ICAO PBN Workshop
Tanzania

RNAV 1 & RNP1

Overview

- RNAV 1 introduction
- Existing guidance material
- Aircraft Requirements
- RNAV 1 Operational approval process
- RNP 1
- Difference between RNP 1 and RNAV 1

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RNAV 1 introduction

It addresses Terminal Area

- Departure (SID) and Arrival (STAR)
- Initial Approach Phase

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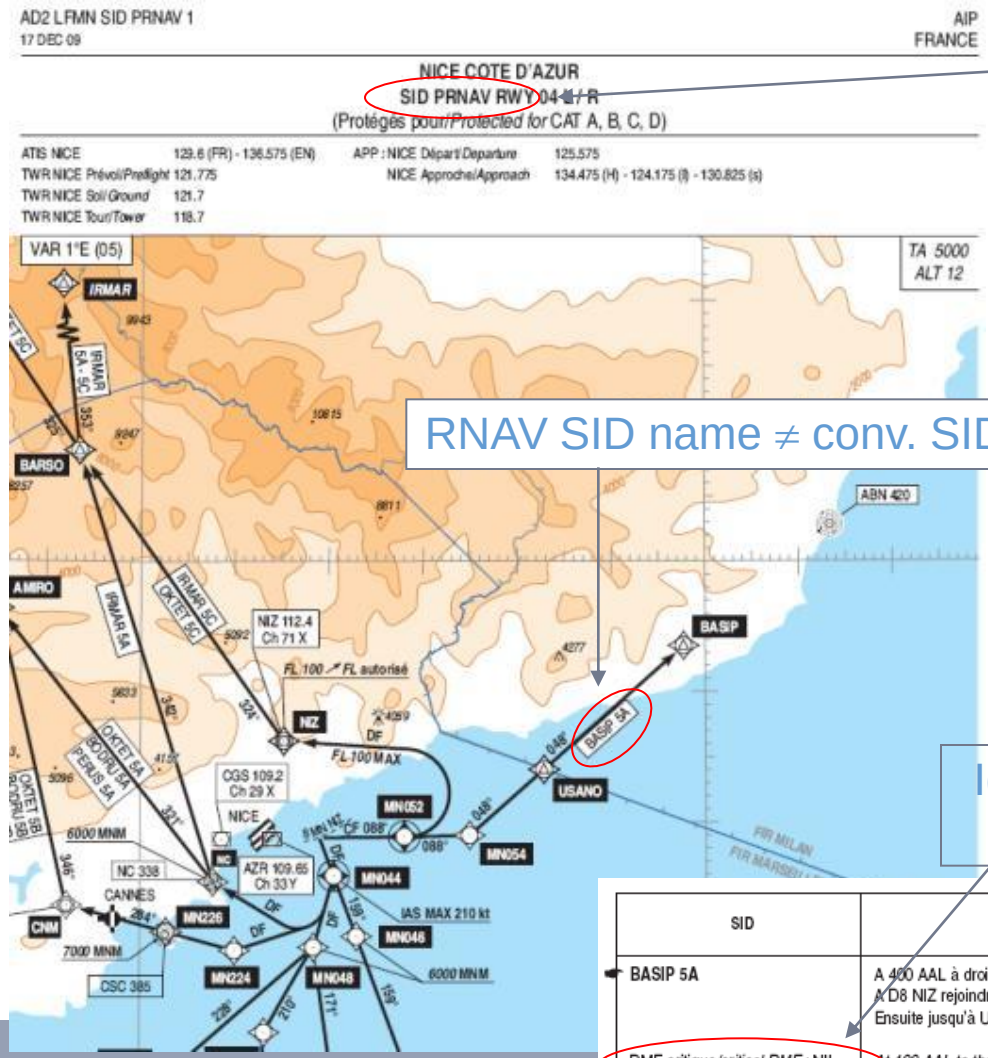
RNAV 1 introduction - SID : AIP information



RNAV SID chart

RNAV SID name ≠ conv. SID

Required sensors: GNSS and DME/DME/INS

3.2.2.2 Départs P-RNAV

L'équipement requis pour l'utilisation des procédures de départ P-RNAV est un équipement P-RNAV utilisant un capteur GNSS ou/et un capteur DME/DME. Toutefois, les équipements P-RNAV ne disposant pas de capteur GNSS devront, en complément du capteur DME/DME, disposer d'une possibilité de navigation inertielle pour utiliser les SIDs P-RNAV.

