Preface

Integrating all of the standard and practical use of Area Navigation (RNAV) and Required Navigation Performance (RNP) operation around the world, International Civil Aviation organization (ICAO) presents a new operational concept as Performance Based Navigation (PBN). PBN concept represents a drift from sensor based to performance based navigation. Utilizing advanced on-board navigation equipage with satellite navigation, PBN promotes safer and more flexible airspace concept and aircraft operation through all phases of flight.

As the State exits between Asian and European continents, Mongolia has over flights from other regions and aircrafts carrying equipments capable of different navigation performance. Mongolia recognizes PBN as the one of the best technology to accommodate their safe and efficient operation. Knowing that Mongolia has bigger airspace rational to its ground navigation aids and lacks of space and ground based satellite system, transition to PBN is more challenging and requires greater amount of time and careful examination. The Civil Aviation Authority of Mongolia (MCAA) prompts any necessary actions to introduce PBN in accordance with ICAO Asia Pacific Regional PBN Implementation Plan.

Derived from dedicated labor of PBN national implementation team work, this document states the policies and implementation plan of Mongolia concerning PBN until 2025. As long as it is considered guidance to stakeholders and international operators anyone within aviation community is welcome to promote comments to improve this document.

Director S. Batmunkh

Civil Aviation Authority of Mongolia

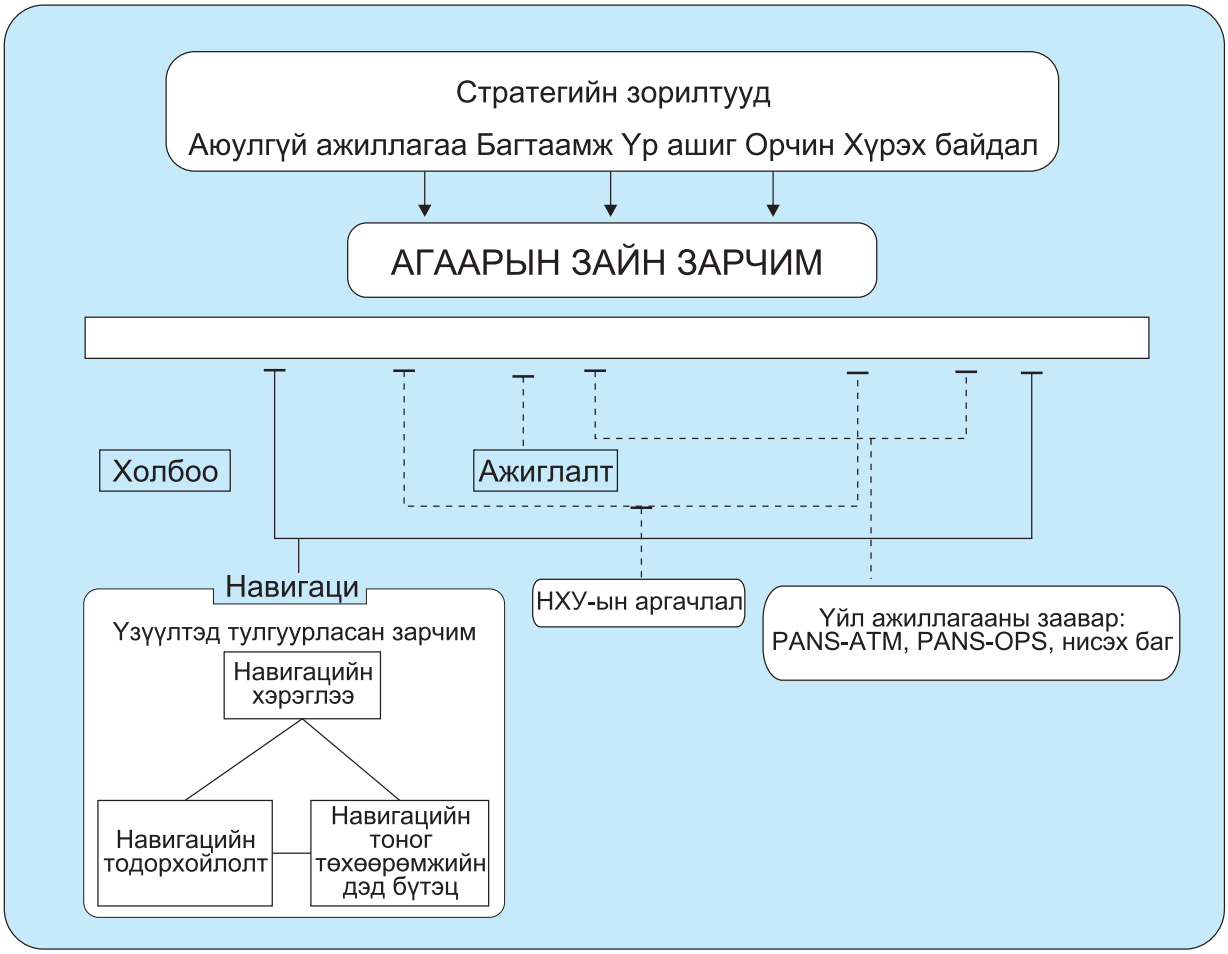
Contents

PBN Concept

In conventional navigation aircraft is guided by ground navigation aids and airspace concept is bound to ground infrastructure and route is designed from one facility to another. Introduction of Area Navigation (RNAV) enabled aircraft to fly less dependent from ground based navigation aids. With RNAV concept, flexible airspace design became possible. As the on-board equipment advanced, aircraft became capable of monitoring and alerting its performance, the Required Navigation Performance (RNP) concept evolved from RNAV.

PBN emerged combining advantage of RNAV and RNP specifications and refers performance requirements in terms of accuracy, integrity, availability, continuity and functionality for aircraft operating under instrument flight rule or in designated airspace. PBN concept represents a drift from sensor based to performance based navigation.

As navigation is one of several enablers of airspace concept, Communications, ATS Surveillance and ATM are also considered.



