PERFORMANCE BASED NAVIGATION IMPLEMENTATION (2017- 19)

PLAN

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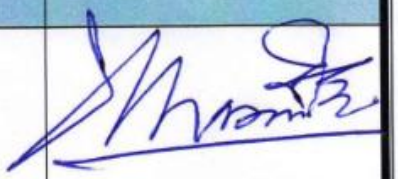
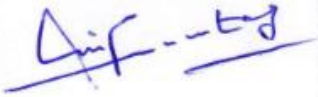
PREPARED BY	MUHAMMAD ASLAM AWAN	Sr. Joint Director Airspace & PBN / ICAO	
REVIEWED BY	ARIF MUMTAZ	Actg. AdlD Flight Procedure Design	
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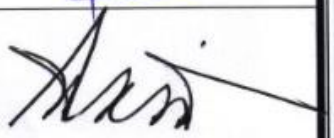
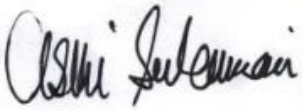
	A/Cdr SYED NASIR RAZA HAMDANI	Director SQMS / MR	
APPROVED BY	ASIM SULEIMAN	Air Marshal (R) Director General Pakistan Civil Aviation Authority	
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EXECUTIVE SUMMARY

Performance Based Navigation (PBN) has promising potential for efficient, reliable air navigation and utilization of airspace. The PBN concept links the Area Navigation application to Oceanic, Continental En route, Terminal Area, and Approach navigation specifications and supporting technologies and ensures worldwide harmonization of Area Navigation. Application of these technologies enhances airspace capacity in line with the projected aviation demand, ensuring fuel saving and reduced environmental impact.

ICAO Assembly vide resolution A36/23 and A37/11 urged member States to implement PBN (RNAV and RNP) for all phases of flight in accordance with the ICAO PBN concept laid down in the Performance Based Navigation Manual (Doc 9613). APANPIRG/18 and 44th DGCA Conference also fully supported the ICAO PBN program. Pakistan is a signatory to the Chicago convention and is accredited to ICAO Asia/Pacific Regional Office. The first version of Performance Based Navigation Implementation Plan (Roadmap) was developed in May 2009 in compliance to initiatives of APANPIRG, DGCA Conference and ICAO Assembly and was subsequently reviewed in 2012.

The PBN Roadmap provided phased strategy for PBN implementation which encompasses instrument approaches, Standard Instrument Departures (SID), Standard Terminal Arrival (STAR) operations and enroute operations in line with Regional PBN Implementation Plan.

Pakistan has shown good progress during the medium term ending by 2016. About 90% of the planned work on PBN (GNSS) Instrument Approach Procedures for instrument runway ends have been completed / implemented. Work on en-route phase is also in progress and almost all major air traffic flow routes supporting air traffic flow between Europe and Asia have been transformed to PBN routes based on RNAV10 and RNAV5 PBN specifications. The revised PBN Plan (Ver.3.0) encompasses Pakistan's actions to accomplish targets for strategic objectives for the triennium 2017 – 2019 and beyond.

The PBN implementation plan is also intended to assist aviation stakeholders i.e. airline operators, general aviators and regulators in understanding the application PBN for meeting operational goals with the focus on addressing future efficiency and capacity needs while improving the safety of flight operations and reducing environmental impacts

(LIAQUAT ALI SHAHZAD)
Director Operations

Dated: _____2017

Contents

GLOSSARY OF TERMS AND ABBREVIATIONS/ACRONYMS

ABAS	Aircraft-Based Augmentation System
AIS	Aeronautical Information Services
APAC	Asia and Pacific
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APCH	Approach
APV	Approach Procedures with Vertical Guidance
ATC	Air Traffic Control
Baro VNAV	Barometric Vertical Navigation
CNS/ATM	Communication Navigation Surveillance/Air Traffic Management
CPDLC	Controller Pilot Data Link Communications
DME	Distance Measuring Equipment
EMA	En-route Monitoring Agency
FASID	Facilities and Services Implementation Document
FIR	Flight Information Region
FMS	Flight Management System
GBAS	Ground-Based Augmentation System
GNSS	Global Navigation Satellite System
GRAS	Ground-based Regional Augmentation System
IATA	International Air Transport Association
IFALPA	International Federation of Air Line Pilots' Associations
INS	Inertial Navigation System
IRU	Inertial Reference Unit
PANS	Procedures for Air Navigation Services
PBN	Performance Based Navigation
PIRG	Planning and Implementation Regional Group
RASMAG	Regional Airspace Safety Monitoring Advisory Group
RCP	Required Communication Performance
RNAV	Area Navigation
RNP	Required Navigation Performance
SARP	Standards and Recommended Practices
SBAS	Satellite-Based Augmentation System
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival
TMA	Terminal Control Area
VOR	VHF Omni-directional Radio-range
WGS	World Geodetic System