Dans ce cas, l'équipage doit s'assurer, avant l'alignement que la précision de la position fournie par le système de navigation est meilleure que 0.17 NM par rapport à une position connue (ex : seuil de piste). Cela peut-être réalisé au moyen d'une fonction de recalage du système de navigation (ex : FMS) automatique (fonction "Automatic runway update") ou manuelle.

update of the IRS if inertial system maybe required

Identification of critical DME

SID	ITINERAIRES / *Routes*	CLR initiale *Initial clearance*	RMK
BASIP 5A	A 400 AAL à droite RM 139°. A D8 NIZ rejoindre MN054 direction 088°, Ensuite jusqu'à USANO et BASIP.	FL 100 (R) FL 070 (H)	
DME critique/*critical DME* : NIL	*At 400 AAL to the right MAG 139°.* *At D8 NIZ proceed to MN054 on course 088°,* *Then to USANO and BASIP.*		

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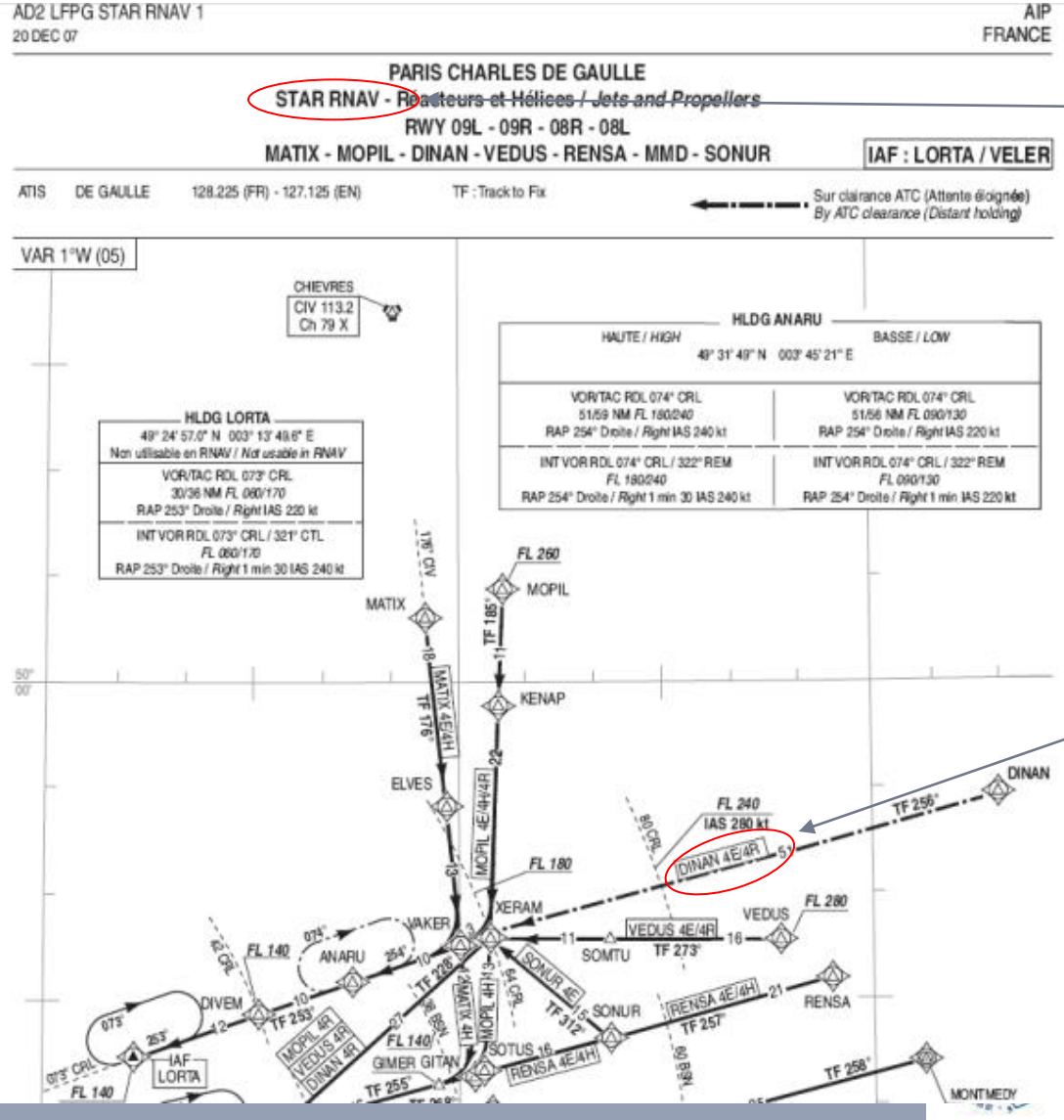
RNAV 1 introduction - STAR : AIP information



