



PERFORMANCE BASED NAVIGATION (PBN) ROUTE LABORATORY

(Nairobi, Kenya, 22 to 26 May 2023)

Review from the Free Route Airspace PMT

PBN routes as per Precursor to FRA

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By the AFI FRA PMT

02/06/2023



FRA, AS PART OF GLOBAL AIR NAVIGATION PLAN

Free Routing Airspace

Free Route Airspace (FRA) is a module of ASBU: module B1-FRTO and therefore forms part of AFI ASBU plan.

FRA is concept that allows States/ANSPs to overcome the challenges in ATM **safety, efficiency, capacity** and **environmental** issues facing aviation.

	GANP - ASBU - FRTO
FRTO-B0/1	Direct routing (DCT)
FRTO-B0/2	Airspace planning and Flexible Use of Airspace (FUA)
FRTO-B0/3	Pre-validated and coordinated ATS routes to support flight and flow
FRTO-B0/4	Basic conflict detection and conformance monitoring
FRTO-B1/1	Free Route Airspace (FRA)
FRTO-B1/2	Required Navigation Performance (RNP) routes



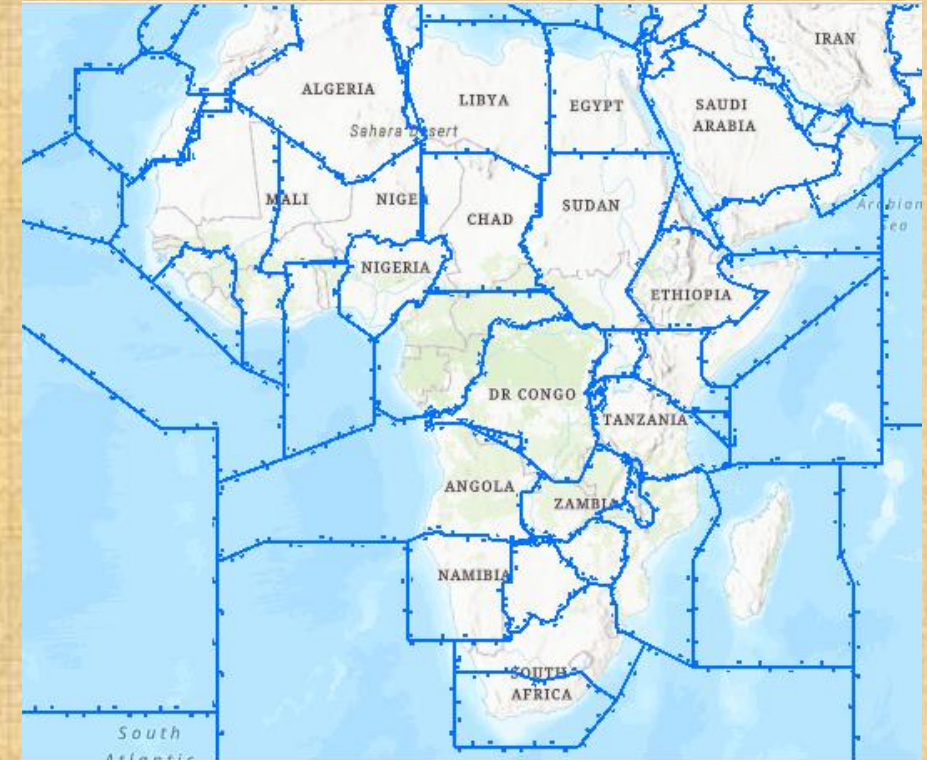
FRA, AS A PRIORITY IN AFI REGION

APIRG/22 Conclusion 22/36: Free Routing Airspace

That, in order to foster the concept of free routing in the **AFI continental airspace** in preparation for the ASBU B1 module,

a) States consider incorporating **Free Route Airspace concept into their national airspace concept and ATM Master Plan in line with the B1-FRTO ASBU module and AAO Sub-Group project plans;** and

b) **East African States including**, Seychelles, **Mauritius**, Kenya, Ethiopia, Tanzania and Uganda **develop and implement Free Route Airspace as a case study for implementation of Free Routing Airspace in AFI Region as part of B1-FRTO ASBU module.**



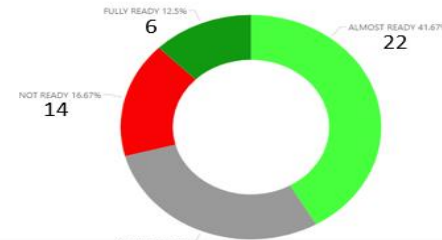
APIRG/23 Conclusion 23/02: Prioritization of Free Routing Airspace implementation



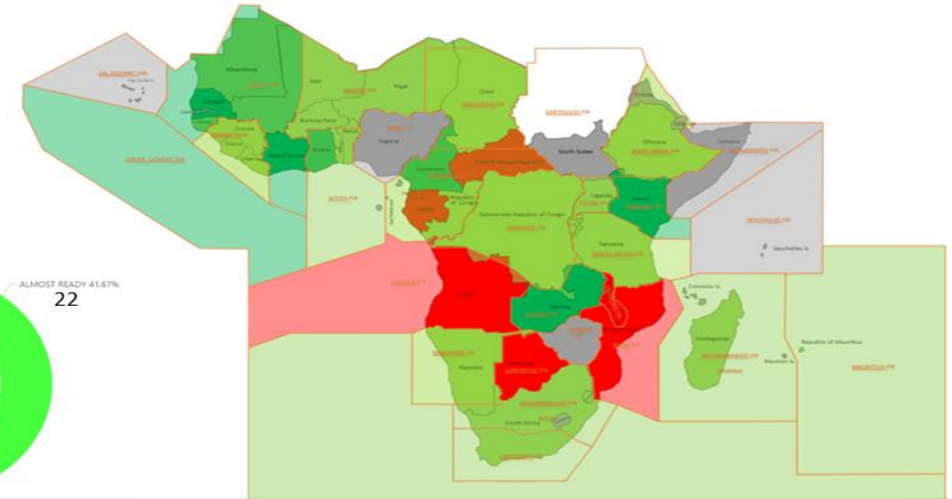
The AFI FRA PMT achievements

- **FRA concept of operations (CONOPS) 2nd Edition** which includes **Procedures for FRA implementation** and some safety requirements,
- **Gap analysis.** The gap analysis revealed the level of **preparedness of the AFI States** in implementing FRA.
- The results of the gap analysis and the CONOPS were shared with states during the **first AFI FRA workshop** held on **6-7 July 2022**.