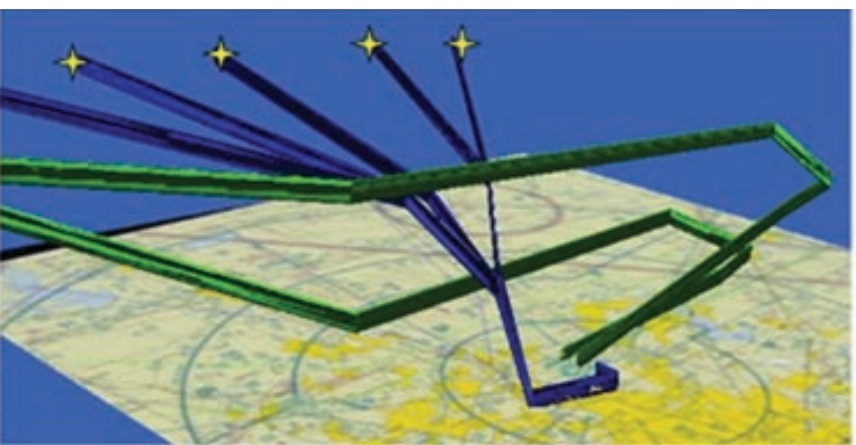
Үзүүлэлтэд тулгуурласан навигаци ба агаарын зайн зарчмын хамаарал

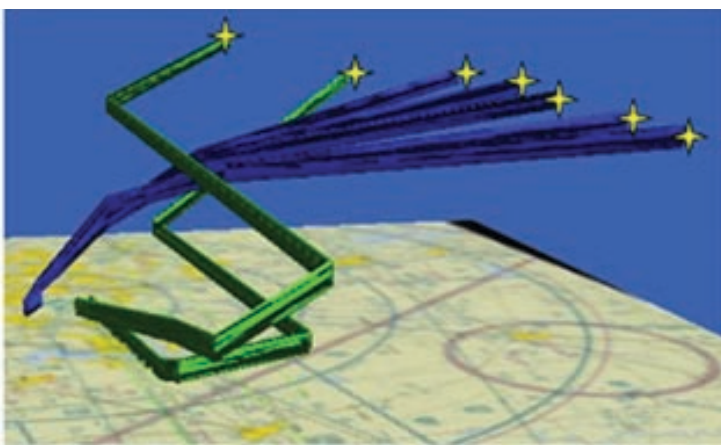
PBN operation has three core components: the navigation application, the navigation specification and the navaid infrastructure. Choosing *navigation specification* regarding CNS/ATM *infrastructure* and fleet readiness *navigation application* is derived.

Benefits of PBN

PBN concept offers more efficient design of airspace and instrument flight procedures and Implementation of PBN will:

- Increase airspace capacity by reducing lateral and longitudinal separation between aircrafts;
- Reduce the risk of controlled flight into terrain through the implementation of continuous and stabilized descent procedures using vertical guidance;
- Improve airport and airspace access in all weather conditions and increase stable flight timetable;
- Increase airspace capacity in terminal area through implementation of additional parallel routes and fixes;
- Decrease controller and pilot workload by applying PBN operation and reduce needs for air ground communication and radar vectoring;
- Result in global harmonization by facilitating RNAV/RNP criteria for all stakeholders and aviation community;
- Decrease fuel consumption and greenhouse gases by straightening conventional routes, and reduce environmental impact by avoiding populated areas;
- Reduce operational cost for maintaining and flight inspection of conventional navigation aids.





ICAO Requirement

In its 36th Session held in September 2007 the ICAO Assembly:

1. *Urged* all States to implement RNAV and RNP air traffic services (ATS) routes and approach procedures in accordance with the ICAO PBN concept laid down in the *Performance Based Navigation Manual* (Doc 9613);

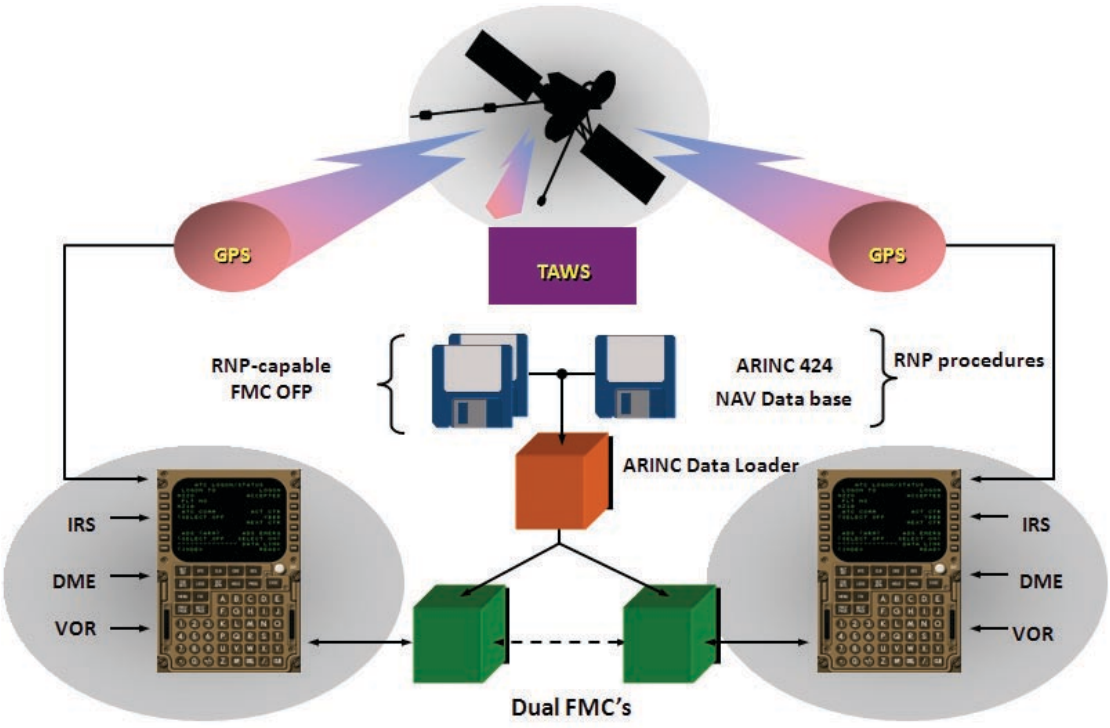
2. Resolved that:

a. States and planning and implementation regional groups (PIRGs) complete a PBN implementation plan by 2009 to achieve:

- implementation of RNAV and RNP operations (where required) for en route and terminal areas according to established timelines and intermediate milestones; and

- implementation of approach procedures with vertical guidance (APV) (Baro- VNAV and/or augmented GNSS) for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014; and

b. *Urged* that States include in their PBN implementation plan provisions for implementation of approach procedures with vertical guidance (APV) to all runway ends serving aircraft with a maximum certificated take-off mass of 5700kg or more, according to established timelines and intermediate milestones;



APAC Regional PBN Implementation Plan

Adopting Assembly Resolution A36/23 Asia/Pacific PBN Implementing plan Version 1.0 was produced and promulgated in September 2009 at APANPIRG20 meeting.