RNAV STAR chart

RNAV STAR name ≠ conv. STAR

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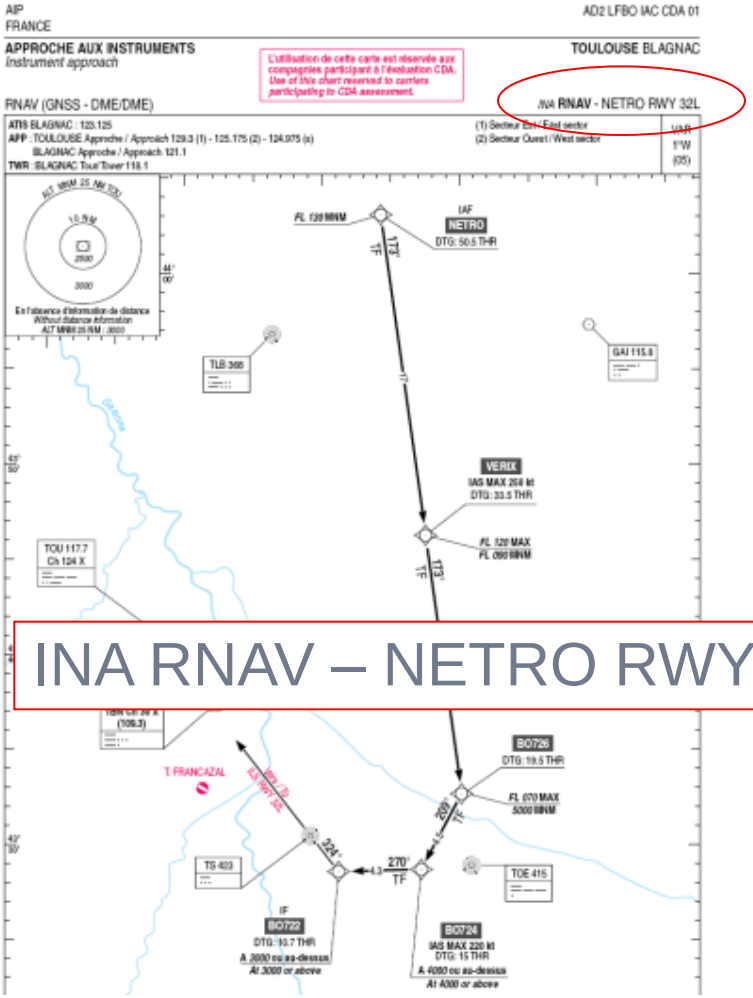
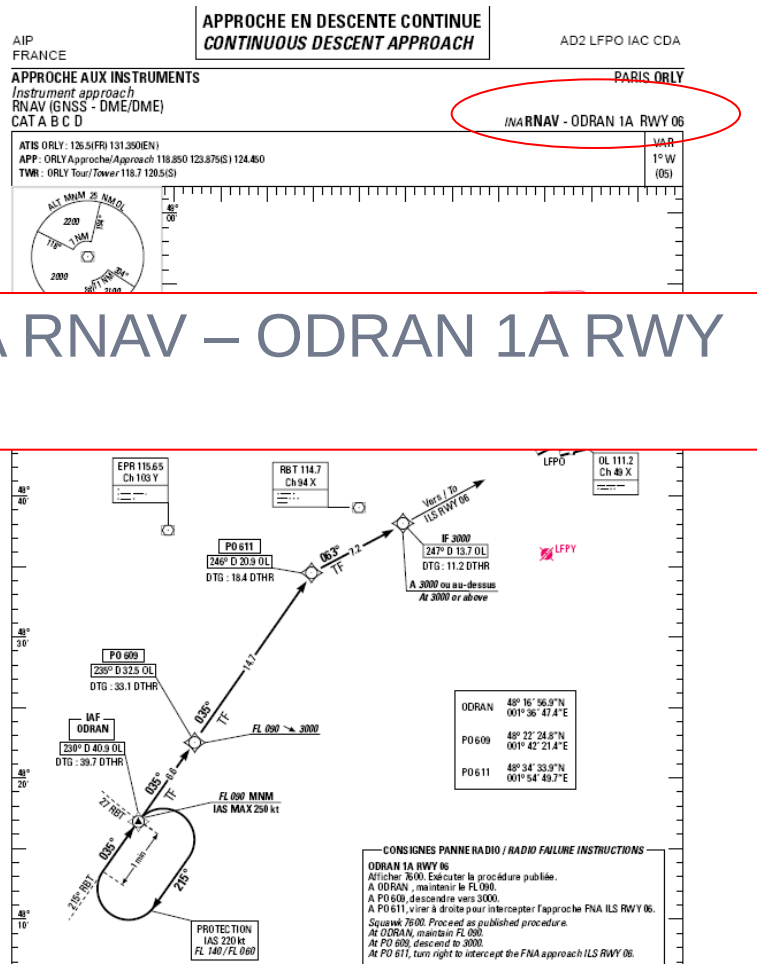
RNAV 1 introduction - INA RNAV



INA RNAV – NETRO RWY 32L



INA RNAV – ODRAN 1A RWY 06

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RNAV1 - regulation guidance materials

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RNAV 1 existing Guidance material

- ICAO Doc 9613 PBN Manuel VOL II Part B Chapter 3: RNAV 1 nav spec

- AC 90-96A: For a US operator to get a P-RNAV approval
- AC 90-100A: Provides operational and airworthiness guidance for operation on U.S. Area Navigation (RNAV) routes, Instrument Departure Procedures (DPs), and Standard Terminal Arrivals (STARs).