Chapter 1

OVERVIEW

1.1 BACKGROUND

1.1.1 ICAO Assembly Resolution A37-11(2010) urged member States to submit National Implementation Plan regarding implementation of Performance Based Navigation (PBN) procedures. The member States are required to develop RNP & RNAV instrument flight procedures for application in en-route, terminal areas and especially approach procedures with vertical guidance (APV) to be implemented on all instrument runway ends by 2016. Accordingly, PBN has been indicated as highest priority for air navigation in the ICAO Global Air Navigation Plan (GANP) issued in 2013 and 2016. A number of Aviation Safety Block Upgrades in the GANP relates to the PBN implementation.

1.1.2 Conventional navigation aids of Directional Beacons (NDBs) and VHF Omni-directional Radio Range (VORs) are about 70 years old technology and do not provide the performance level which can be achieved from satellite navigation. It is also becoming increasingly expensive to maintain these facilities. The PBN operations based on RNP procedures supported by GNSS and / or Barometric Vertical Navigation (Baro-VNAV) provide continuous lateral and vertical guidance without the need for terrestrial radio navigation aids, thus reduces the cost significantly with increased safety. APV approaches are recognized internationally as more safe.

1.2 PURPOSE

1.2.1 The purpose of Performance Based Navigation implementation plan is to ensure progressive implementation of Performance Based Navigation in Pakistan in line with ICAO Global and Regional (APAC) Air Navigation Plans. It details the framework within which the ICAO PBN concept is being implemented in Pakistan with timelines. It will provide guidelines for ANS and Regulatory Divisions for phase wise activities between 2017 – 2019 and beyond.

1.2.2 The intent of the PBN Implementation Plan is to assist members of the aviation community to plan and execute a swift transition to the PBN (RNAV and RNP) applications in order to maximize the safety, economic and environmental benefits.

1.2.3 Pakistan's methodology for the transition to PBN is:

1.2.3.1 Initially continuation of present navigation capability to support mix aircraft operation.

1.2.3.2 Transition to ICAO PBN specifications (RNAV and RNP) in harmony with regional / adjacent States.

1.2.3.3 Introduction of limited APV capability (where required) through barometric vertical navigational guidance.

1.2.3.4 Utilization of GNSS as the enabling technology / navigational reference for the implementation of PBN.

1.2.3.5 Rationalizing terrestrial radio navigation aids (the backup network) to support non PBN arrivals and non precision approaches at selected aerodromes.

1.3 STRATEGIC OBJECTIVES

1.3.1 The implementation of PBN provides significant benefits in terms of safety, efficiency and environmental protection besides cost effective. High accuracy lateral guidance and use of vertical guidance for arrival and approach operation greatly enhances safety. Optimized flight paths (lateral and vertical) increase operating efficiency and minimize fuel consumption and emissions.

1.3.2 Pakistan's PBN Plan mainly focuses on ICAO 05 strategic objectives set for the triennium 2017-19, except Sub- Para "C" below which is not in the scope of PBN and being addressed separately;

- **Safety** - Enhance global civil aviation safety.
- **Air Navigation Capacity and Efficiency –** Increase capacity and improve efficiency of the global civil aviation system.
- **Security and Facilitation -** Enhance global civil aviation security and facilitation.
- **Economic Development of Air Transport -** Foster the development of a sound and economically-viable civil aviation system.
- **Environmental Protection -** Minimize the adverse environmental effects of civil aviation activities.

1.3.3 RNP is a necessary enabler to transition from navigation along fixed routes to more efficient Flexi Tracks to achieve savings of fuel & reduction in CO2 emissions. The implementation of Continuous Descent Operations (CDO) during arrival and approach where the aircraft engines are placed at idle from top of descent and the aircraft "glides" to the runway is planned to meet this objective.

1.3.4 Reduction in the cost of regulatory oversight through inter-State recognition of internationally adopted regional / global standards thus avoiding multiple aircraft approvals of State specific area navigation specifications.

1.3.5 The PBN implementation will address the airspace capacity limitations by optimizing airspace capacity through availability of parallel routing based on PBN navigation specifications in all classes of airspace.