Summary table & Implementation targets

Short Term (2008-2013)*		
Airspace Preferred	**Nav. Specifications**	**Acceptable Nav. Specifications**
Route – Oceanic	RNP 4	RNAV 10
Route – Remote continental	RNP 4	RNAV 10
Route – Continental en-route	RNAV 2, RNAV 5	
TMA – Arrival	RNAV 1 in radar environment and with adequate navigation infrastructure. Basic-RNP 1 in non-radar environment.	
TMA – Departure	RNAV 1 in radar environment and with adequate navigation infrastructure. Basic-RNP 1 in non-radar environment	
Approach	RNP APCH with Baro-VNAV in most possible airports RNP AR APCH in airport where there are obvious operational benefits.	

Implementation Targets

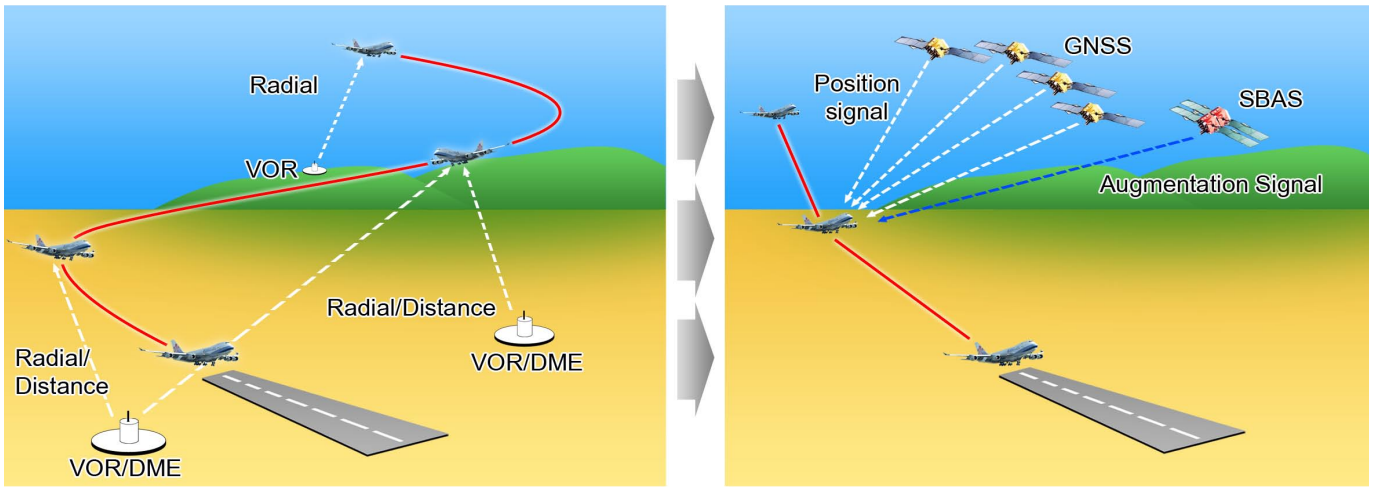
- RNP APCH (with Baro-VNAV) in 30% of instrument runways by 2010 and 50% by 2012 and priority should be given to airports with operational benefits
- RNAV 1 SID/STAR for 50% of international airports by 2010 and 75% by 2012 and priority should be given to airports with RNP Approach
- Re-defining existing RNAV/RNP routes into PBN navigation specification by 2012
- Implementation of additional RNAV/RNP routes

Medium Term (2013-2016)*		
Airspace Preferred	**Nav. Specifications**	**Acceptable Nav. Specifications**
Route – Oceanic	RNP2**, RNP4	RNAV10
Route – Remote continental	RNP2	RNAV2, RNP4, RNAV10
Route – Continental en-route	RNAV1, RNP2	RNAV2, RNAV5
TMA – Arrival	Expand RNAV1 or RNP1 Application Mandate RNAV1 or RNP1 approval for aircraft operating in higher air traffic density TMAs	
TMA – Departure	Expand RNAV1 or RNP1 Application Mandate RNAV1 or RNP1 approval for aircraft operating in higher air traffic density TMAs	
Approach	Expansion of RNP APCH (with Baro-VNAV) and APV Expansion of RNP AR APCH where there are operational benefits Introduction of landing capability using GNSS and its augmentations	

Implementation Targets

- RNP APCH with Baro-VNAV or APV in 100% of instrument runways by 2016
- RNAV1 or RNP1 SID/STAR for 100% of international airports by 2016
- RNAV1 or RNP1 SID/STAR for 70% of busy domestic airports where there are operational benefits
- Implementation of additional RNAV/RNP routes

Conventional navigation *to* *PBN*



PBN National Team

Recognizing importance, scope and benefits of PBN implementation, the Civil Aviation Authority of Mongolia (MCAA) has formed National PBN implementation team including airspace designer, procedure designer, air traffic controller, pilot and airworthiness inspector. The team is assigned to produce national PBN implementation plan in accordance with Asia/Pacific regional PBN Implementation Plan.

The PBN team has four main functions regarding for implementation of performance based navigation procedures in Mongolian airspace. These functions are in sequence and as follows:

- Conduct surveys regarding operational readiness
- Formulate policy & issue implementation action plan
- Promulgate regulation and standards
- Aid communication

Conduct surveys regarding operational readiness

In this planning phase the team is responsible for assessing ATC workload and fleet capabilities and CNS infrastructure operating within the designated airspace and consult stakeholders.

Formulate policy & issue implementation action plan

In this phase team is responsible for updating implementation plan and developing action plans considering safety and efficiency, and submitting any recommendation effecting aviation policy to management for approval. The team must consider revised navigation strategy for the Asia/Pacific region.

Promulgate regulation and standards

The team is responsible for identify and establishing standard and procedures for PBN implementation activities in accordance with regional standard and practices. Studying ICAO SARP concerning GNSS status monitoring, flight validation, RNAV/RNP separation standards, airworthiness and operational approval of PBN operation, the team is obliged to propose all necessary amendments to MCAR-Mongolian civil aviation rules.