- JAA TGL10: Airworthiness and operational approval for Precision RNAV operations in designated European airspace.

- P-RNAV is the application of RNAV 1 in Europe

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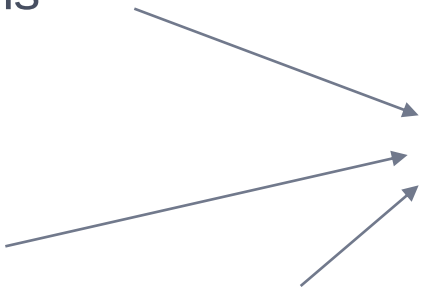
RNAV 1 existing Guidance material

The TGL 10 contains

- Airworthiness certification means
  - Accuracy
  - Integrity
  - Continuity of function
- Functional requirements
- Acceptable means of Airworthiness compliance



Aircraft requirements For certification by EASA

- Operational Criteria (Chapter 10)

For OPS approval by National Authority

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Aircraft Requirements for RNAV 1

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RNAV 1 & 2 ICAO PBN Manual Summary

PBN APPLICATION		RNAV2	RNAV1
Navaid infrastructure		DME GNSS INS	DME GNSS INS
Nav Spec	On board	GNSS DMEDME DMEDME/IRU	GNSS DMEDME DMEDME/IRU
	TSE	<2 NM	<1 NM
	Leg type	IF CF TF DF VA VM VI CA FA FM	IF CF TF DF VA VM VI CA FA FM
	Function	Data base (LOA) FB turn	Data base (LOA) FB turn
Surveillance		Radar	Radar separation Specific Safety Assessment
Communication		voice	voice
ATM	Separation minima	Radar separation	Radar separation
	Publication	RNAV 2 Critical DME if any	RNAV1 Critical DME if any

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RNAV 1 – Aircraft requirements

Lateral navigation

- The Flight plan is generated from the arrival or the departure procedure extracted from the navigation data base
- RNAV system performance must be based on GNSS, DME/DME, or DME/DME/IRU. Possible positioning sensors DME/DME, GNSS and INS with automatic radio updating
- The RNAV system outputs necessary navigation parameters and desired path to displays and autopilots

Vertical navigation

- No requirement (optional function)

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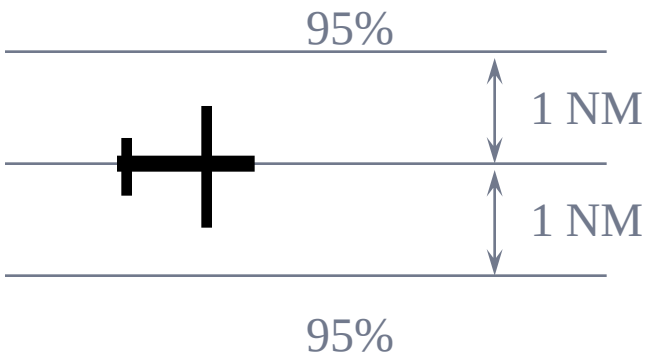
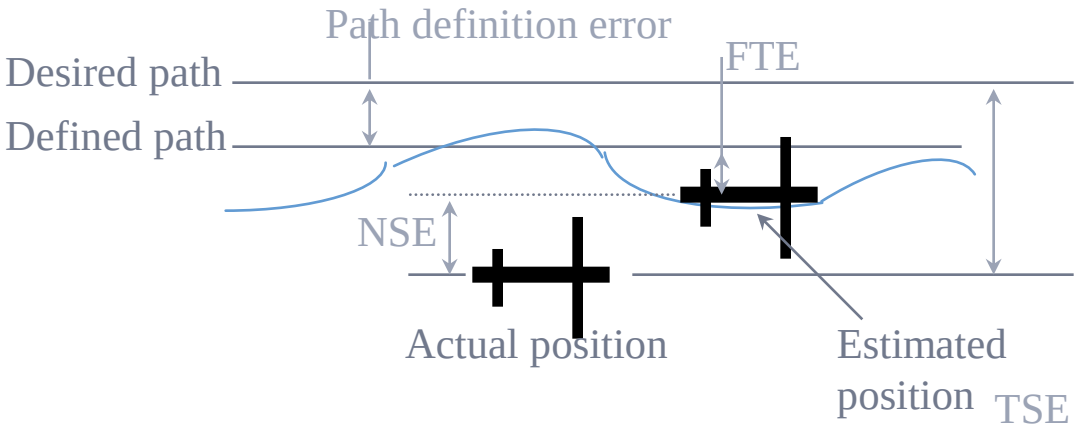
RNAV 1 – Aircraft requirements

The lateral TSE must be within ±1 NM (95%)

The TSE is the Root Sum Square (RSS) of

- Navigation system error (NSE)
- Path definition error (PDE)
- Flight technical error (FTE)





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RNAV 1 – Aircraft requirements

Integrity and continuity requirements

- Probability of displaying Hazardously Misleading navigational or positional information simultaneously to both pilot shall be improbable (occurrence should be less than 10-5 per flight hour)
- Probability of loss of all navigation information should be improbable (occurrence should be less than 10-5 per flight hour).