FRA FIRs Readiness by weights combined



AFI Region Implementation of Airspace Layout



Areas of Focus

- Surveillance
- Communication
- Coordination
- Navigation
- Safety nets
- Airspace procedures
- ADS-C/B, SSR, PSR, MLAT
- VHF, CPDLC, HF
- AMHS, AFTN, OLDI/AIDC
- GNSS, VOR/DME
- APW, M/STCA, CD/R, MONA
- FRA, FUA, ATFM



The AFI FRA PMT achievements (continued)

Roadmap, F2F workshop in Mauritius (25-28 October 2022):

- Review of the **level of preparedness** at regional level, setting implementation target date as guided by **the road map** and **sharing lesson learned** from pioneers states/organization

FRA Safety Assessment workshop :

Excel spreadsheet template with some examples (27 February –2 March 2023, virtual)

➤ Templates

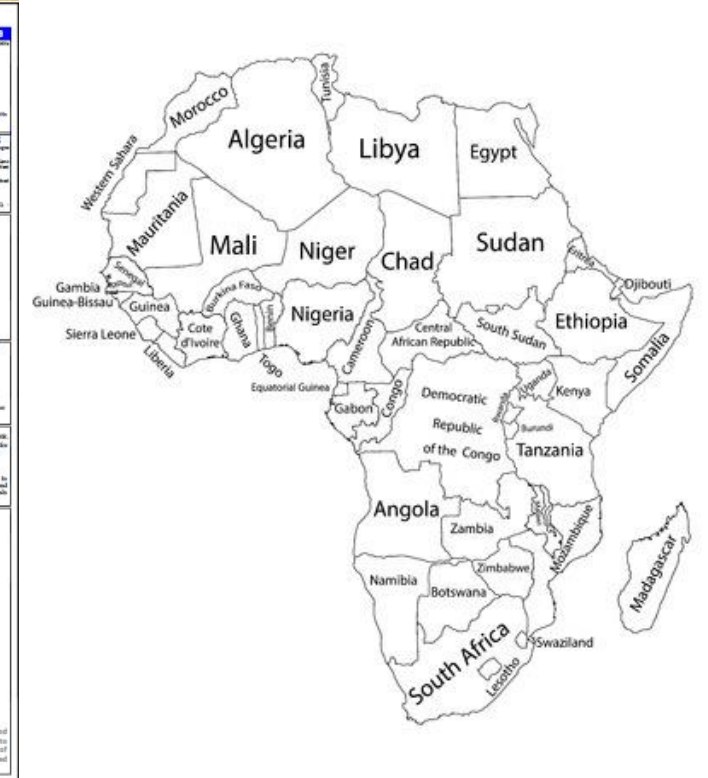
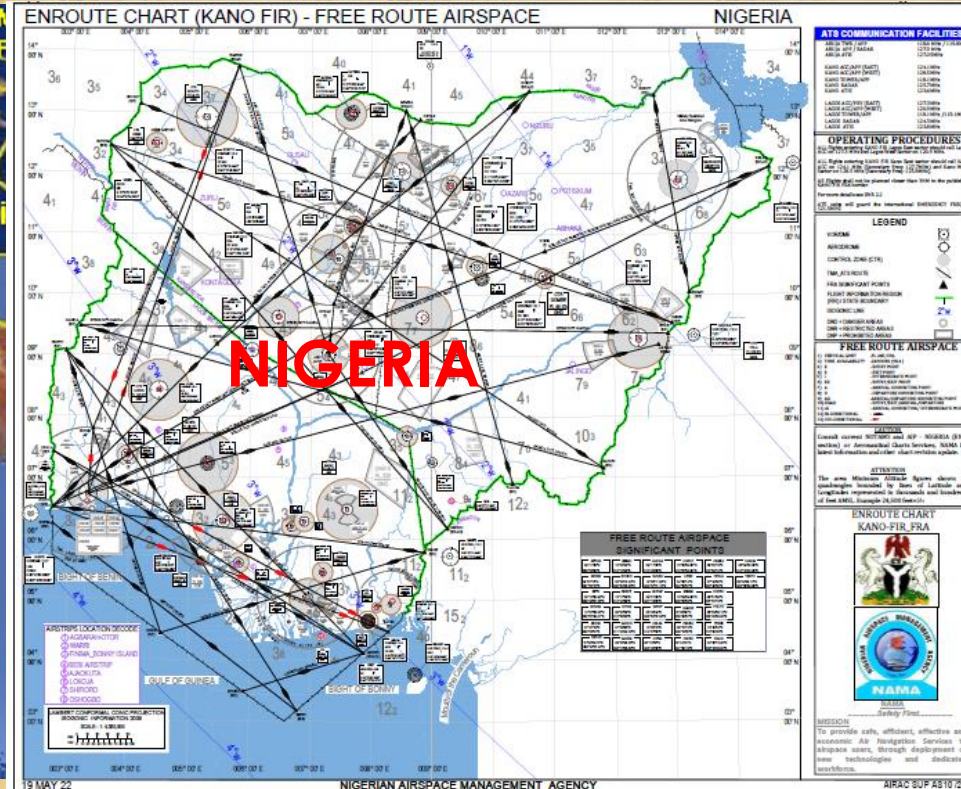
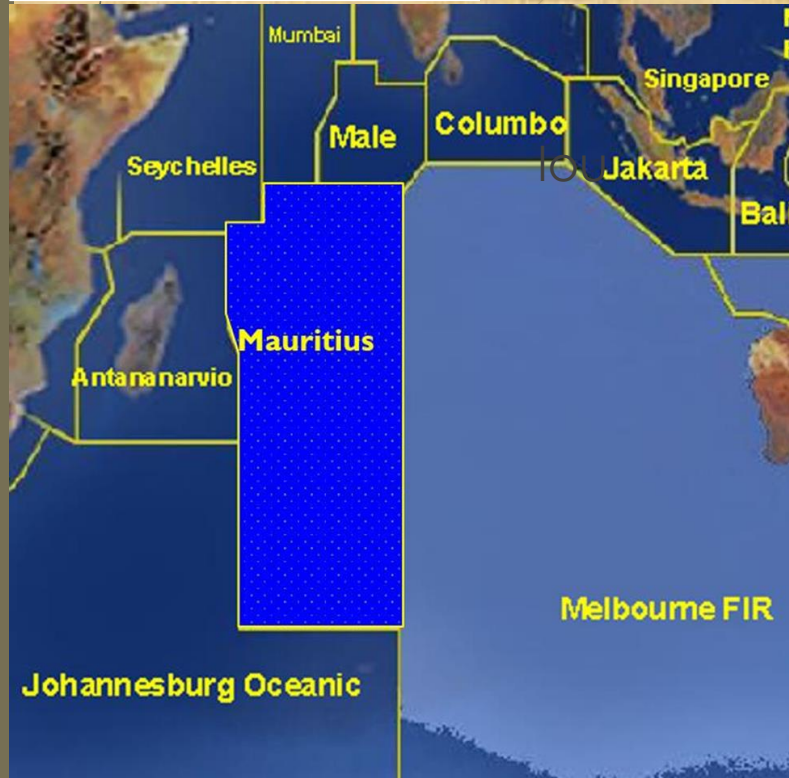
- Readiness data collection checklist / form
- Flight plannable direct AIC Template
- FRA AIRAC AIP/SUP and KPI examples