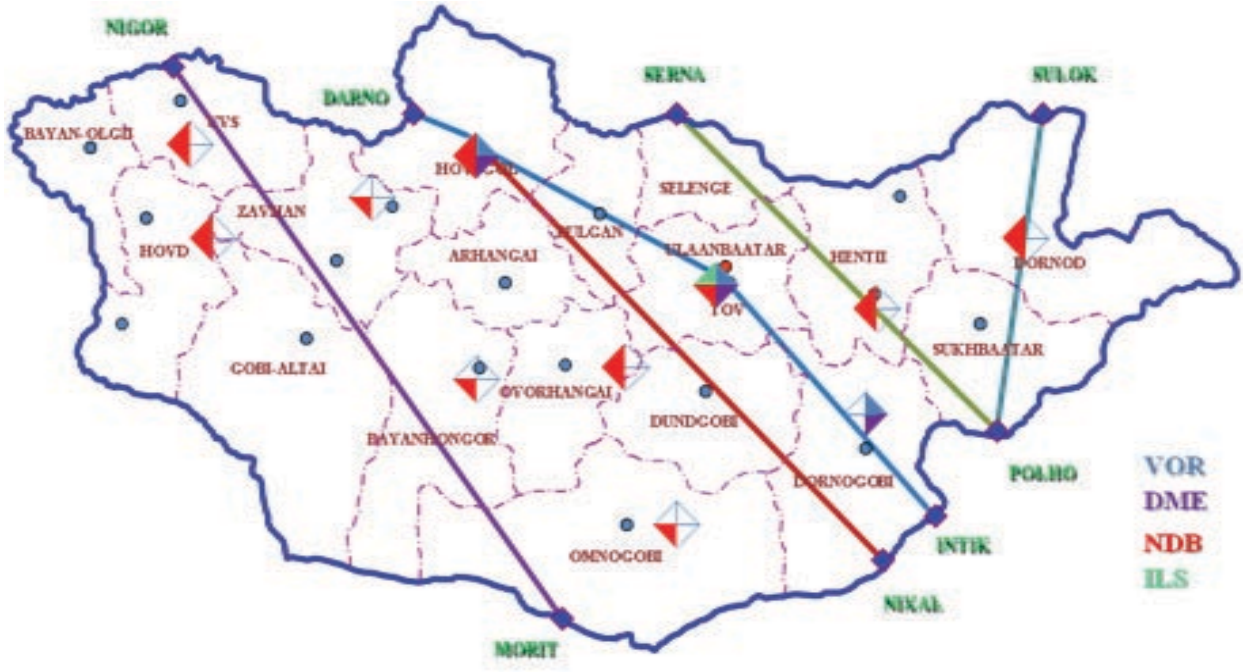
Aid communications

As the Implementation of PBN affects safety policy of flight operation, the team is responsible for promoting guidance materials and information relating PBN operation to aircraft operators and gather inputs from all stakeholders.

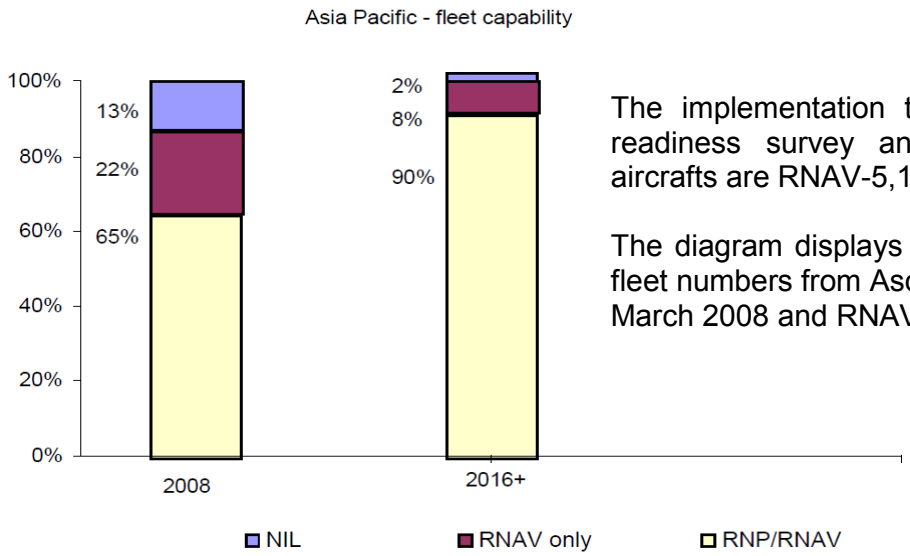
Current Status

2009 traffic & ground navigation aids

The main air traffic is over-flights which 14 times greater than the terminal flights.



Main trunk consists of A575, B208, M520 bearing the more than 75% of all traffic, which lies along from northwest to southeast connecting Europe and Asia.



The implementation team has conducted the fleet readiness survey and recognized that the most aircrafts are RNAV-5,10 and RNP-4 compatible.

The diagram displays a high level analysis based on fleet numbers from Ascend Online Fleets database March 2008 and RNAV/RNP classification by IATA.

En-route

Mongolian all upper routes are conventional except M520, which is the only route that requires navigation performance. As Mongolia has vast territory compared to ground navigation aids it has, the most of domestic routes are defined by RNAV basic GNSS specification as a supplement to those fewer NDB and VOR defined routes. MCAA has purchased and installed 4 new D-VOR/DME to equip main over flight trunks as depicted in figure for support of the MSSR. The transition to radar control would take another 2 or more years, those 4 D-VOR/DME alone are not enough to support RNAV 5 and RNAV1 & 2 operation continuously though main trunk.

Terminal & Approach

Terminal traffic is 5 to 10 ten flights a day at domestic airports, Chinggis khan, the main international airport has 10 to 30 flights a day and its approach and tower controls are not separated yet.

Using combination of two Non Directional Beacon (NDB) for terminal and approach purpose is common. One is for en-route and another for approach. Now MCAA is relocating one of the coupled NDBs to other airports.

In 2001 and 2002 with the assistance of expert from ICAO and Australia MCAA has promulgated 16 RNAV GNSS non precision approach procedures (NPA). Nonetheless their specifications doesn't meet the improved RNP requirement, first of all, MCAA will reconstruct them with basic RNP-1 specification.

Airworthiness and operational approval

Although, operational requirements regarding GNSS and RNP are published in MCAR, some important requirements such as governing the installation of approved RNAV and RNP equipment onboard aircrafts are unclear, and its contents are outdated.

PBN implementation team is responsible for updating PBN related requirements and producing guidance manual and technical standards.