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RNAV 1 – Aircraft requirements

Required functions

- Display indicator with course selector automatically slaved to the RNAV computed path
- Navigation data base (should include the complete RNAV procedure)
- Display of the active navigation sensor type, the active (TO) waypoint, the distance and bearing to the active (TO) waypoint and the ground speed or time to the active (TO) waypoint
- Automatic tuning of DME navigation aids with capability to inhibit individual navaids (When RNAV system is based on radio sensor).
- Capability for the « Direct To » function

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RNAV 1 – Aircraft requirements

- Capability to execute transition database procedures (Fly-over and Fly-by turns)
- Capability to automatically execute leg transitions and maintain tracks consistent with the following path terminators :
  - Initial Fix (IF)
  - Track between two Fixes (TF)
  - Course to a Fix (CF)
  - Direct to a Fix (DF)

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RNAV 1 – Aircraft requirements

- Capability to automatically execute leg transitions, or provide adequate means to manually follow, and maintain tracks consistent with the following path terminators:
  - Course to an Altitude (CA)
  - Fix to a Manual Termination (FM)
  - Heading to an Altitude (VA)
  - Heading to an Intercept (VI)
  - Heading to a Manual Termination (VM)

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RNAV 1 – Aircraft requirements

Recommended functions (for TGL 10)

- Capability to fly parallel route (Offset function)
- Coupling to Flight director and/or automatic pilot
- Capability for vertical navigation based upon barometric inputs
- Means for automatic runway position update at the start of the take-off for non-GPS installation (To prevent the « map shift » at Take-Off)
- Capability to execute following leg transitions:
  - Holding pattern (Hx including HM, HA et HF)

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RNAV 1 – Aircraft requirements

Display system : course selector automatically slaved to the RNAV computed path

Remote annunciator and selection

Standalone RNAV system TSO C129

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RNAV 1 operational approval process

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RNAV 1 – Ops approval

General aviation

- Aircraft has to be certified in accordance with TGL 10
- Operators have to modify their ops manual, check-list and QRH, an MEL (or equivalent documentation)
- No specific approval granted

Commercial Air Transport

- They have to be approved by their supervision authority to fly RNAV 1 procedures

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PBN ops approval process– General Method
Impact of PBN in the OPS manual

Documents provided by the operator to approve the PBN approval request

1. type, and registration number of the applicable aircraft => B1.
2. List of the navigation systems (name, version or part number, installed number) => B12
3. Aircraft Flight Manual (AFM) Pages giving the RNAV1 capability .
4. Description of the navigation system => part B12
5. Limitations of the system => B1/B12
6. Normal / abnormal / contingency operations (included in the operations manual)
7. MEL => B9
8. Crew training => part D
9. Navigation database policy
10. Aerodromes information => part C depending on the PBN nav spec approval request
11. Specific maintenance task if applicable

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RNAV 1 -Aircraft eligibility

AFM

- In most of the cases P-RNAV certification or RNAV 1 certification should be mentioned with the reference to the standard in AFM.
- Check : Reference to TGL-10 and/or AC 90-100A
- Check on which sensors the certification has been done. (DME/DME, GNSS,..)

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RNAV 1 – Flight preparation

OPS manual part A
Pre-flight Planning

- Check that the procedures are based upon WGS 84.
- Procedures not based on WGS-84 should not be accessible by database, or should be forbidden by an airline NOTAM.
- Check the availability of the navigation infrastructure required for the intended operation,
- Required navigation aids critical for the operation has to be available
- Check the adequacy of the published RNAV1 procedure and the A/C capability
- Availability of the onboard navigation equipment necessary for the route to be flown must be confirmed.