- Close collaboration with all related stake holders and pioneers (IATA, Eurocontrol, CANSO, FRAA, States, Airlines, ANSPs, etc.)





AFI FRA states' achievements



MAURITIUS FRA Trial, experience gained from previous UPR implementation, sensitization at state level, safety assessment ok, implementation in a portion of its FIR, mostly oceanic

NIGERIA FRA study case, incremental process, all stake holders involved since inception, focussing on requests made gradually by AOs, implementing in the entire FIR, continental

Other AFI region FIRs (ASECNA's, UGANDA, DRC, KENYA, ACCRA, TANZANIA) have implemented DRO. Safety assessment done or in progress as well.



FRA CONCEPT DEFINITION

- A **specified airspace** within which users may freely **plan a route between a defined entry point and a defined exit point**, with the possibility to route via intermediate (published or unpublished) way points, **without reference to the ATS route network**, subject to airspace availability.
- Free Route operations enable airspace users to fly as closely as possible to their preferred trajectory **without being constrained by fixed route networks or structures**. In an FRA airspace, all fixed route networks can be removed.
- Flights remain subject to air traffic control.
- Active airspace reservations are crossed or avoided depending on the degree of coordination (including civil/military coordination) and the status of the activity in the area.
- It is important to note the difference between “Direct Routing Operations” (DRO) and “Free Route airspace” (FRA) operations.
- Direct Route Operations will precede the implementation of Free Route Airspace.



FRA SIGNIFICANT POINTS

A navigation point has one or more roles in the FRA air space:

Role	Description	Usage
"E"	Entry point	For entering the free route airspace
"X"	Exit point	For exiting the free route airspace
"I"	Intermediate point	For flight level/direction changes
"D"	Aerodrome Departure Point	at the end of SID or at departure aerodrome
"A"	Aerodrome Arrival Point	at the start of STAR or at arrival aerodrome

in a given FRA space, the flight path will be :

Overflight:	$E \Rightarrow I^* \Rightarrow X$
From external FRA to a an aerodrome under FRA:	$E \Rightarrow I^* \Rightarrow A$
From an aerodrome under FRA to the outside:	$D \Rightarrow I^* \Rightarrow X$
Flight linking two aerodromes under FRA :	$D \Rightarrow I^* \Rightarrow A$

* as needed, one or more

Ex FRA point : OPERO(EX), PISPA(I)

Possible Role combination

EX, AD, (EXAD to be discussed) ,...

FRA points founded on 5LNC and NAVAIDs coding

FRA is based on very simple procedures derived from the use of DCT



Direct routing operations

➤ **Tactical DCT** : request on radio during flight, if granted by ATC, fuel saved but still carried on board and not converted into a marketable load (pax or cargo.) in flight.

➤ **Plannable DCT** : based on study, granted and published in advance by ANSP, AO can convert the fuel gain into payload.

OPS	TYPE	COMMENT
TACTICAL DCT	LOCAL	FRA PMT encourages to move to plannable directs
	CROSS-BORDER	Not encouraged at this stage, coordination required with adjacent FIR
PLANNABLE DCT	LOCAL	AIC/AIP SUP being issued by States/FIR; repository of plannable DCT being prepared,
	CROSS-BORDER	Not a focus at this stage, coordination required with adjacent FIR and LoPs will need to be revised, has linkage with PBN route implementation or DCT trials
FRA	LOCAL	Current focus of FRA PMT : state level, some planning implementation by December 2023
	CROSS-BORDER	At regional level, more benefits, future steps, enhanced coordination



FRA benefits to airspace users

States or Regions that have developed and successfully implemented FRA concept of operations have demonstrated that there are clear benefits to airspace users as well as improvement of airspace utilization. The overall benefits are : reduced flight time, fuel consumption and CO2 emissions.

The slide features a blue header with the NAV Portugal, E.R.E. logo and flight information: R20460, A0454, 338 27, TCVE09, 1149240, 361 11, and CSADF, 011-015, 071 00. The main content is white with orange text: 'FRAL project', 'Free Route Airspace', and 'LISBOA FIR'. At the bottom, there is another NAV Portugal, E.R.E. logo, the text 'Vanda Cruz MAR 2011', and two circular logos for 'Lapcer' and 'E-Net'.