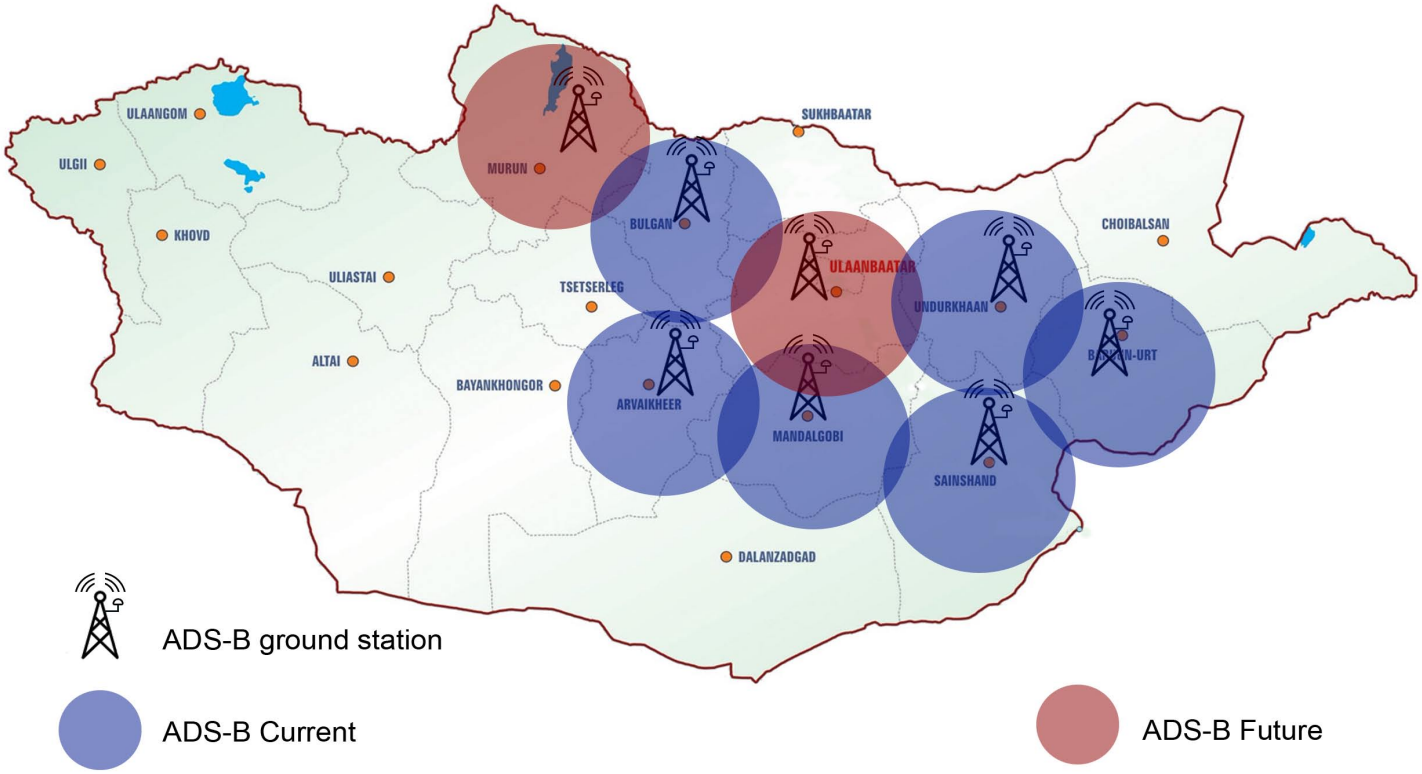
Surveillance

Knowing that the Surveillance is one of the most important enabler of an airspace concept in advanced navigation, MCAA has been taking several attempts regarding Surveillance.

MSSR

MSSR does not entirely rely on GNSS while ADS and MLAT have the potential for a common mode failure.

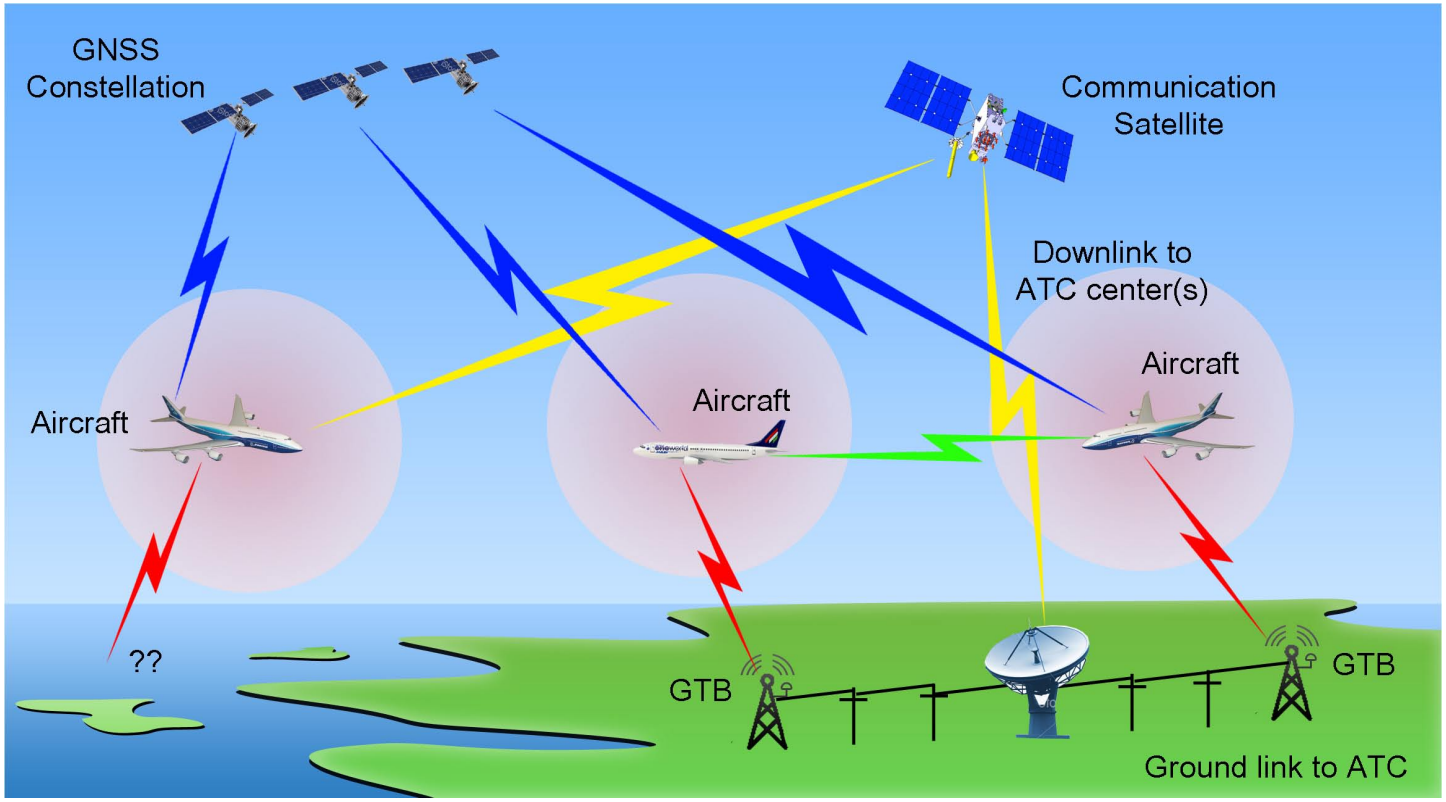
MCAA has installed three Secondary surveillance radar and D-VOR/DME along the main trunk to support the increasing traffic. It is certain that the transition to radar control will take at least another 2 years.



ADS-B

Since operational capabilities supported by ADS-B and MLAT that exceed basic “radar-like” surveillance, and ADS-B could be used as a surveillance tool to achieve a five nautical mile separation standard. MCAA is pursuing a goal regarding ADS-B.