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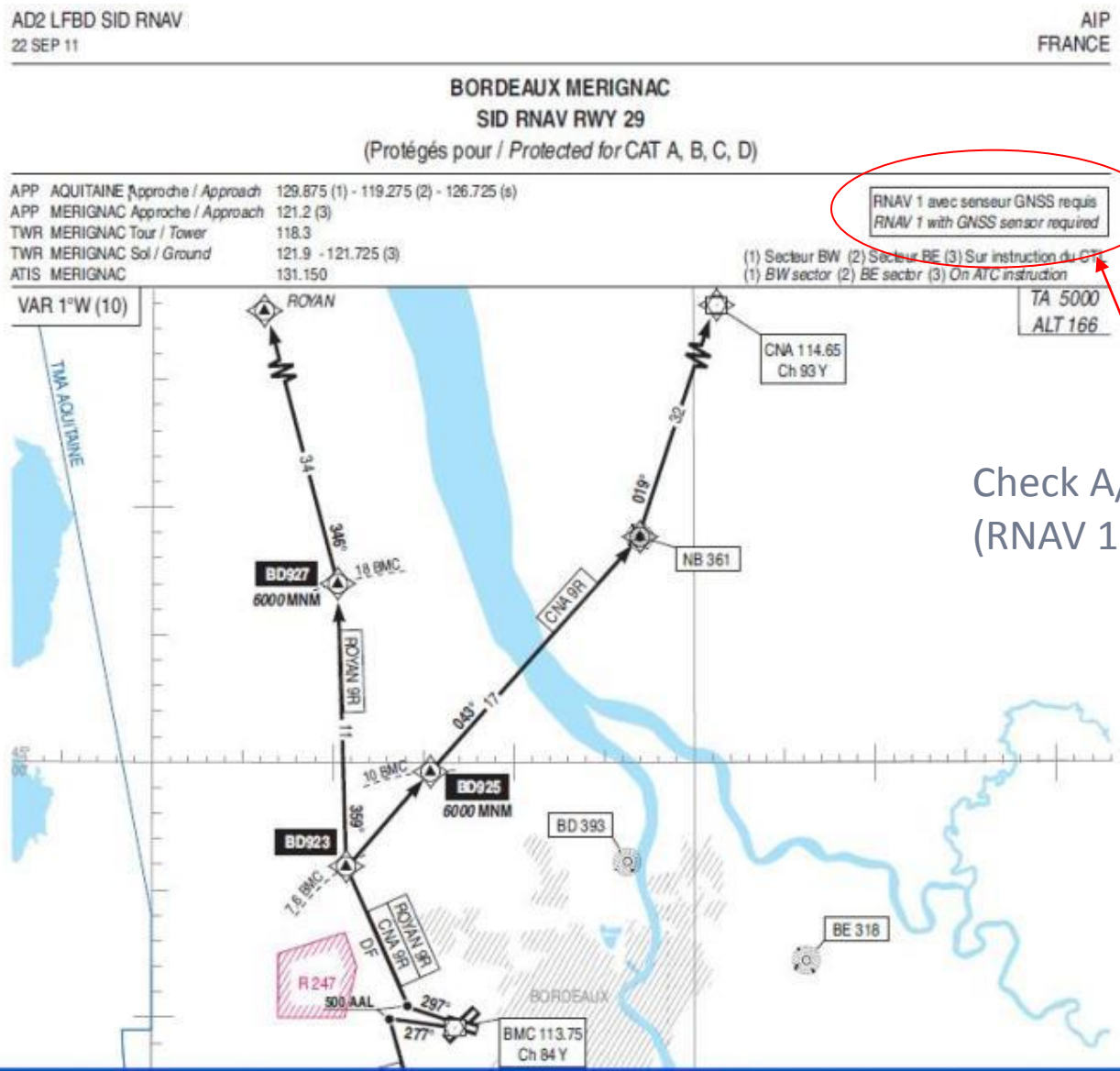
RNAV 1 – A/C adequacy



Check A/C capability is adequate
(RNAV 1 with GNSS)

RNAV 1 – Flight preparation

- If a stand-alone GPS is to be used for P-RNAV, the availability of RAIM must be confirmed during the time the procedure will be used (15mn before the procedure, until 15mn after the procedure use)

- Check NOTAM to take into account the latest information of eventual satellite non-availability => This information has to be used in the RAIM prediction

- Exceptionally Where the responsible airspace authority has specified in the AIP that dual P-RNAV systems are required for specific terminal P-RNAV procedure, the availability of dual P-RNAV systems must be confirmed.

- The Navigation database has to be validated in accordance with the procedure chosen by the airline.

- The flight plan has to be filled in in accordance with the capability.

  See PANS ATM doc 4444

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PBN OPS approval process – Flight Plan

Item 10 = R and Item 18 = PBN / following letters in accordance with the following table

	RNAV SPECIFICATIONS
A1	RNAV 10 (RNP 10)
B1	RNAV 5 all permitted sensors
B2	RNAV 5 GNSS
B3	RNAV 5 DME/DME
B4	RNAV 5 VOR/DME
B5	RNAV 5 INS or IRS
B6	RNAV 5 LORANC
C1	RNAV 2 all permitted sensors
C2	RNAV 2 GNSS
C3	RNAV 2 DME/DME
C4	RNAV 2 DME/DME/IRU
D1	RNAV 1 all permitted sensors
D2	RNAV 1 GNSS
D3	RNAV 1 DME/DME
D4	RNAV 1 DME/DME/IRU
	RNP SPECIFICATIONS
L1	RNP 4

Note.- Operators of aircraft approved for P-RNAV relying solely on VOR/DME for the determination of position shall insert 'Z' in item 10 of the flight plan and the descriptor EURPRNAV in item 18 of the flight plan, following the NAV/ indicator.