Testimony from Lisboa FIR :

"On the 7th of May 2010, the Free Route Airspace concept in Lisbon FIR, FRAL project, celebrated its first anniversary with the satisfactory recognition from the airspace user's community in favor of the success of the project. After this first year it can be concluded:

- FRA was founded in a simply and basic number of general procedures;
- No new technical equipment was required, just basic RNAV capability;
- Simplicity has facilitated the success in the execution of the flight planning;...
- Efficiency and flexibility were most appreciated by airline operators;....
- Huge benefits can be obtained for AO's (>1 million NM, >8.000 Tons fuel, >27.000 Tons CO2)."



FRA Connection with lower airspace ATS fixed route Network

- **The inter connectivity between FRA and the underlying fixed ATS route network shall be ensured through the availability of a set of waypoints taking into account the various climbing and descending profiles**
- **The publication of extended SIDs/STARs or published connecting ATS routes are also operationally recommended options.**
- **Access to/from Terminal Airspace will need to be considered and appropriate refinements to TMA structures initiated.**
- **This may include the definition of additional SIDs/STARs to permit more flexibility.**

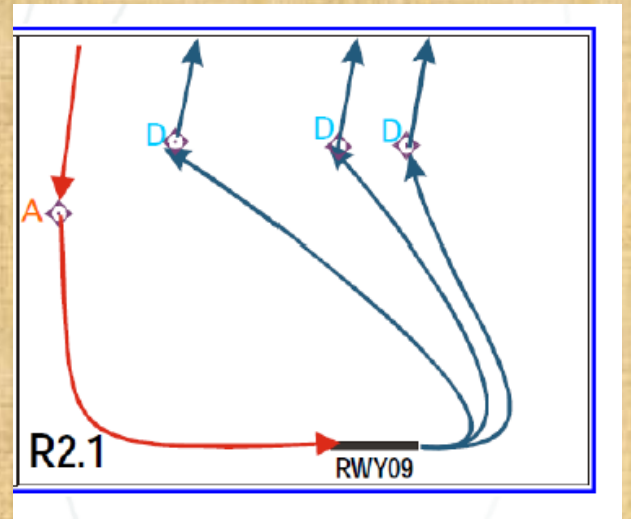
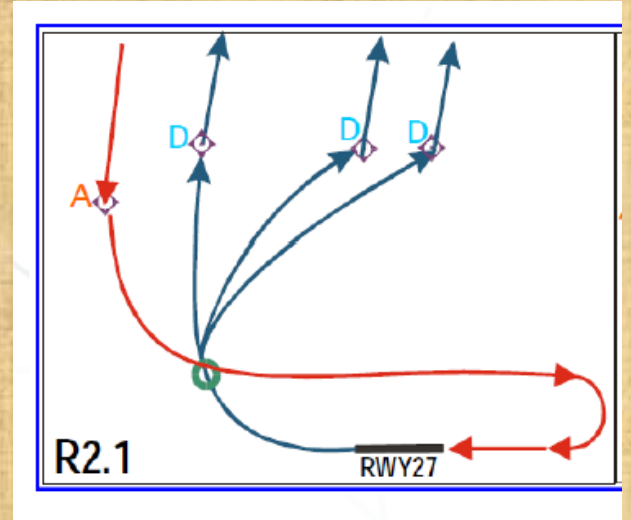


Refining fixed ATS route network

Some fixed routes requested by airlines are no longer used, it is important to review and clean up the fixed route network.

To maximize the efficiency of FRA and to ensure safe and efficient transfer of flight, all efforts need to be made to ensure any required realignment of the fixed ATS route network in adjacent airspace (such as lower airspace) not applying FRA

Wherever a fixed ATS route network will remain in operation below the FRA, this underlying ATS route network shall be refined and coordinated at network level to take into account the needs of free route operations in the airspace above.





RNAV AND RNP SPECIFICATIONS

Doc 9613 Part / Chapter	Navigation Specification	Phase of flight							
		En-route oceanic/ remote	En-route continental	Arrival	Approach				DEP
					Initial	Inter-mediate	Final	Missed ¹	
B Ch.1	RNAV 10	10							
B Ch.2	RNAV 5²		5	5					
B Ch.3	RNAV 2		2	2					2
B Ch.3	RNAV 1		1	1	1	1		1	1
C Ch.1	RNP 4	4							
C Ch.2	RNP 2	2	2						
C Ch.3	RNP 1³			1	1	1		1	1
C Ch.4	RNP avanced	2⁵	2 or 1	1	1	1	0,3	1	1
C Ch.5	RNP APCH⁶				1	1	0,3⁷	1	
C Ch.6	RNP AR APCH				1-0,1	1-0,1	0,3-0,1	1-0,1	
C Ch.7	RNP 0.3⁸		0.3	0,3	0,3	0,3		0,3	0,3



PBN compared to FRA

PBN : NAVIGATION METHOD

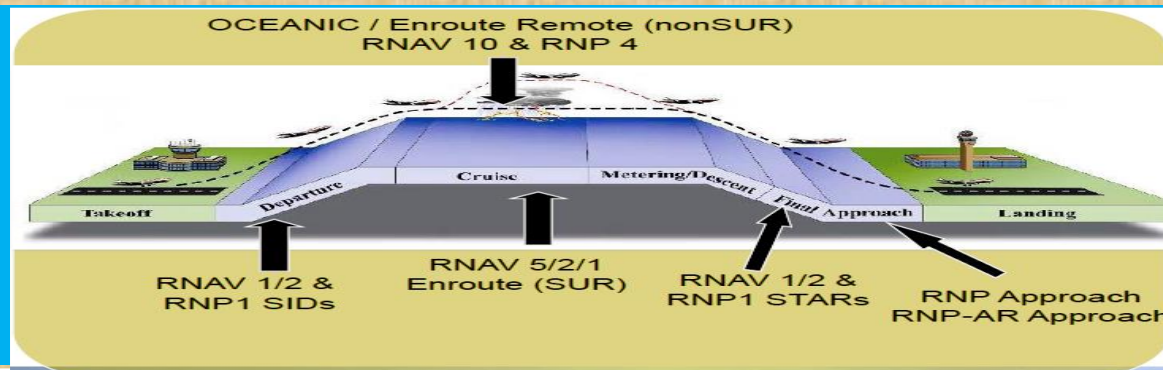
- Navaid Infrastructure, Navigation application, Navigation specification
- Waypoints
- Fixed route network
- Path terminators
- Fly by / fly over
- Offset
- PBN implementations is currently based on both RNAV and RNP specifications, (RNAV10 in AFI or RNAV5)
- Future development of PBN will focus on RNP specifications under (FRTO-B1/2)
- RNAV/RNP specification impact on path/trajectory spacing, buffers or protection areas(primary and secondary)