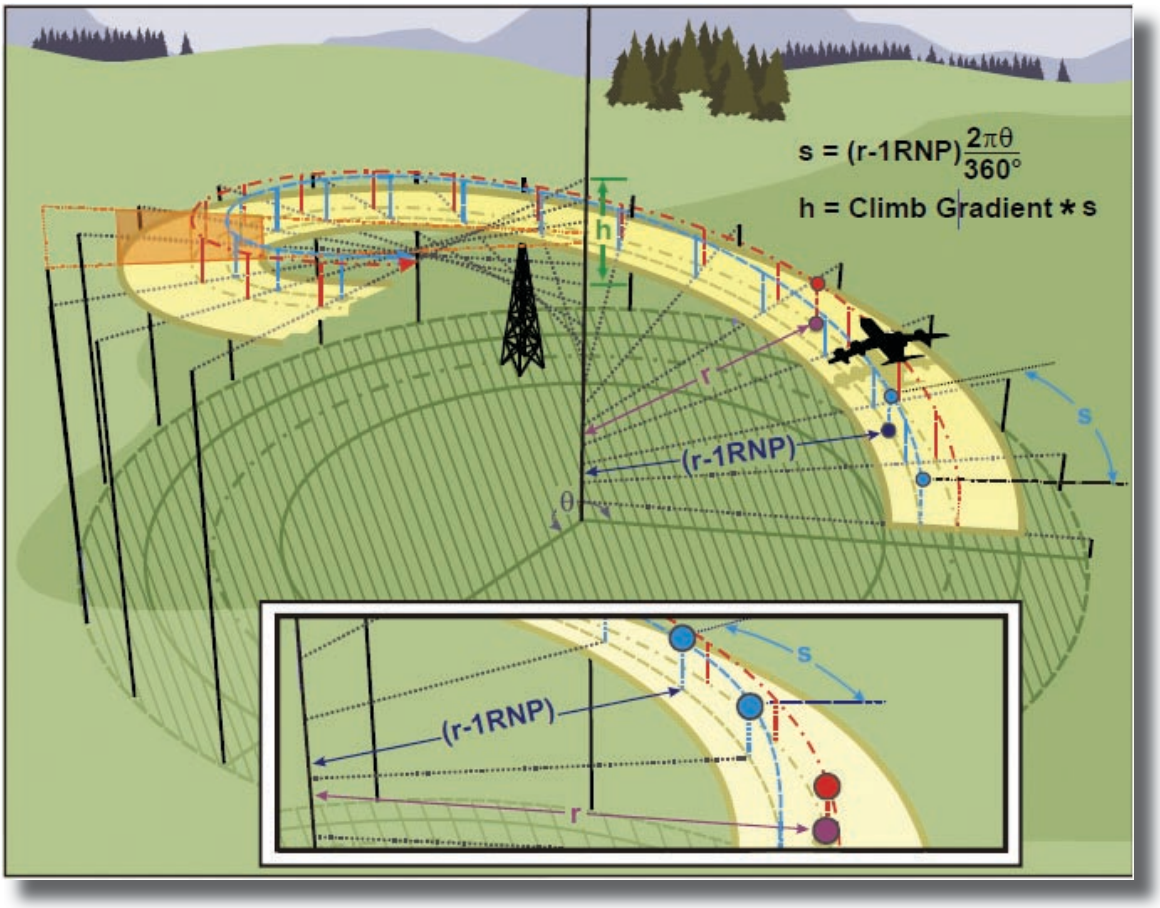
In November 2002, MCAA conducted ADS-B demonstration successfully using 2 ADS-B stations located near Muren and Ulaanbaatar. 2 aircraft equipped with ADS-B transponder were involved one was Mi-8 helicopter and another was An-24.



Procedure design

Recognizing that the instrumental flight procedure design capability is the fundamental element of the successful transition to PBN operation. MCAA has signed to actively participate in Flight Procedure Design Program, hoping to improve its related capability.

Participation to FPP program is deemed to be the best solution for MCAA to introduce safe and applicable PBN procedures.



Flight validation

Finding that flight inspection is costly, and even higher to be conducted by other states, MCAA had formed its own flight inspection team in 1999. During this time IFP has evolved into higher stage and the members had not updated their training, it become obsolete. Regarding APANPIRG Conclusion 20/49, PBN implementation team studied available Flight Inspection equipment on the market and found AT940 portable Flight inspection equipment capable of validating PBN procedures and ADS, Multilateration, SSR and suggested the proposal to MCAA Administrative Committee for approval.

Implementation Plan

The MCAA has planned to implement PBN in three phases, short term(2010-2013), medium term (2013-2016) and long term (2016 and further). Action plans will be developed by PBN implementation regarding actual situation by the implementation team.

Short term (2010-2013)

En-Routes

During 2010-2013, MCAA will consider RNAV(RNP)10 navigation specification for remote routes and RNP4 for main trunk as it has ADS-C coverage. Meanwhile with implementation of adequate Surveillance system (ADS-B & Multilateration) RNAV5 navigation specification should be considered. As VOR has operational and economical disadvantage to DME/DME, RNAV 2 navigation specification must be considered for main trunk.

Terminal

Mongolia is to upgrade Muren Choibalsan, Ulgii and “Gurvansaikhan” airports to International airport during this period. As Muren has D-VOR/DME within its terminal area RNAV5 STAR will be implemented to enhance safety. For the rest, those which don’t have adequate ground navigation aids, Basic RNP1 SID/STAR will be implemented respectively.

Approach

Within this timeline RNP APCH will be implemented for all possible runways. First, RNAV GNSS procedures will be replaced by basic RNP 1 and RNP APCH procedures as appropriate. Meanwhile Baro-VNAV procedures will be considered after successful implementation of RNP APCH procedures accordingly as the ILS system is expensive.

Medium term (2013-2016)

To keep pace with Regional implementation plan Mongolia need formidable CNS infrastructure that’s what we lack today. By this time, 3 MSSR and ADS system expected to be operational, which will let us enjoy its greatness/benefits.

En-Routes

During this period, MCAA will begin replacing RNP4 and RNAV(RNP)10 routes to RNAV2 and RNAV1 respectively. DME will govern as the primary navigation aid.

Terminal

By this time most aerodromes will be under adequate Surveillance coverage. MCAA will mandate RNAV 1 or RNP1 approval for aircraft operating in higher air traffic density.

Approach

Within this period MCAA will complete implementation of Baro-VNAV procedures for all possible runways and mandate it as a primary procedure where there is no ILS.