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RNAV1 - Normal procedures

The ops manual has to contain the following flight crew check and limitations

- The Navigation Data Base has to be current
- Check the active flight plan by comparing the charts with the MAP display and MCDU
  - WPt sequence,
  - reasonableness of track angles, distances,
  - altitude and speed constraints if any,
  - fly-by and fly-over WPts
- If the procedure requires it, check that updating will use the specific navaid
- Creation of new WPt by manual entry is not permitted
  - Modification of a published procedure is forbidden
- Monitor the trajectory by cross checks with conventional navigation aids

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RNAV 1 - phraseology

Phraseology has to comply with Doc 7030 and 4444

Example:

Abnormal situation because of a system failure the crew has to warn the ATC

« Unable RNAV »

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RNAV 1 - Contingency procedure

- Contingency procedures have to be developed to address
  - Failure of the RNAV system
  - Failure of the navigation sensors
  - Coasting on inertial sensors beyond a specified time limit
- The RNAV 1 capability loss has to be notified to ATC in order to decide the appropriate course of action
- In case of RNAV 1 capability loss, the crew should invoke contingency procedures and navigate using alternative means of navigation.

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RNAV 1 - Incident reporting

- Any significant incidents experienced during RNAV 1 procedures have to be reported
  - Navigation database errors
  - Unexpected deviations in lateral or vertical not caused by the pilot.
  - Misleading information without failure warning
  - Map shifts
  - Total loss of navigation equipment
  - Pb with ground navigational facilities

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RNAV 1 - MEL

MEL

- The airline must develop a MEL taking into account its operational capability (in our case RNAV1).
- Loss of functions (systems)
- Database out of date (taken into account by TGL 26)

JAA Administrative & Guidance Material
Section Four: Operations, Part Three: Temporary Guidance Leaflet (JAR-OPS)

LEAFLET NO. 26 - SECTION 5: Additional MEL Policy

ATA Chapter: 22 Autoflight					PAGE: 22-1
(1) System & Sequence Numbers ITEM		(2) Rectification Interval	(3) Number installed	(4) Number required for dispatch	(5) Remarks or Exceptions
ATA					
22-10	Flight Director	C	-	-	(O) One or more may be inoperative provided: (a) Applicable operating minima do not require their use, and (b) The navigation specifications of the route to be flown do not require their use.
22-71	Navigation Database(s) Note: Database(s) which is/are out of date is/are considered to be inoperative	C	-	0	(O) One or more may be inoperative for the intended route where conventional (non-RNAV) navigation is sufficient, provided: (a) Current aeronautical information (e.g. charts) is available for the entire route and for the aerodromes to be used, and (b) Navigation database information is disregarded.
		C	-	1	Any in excess of one may be inoperative provided: (a) The operative database must be up to date for routes, departures, arrival and approach procedures that require the use of navigation Database for RNAV, and (b) This up to date Database is readily available to the flight crew member(s) responsible for navigation. (cont.)

Section 4/Part 3 (JAR-OPS) 26-120 01.06.08

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RNAV 1 Flight Crew training

- Pilots must be familiar with
  - the basic principles of RNAV,
  - limitations and functions of the RNAV system.
  - the operation and particularities of the RNAV equipment
- They should be aware of the operational procedures applicable
  - to pre-flight planning
  - performance of these procedures.
- The minimum training shall comprise a theoretical part and a practical part.
  - Use of the RNAV system
  - Training to cover the impact of the RNAV 1 capability loss
  - Ability to manage correctly « direct To » clearance, Radar « headings », insertion of Wpt from the database (user Wpt or Wpt entered manually are forbidden).

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RNAV 1 navigation database

Navigation data base integrity

- Shall comply with ED 76/DO 200A methodology standard or an equivalent approved procedure.
  - ➢ A navigation data base supplier holding an FAA or EASA LOA (Letter Of Authorization)

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Area of Operation: TERMINAL

RNP 1

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Area of Operation: TERMINAL

PBN APPLICATION		RNP1
Navaid infrastructure		GNSS
Nav Spec	On board	OPMA
	TSE	<1Nm
	Leg type	IF CF TF DF VA VM VI CA FA FM RF
	Function	Data base FB turn
Surveillance		Procedural
Communication		Voice
ATM	Separation minima	Vary Cf doc4444
	Publication	RNP1

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RNP 1 vs RNAV 1

Main differences between RNP 1 and RNAV1 ?