FRA : AIRSPACE

- CNS infrastructure/ATM tools and procedures
- Airspace organization
- ENTRY / EXIT POINTS/INTERMEDIATE POINTS
- ARRIVAL / DEPARTURE CONNECTING POINTS
- DIRECT TACTICAL AND DIRECT PLANNABLE (DCT)
- FLEXIBLE USE OF AIRSPACE (FUA)
- LOCAL (STATE/FIR) FRA AND CROSS BORDER FRA
- COORDINATION WITH NEIGHBORING STATES and LOA UPDATES
- The available entry and exit points must be published in official documentation such as the AIP.
- Path spacing take into account ATC surveillance



ASBU PBN MODULES UNDER APTA AND FRTO



PBN UNDER APTA ELEMENTS

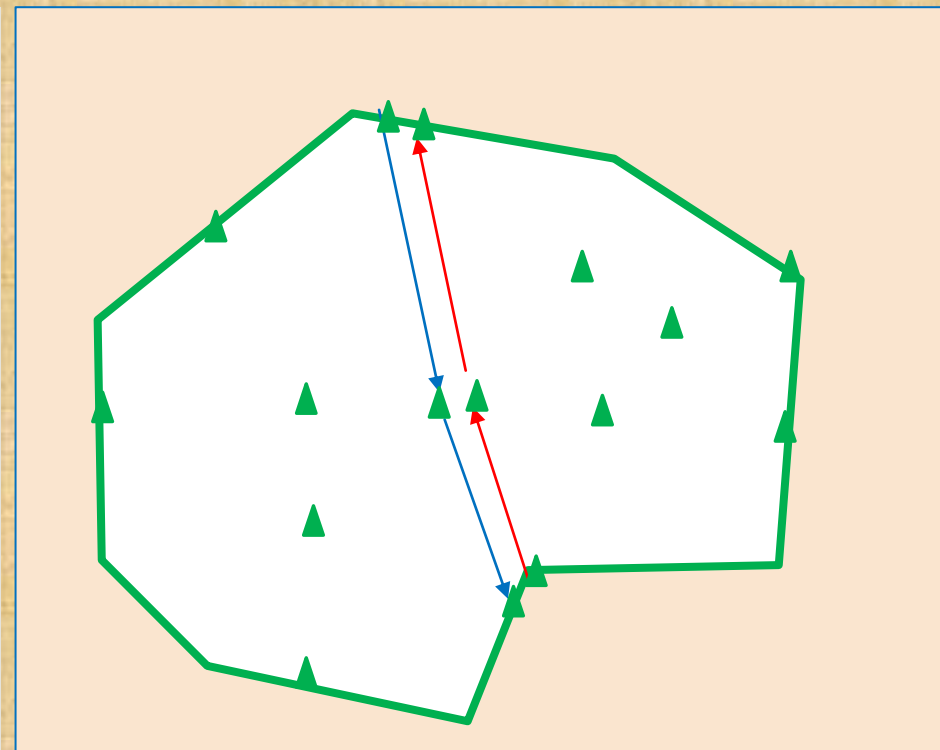
PBN UNDER FRTO ELEMENTS

APTA-B0/1	PBN Approaches (with basic capabilities)	FRTO-B0/1	Direct routing (DCT)
APTA-B0/2	PBN SID and STAR procedures (with basic capabilities)	FRTO-B1/1	Free Route Airspace (FRA)
APTA-B0/3	SBAS/GBAS CAT I precision approach procedures	FRTO-B1/2	Required Navigation Performance (RNP) routes
APTA-B0/4	CDO (Basic)		
APTA-B0/5	CCO (Basic)		
.....		



FRTO-B1/2 Required Navigation Performance (RNP) routes

- RNP routes should be deployed within en-route airspace where Free Route Airspace (FRA) is not planned or if FRA is deployed the RNP routes should ensure the connectivity between FRA and TMAs.
- The objective is to provide consistent navigation using the most appropriate PBN type, infrastructure and navigation applications
- Performance-based navigation (PBN) specifications allow aircraft to fly a specific path between two 3D-defined points in space. The new capability refers to the Implementation of PBN/RNP routes within en-route airspace.
- With the introduction of a RNP navigation specification, the advantages gained from RNAV will be further enhanced by on-board performance monitoring and alerting and the execution of more predictable aircraft behavior.
- Design of optimized routes which may include closely spaced parallel routes, Fixed Radius Transition (FRT) and Tactical Parallel Offset (TPO) functionality in en-route, supported by infrastructure and system improvements to support PBN routes.



FURTHER STEPS

An example of two (2) unidirectional RNP 2 routes spaced by 15 NM.