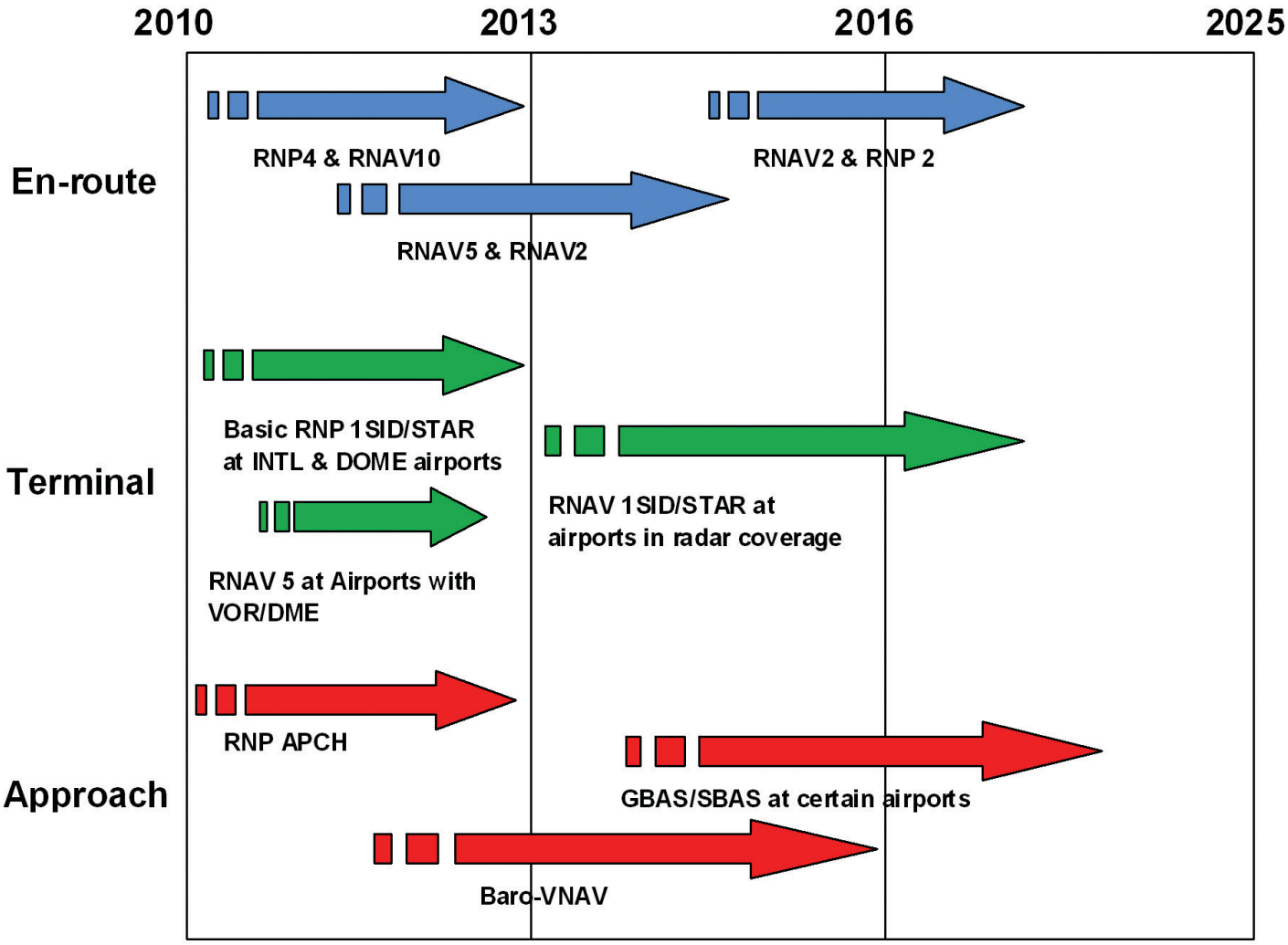
MCAA will consider implementing GBAS procedure at certain airports regarding operational benefits.

Russian Federation has declared to improve their “GLONASS” system, and it will be used for civil purpose by 2015. This system has coverage over Mongolian territory/airspace.

China is developing “Compass” satellite navigation system, which also has coverage over Mongolia although it’s operational dates unclear now.

Long term (2016-2025)

All PBN procedures will be implemented by this time. Co-existing conventional procedures would be extricated and dissolve into PBN. GNSS is expected to be primary navigation infrastructure. And more augmentation systems for satellite navigation are coming. DME would serve as back up for GNSS.



Safety Aspects in Implementation

As implementation of PBN greatly influences flight safety, several steps must be taken before establishing RNAV/RNP procedures. The action plans will be produced by PBN team concerning specific phase of PBN implementation.

These steps include setting enough transition time for operators to equip their aircraft and keep existing conventional navigation aids for certain period of time to allow gradual transition to PBN.

Implementation of PBN shifts balance from ground navigation to satellite navigation, having not enough ground navigation aids and surveillance, Mongolia will rely more on GNSS. Therefore MCAA will work closely with RASMAG to conduct GNSS assessment.

MCAA will intensify her cooperation with adjacent and regional states to increase the continuity of PBN application.

Ground Navigation Infrastructure Strategy

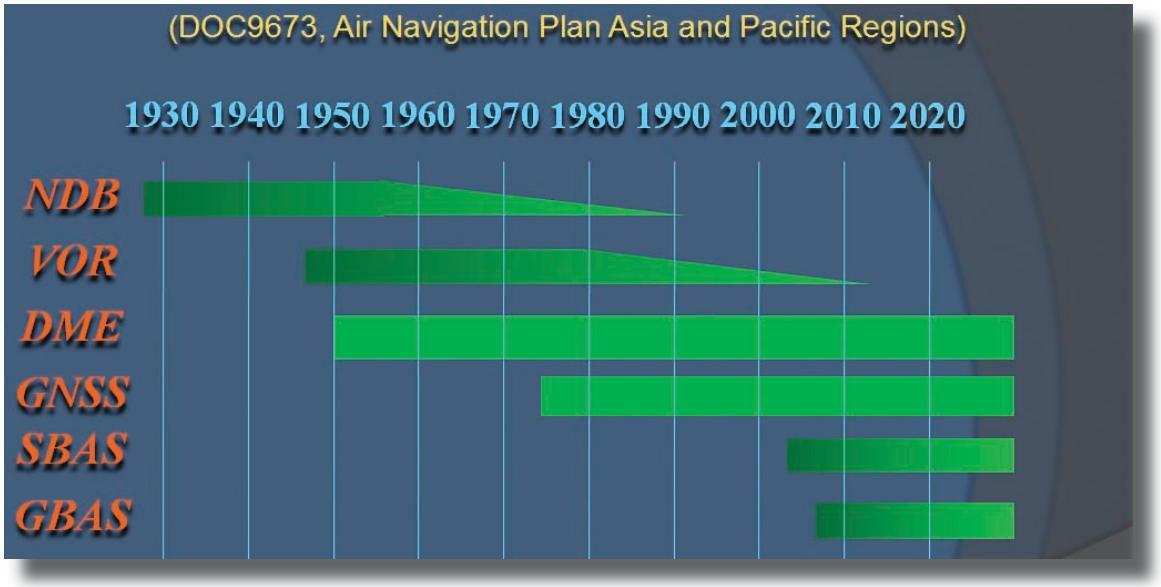
Although ultimate solution of PBN concept is to use Satellite navigation entirely through all phase of flight operation, GNSS is still expected to be primary in PBN operation beyond 2016. Besides, real backbone of ADS-B/C and Multilateration system is GNSS, For those reason DME would serve as the primary navigation aids until GNSS becomes primary means of navigation.