- Performance differences:
  - RNP 1 is a RNP nav spec : Integrity has to be managed.
  - RNP 1 accomodates GNSS whereas RNAV 1 can accomodate GNSS, DME/DME and DME/DME/IRS
- Functional differences
  - RF leg is optional for RNP 1 whereas it is not considered in RNAV1

- What does it mean ?
  - A state publishing a RNP 1 SID or STAR would protect the procedure with the exclusive use of GNSS and may decide to use a « RF leg » in the procedure. In that case RNP1 and « RF required » should be clearly required on the chart.
  - Some discussions at ICAO to open the RNP1 to DME/DME. The question therefore is how to handle integrity of the « DME/DME signal » ?
    - It could be done with additional on board information (IRS for instance)
    - Taken into account that DME infrastructure is sufficient (RNAV1 DME infrastructure could be sufficient => clarification still needed)

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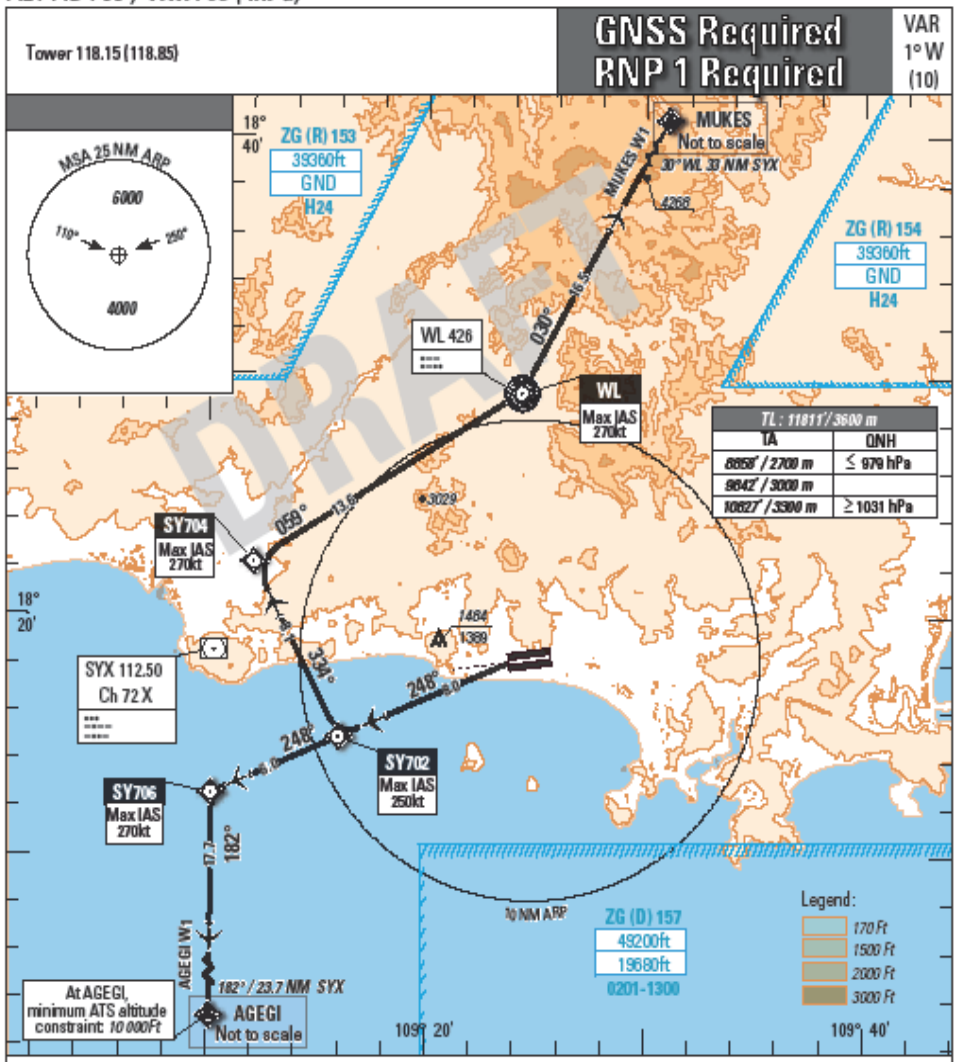
STANDARD INSTRUMENT DEPARTURE
CAT. A B C D
ALT AD : 95 , THR : 95 (4hPa)

SANYA - ZJSY
RNAV-SID AGEGI-MUKES-RWY 26



DRAFT

Procedure design and charting : by ENAC/CGx-AERO in SYS-Proc for QUOVADIS/AIRBUS - © 2010

MUKES W1: From DER, climb (1) Mag Track **248°** to **SY702**, then proceed to **SY704**, **WL** and **MUKES**.

(1) The minimum Procedure Design Gradient is 3.7% until *3300ft* disregarding the trees 244m from DER, both sides of the axis.

AGEGI W1: From DER, climb (1) Mag track **248°** to **SY702**, then proceed to **SY706**, then to **AGEGI**.

(1) The minimum Procedure Design Gradient is 3.3% disregarding the trees 244m from DER, both sides of the axis.

Nº & AIP-GIS Charting®