Optimizing the ATS route structure

APIRG Conclusion 24/14

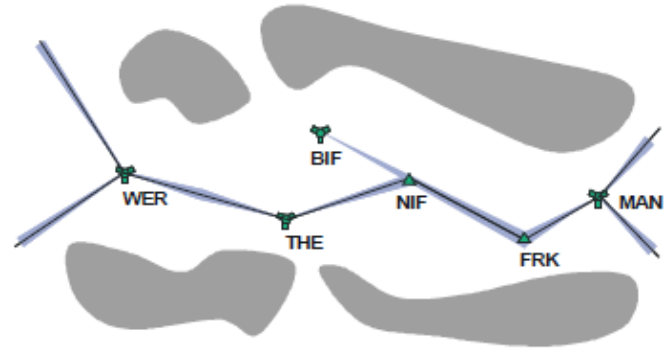
That;

In order to optimize the ATS route structure in the AFI En-route airspace and foster the harmonized implementation of the RNAV/5, RNP/4, and RNP/2:

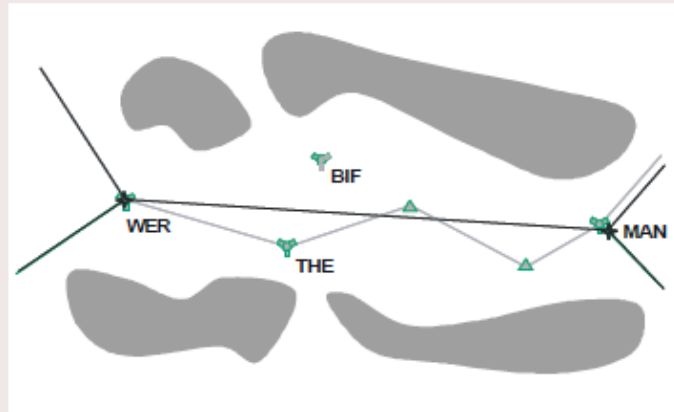
- a. States/ANSPs, IATA and AFRAA to collaborate and conduct a survey of aircraft equipage in the AFI region to facilitate RNAV/5, RNP/2 and RNP/4 planning decisions by 31 March 2022;**
- b. States in coordination with ICAO, IATA, AFRAA and the AFPP identify trunk routes connecting major city pairs in the upper airspace and transit to/from aerodromes for RNAV/5, RNP/2 and RNP/4 implementation by 31 October 2022;**
- c. ICAO Regional Offices and AFPP conduct a workshop by end of June 2022 on RNAV/5, RNP/2 and RNP/4 airspace concept design and assist States in developing capacity for required RNP regulatory approvals and in the implementation activities, for a safe and timely RNP implementation in the AFI**



PBN and DRO under FRA

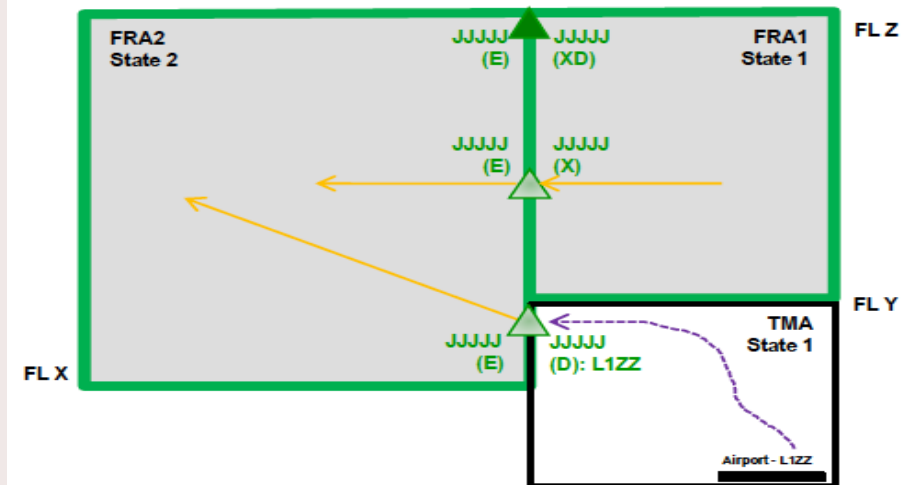
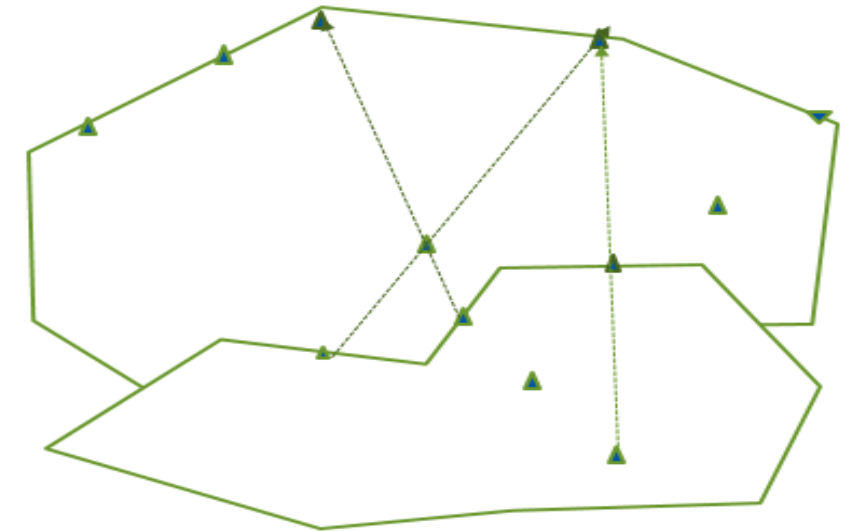