- VOR – mainly supports RNAV-5 operation with DME, until sufficient DME/DME coverage achieved;

- NDB – serves conventional routes and coupled NDBs will be relocated;

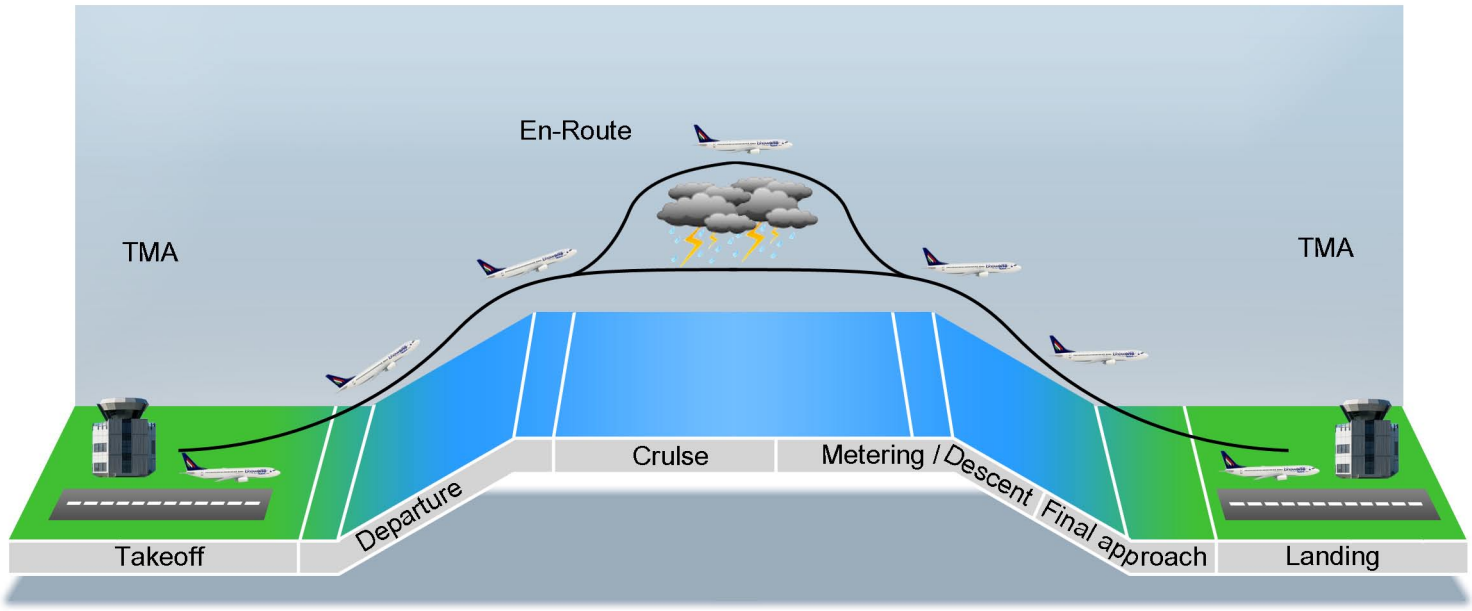
- ILS – stays as primary navigation facility for landing operation.

MCAA will not buy any new NDB/VOR. The main trunk will be facilitated with sufficient DME stations as soon as possible.



Appendix A

PBN Navigation Specification by ICAO document 9613



ICAO PBN Nav spec	Application of Navigation Specification by Flight Phase								Aircraft CNS capabilities by PBN Nav.Spec			Route spacing
	En route oceanic remote	En route continental	ARR	Approach				DEP	Primary navigation sensor	Ground navaid Infrastructure	Communication/Surveillance	
				Initial	Interm	Final	missed					
RNAV 10 (RNP10)	10								GNSS, INS/IRS	N/A	None specified	50
RNAV-5		5	5						GNSS, DME/DME, VOR/DME	DME, VOR	Voice / radar	30 (18-16.5)
RNAV-2		2	2					2	GNSS, DME/DME, INS/IRS	DME	Voice / radar	At least 8
RNAV-1		1	1	1	1		1	1	GNSS, DME/DME, INS/IRS	DME	Voice / radar	
RNP-4	4								GNSS	N/A	Voice or CPDLC/ADS-C	30x30
RNP-1			1	1	1		1	1	GNSS, DME/DME	DME (recovery)	No Com or Sur specified	
RNP APCH				1	1	0.3	1		GNSS	VOR, DME, NDB (missed approach)	No Com or Sur specified	
RNP AR APCH				1-0.1	1-0.1	0.3-01	1-0.1		GNSS	N/A	No Com or Sur specified	

Appendix B

Abbreviation

ADS-B	Automatic dependent surveillance—broadcast
ADS-C	Automatic dependent surveillance—contract
APV	Approach procedure(s) with vertical guidance
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic services
Baro-VNAV	Barometric vertical navigation
CNS	Communication, navigation, and surveillance
CPDLC	Controller-pilot data link communication
DME	Distance measuring equipment
FANS	Future Air Navigation System
FMS	Flight management system
GBAS	Ground-based augmentation system
GLONASS	**ГЛО**бальная **НА**вигационная **С**путниковая **С**истема (Russian version of GNSS)
GNSS	Global navigation satellite system
GPS	Global positioning system
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILS	Instrument landing system
INS	Inertial navigation system
NDB	Non directional beacon
PANS	Procedures for air navigation services

PBN	Performance based navigation
RAIM	Receiver autonomous integrity monitoring
RNAV	Area navigation
RNP	Required navigation performance
RNP AR	Required navigation performance, authorization required
RNP AR APCH	RNP authorization-required approach
SARP	Standards and recommended practices
SBAS	Space-based augmentation system
SID	Standard instrument departure
MSSR	Mono-pulse secondary surveillance radar
STAR	Standard terminal arrival route
VOR	VHF omni-range (navaid)