environment, all failure conditions are appraised and, where necessary, mitigations are implemented to meet the safety criteria.

## 5. CONCLUSION

The Constant Angle Non-Precision Approach (CDEFA) concept has replaced the non-stabilized final segments associated with the old step down Non-Precision Approaches (NPA).

RNP and RNP AR approaches are basically defined as RNAV approaches within a performance based navigation concept. The main difference is that they do not require ground facilities for navigation as they use the navigation performance of the aircraft.

For suitably equipped aircraft, RNP and RNP AR approaches provide an alternative “precision like” approach option for NPAs. All Airbus

FBW aircraft with GPS are currently certified to fly RNP approaches, which are suitable for the vast majority of airports.

In specific cases the added flexibility of RNP AR will be needed under certain terrain/approach and airfield situations.

Compared to visual and circling approaches the trajectory of the RNP/RNP AR approach is predictable, therefore facilitating situational awareness and decision making. The replacement of visual and circling approaches by RNP/RNP AR approaches is therefore a safety enhancement.

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### Airbus

**Product Safety department (GS)**  
**1, rond point Maurice Bellonte**  
**31707 Blagnac Cedex - France**  
**Fax: +33(0)5 61 93 44 29**  
**[safetycommunication@airbus.com](mailto:safetycommunication@airbus.com)**



**A350 XWB**  
*First flight of A350  
XWB at Toulouse-  
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