Conventional Navigation overhead or intersections



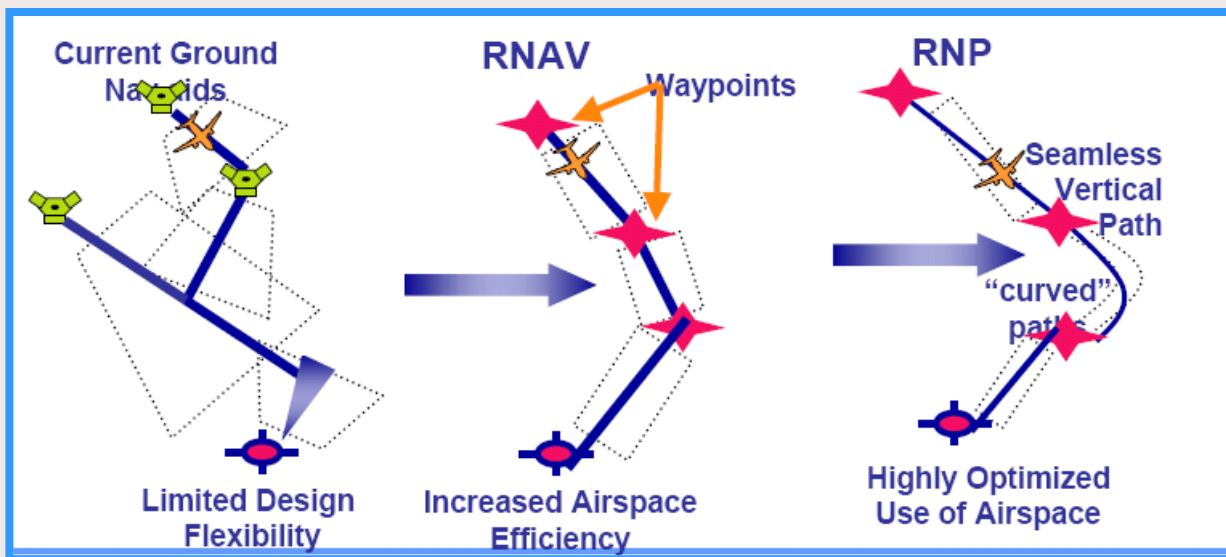
Area Navigation waypoint to waypoint

- ICAO GANP ASBU requirement Block 01
- Establishment of Significant Points
 - Entry Points (E), Exit Points (X), and Intermediate Points (I)
 - Arrival / Departure Connecting Points (A) / (D) / (AD)
- Fixed ATS Route Network may be removed (or improved to fit) in Free Route Airspace (FRA)
- Flight Level Orientation Scheme (FLOS) compliance
- FRA Connecting Routes will increase efficiency

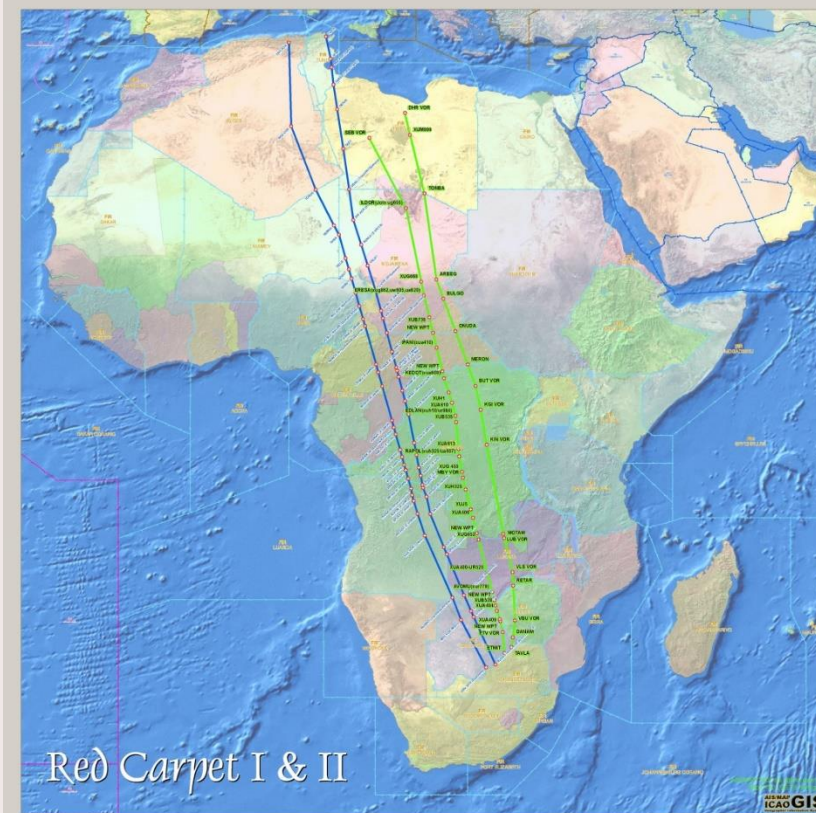




PBN Routes as a precursor to FRA



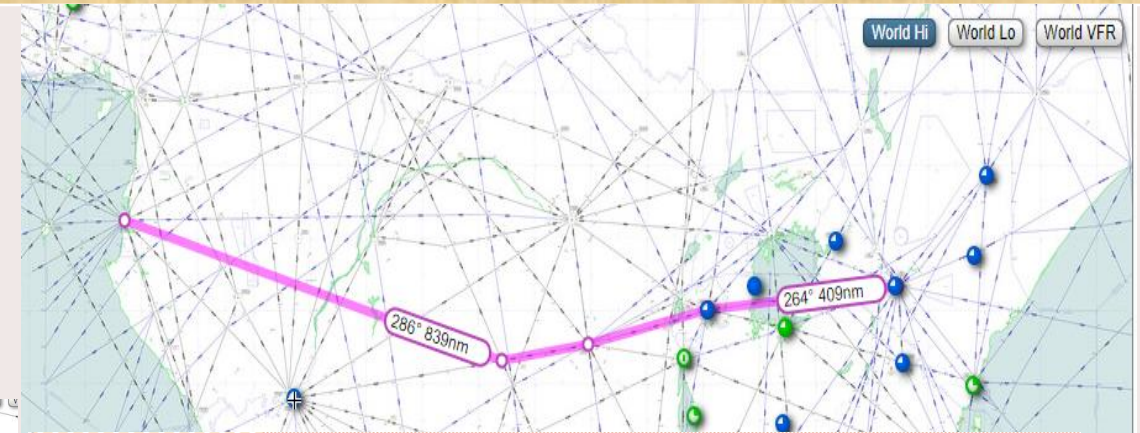
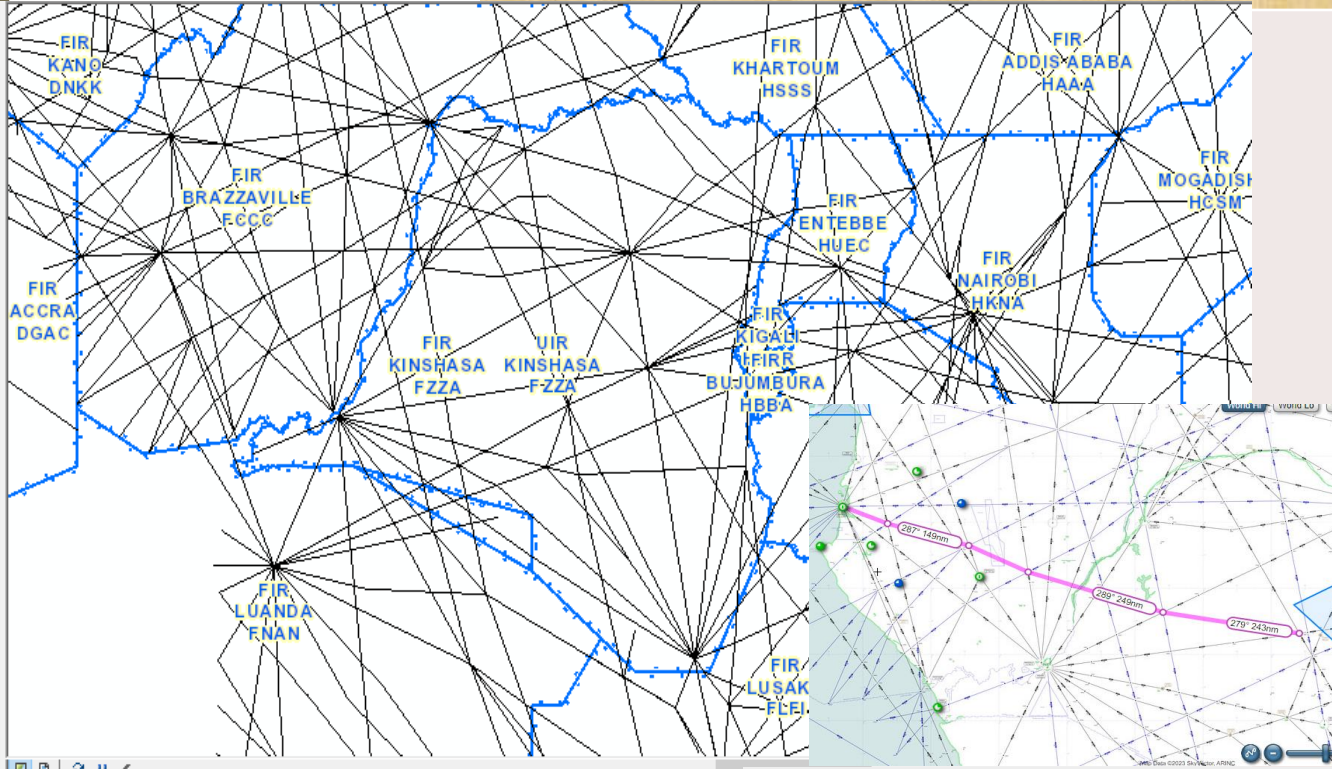
Equipped with both **Flight Management System (FMS) on-board aircraft** and **satellite-based navigation system**, pilots can now navigate through a **user preferred route trajectory (UPR)** without reference to ground systems under the performance-based navigation (PBN) criteria and within a level of precision that was not available before.



- 4 RNAV bi-directional routes in continental space :
- **UM731,UM998 (Red Carpet I)**
 - **UM214,UM215 (Red Carpet II)**



PBN Routes as a precursor to FRA



WP	LAT	LONG	DM	COMMENT
PISPA	S03° 21' 54.00"	E022° 49' 42.00"	0.9E	X UA607, UA613
WP1	S02°24'43.08"	E019°27'48.21"		X UB535
WP2	S02°12'00.98"	E018°43'15.15"		X UM731
WP3	S01°44'47.74"	E017°08'04.96"		X UV30
WP4	S01°42'10.50"	E016°58'56.37"		X UM998
WP5	S01°36'04.73"	E016°37'40.87"		X FIR FZZA FCCC
WP6	S01°30'26.47"	E016°18'02.02"		X UA410
WP7	S01°16'23.90"	E015°29'08.81"		X UA403
WP8	S01°14'18.92"	E015°21'53.67"		X UQ580
WP9	S01°04'28.31"	E014°47'40.38"		X UG727
WP10	S00°37'53.12"	E013°15'20.83"		X UT419
WP11	S00°34'36.73"	E013°03'59.31"		X UR986
WP12	S00°27'38.39"	E012°39'48.17"		X UA604
WP13	S00°12'54.08"	E011°48'41.33"		X LV UTA
WP14	N00°03'20.67"	E010°52'22.05"		X UQ582
WP15	N00°06'32.34"	E010°41'17.50"		X UG861
LV	N00° 28' 47.45"	E009° 24' 07.14"	1.1° W	LV

Options :

- Straight DCT (multiple crossings)?
- Direct segment through existing points?
- FRA with entry/Exit/intermediate point without constraint of existing route network?

➔ PISPA ➔ ILDIV ➔ IKSOR ➔ LIPER ➔ AYELA ➔ LV



FRA PMT TODAY'S FOCUS

- **Updating roadmap within the clusters and then at regional level**
- **Foster DCT plannable implementation as a precursor to FRA**
- **City pairs linkages under PBN as a precursor to FRA**
- **Conduct safety assessment**
- **Local FRA implementation as a priority**
- **Refining and realining ATS route network when necessary for connexion to FRA**
- **FRA PMT open to the support offered by Eurocontrol, CANSO, etc.**
- **FRA PMT always ready to provide support in the context of “No country left behind”**
- **Saving distance, time and fuel thus protecting our environment.**



AFI FRA FAQ

Questions	Answers
Intermediate points every 200NM?	Doc4444, recommended practice for DCT, local procedures to specify
FRA and Nav Specification?	No nav specification defined, even basic RVAV can do
FRA a/c approval required?	No, current navigation capability fits.
FRA horizontal boundary same as FIR boundary?	Not necessarily, same FIR can comprise 1 or more FRAs
Conflict detection becomes harder ?	ATC automation provided with conflict detection tools, further training if needed
Congestion at EX points?	Good coordination required
Point beyond FIR for automated ATS coordination?	Insert a published FRA significant point beyond in FPL



AFI FRA FAQ



Questions?

Comments?

Thank you.