1.3.6 APV are an ICAO safety initiative directed at reducing the rate of high fatality CFIT accidents that are typical in approach to land operations without vertical guidance. ICAO recognizes Baro-VNAV and augmented GNSS as suitable technologies to support vertical guidance. Pakistan does not have Satellite Based GNSS Augmentation System and until an SBAS service is acquired, APV though Baro-VNAV will be implemented.

1.3.7 The intent of the Pakistan PBN Implementation Plan is to assist members of the aviation community to plan and execute a swift transition to the RNAV and RNP concepts in order to maximize the safety, economic and environmental benefits of PBN and to guide synchronized investment in new technology and infrastructure.

1.3.8 Reduction in fuel burns and CO2 emissions to minimize the environmental affects.

1.4 ASSUMPTIONS:

1.4.1 The implementation of PBN in Pakistan is based on the following principles:

1.4.1.1 Continued application of conventional air navigation procedures during the transition period to assure availability to users that are not yet RNAV and/or RNP approved.

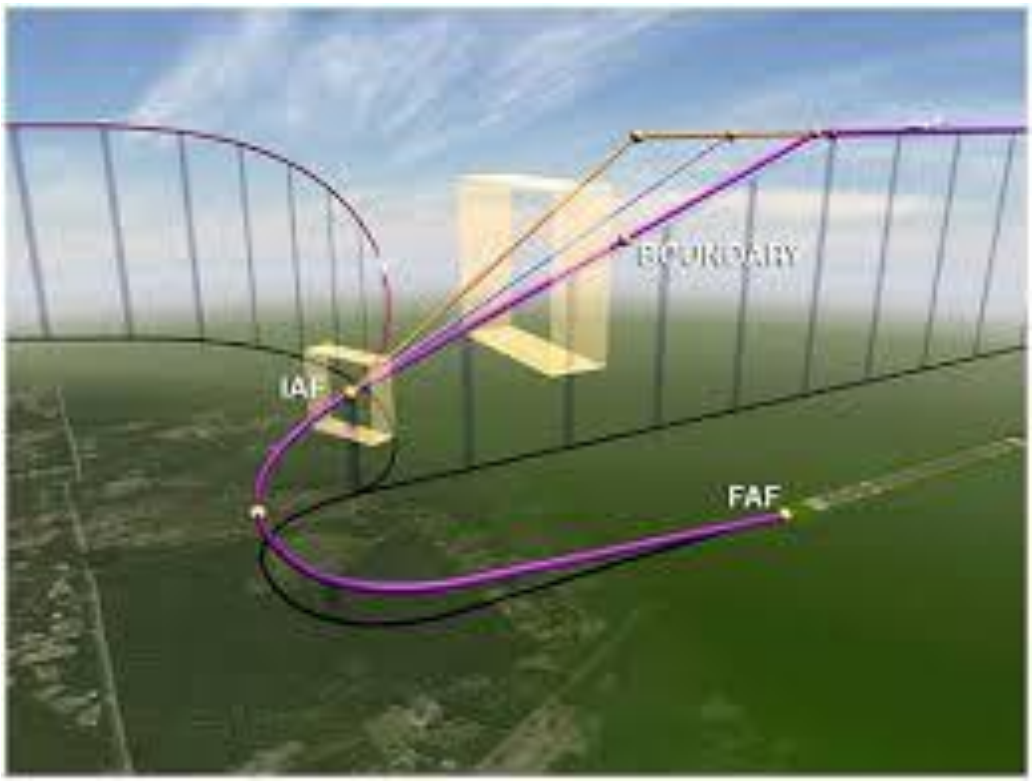
1.4.1.2 Selection of appropriate PBN navigation specifications by developing the airspace concept under the guidance available through relevant documents to support the navigation applications.

1.4.1.3 The PBN (RNAV or RNP) system is expected to access a navigation database. The navigation database contains pre-stored information on NAVAID locations, waypoints, ATS routes and terminal procedures, and related information. The PBN system will use such information for flight planning and may also conduct cross-checks between sensor information and the database.

1.4.1.4 Conduct of cost-benefit analyses to justify the implementation of the RNAV and/or RNP navigation specification.

1.4.1.5 Conduct of pre and post implementation safety assessments to ensure the application and maintenance of the established target levels of safety.

1.4.1.6 Harmonization with the regional PBN implementation plan



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Chapter 2

PERFORMANCE BASED NAVIGATION

2.1 PBN CONCEPT

2.1.1 PBN refers to the aircraft's performance requirements in terms of system accuracy, integrity, availability, continuity, and functionality for operations along a given route, within an instrument flight procedure or a particular airspace, and with the availability of pertinent navigation infrastructure. Performance based navigation is considered as the most practical solution for regulating the expanding domain of navigation systems.

2.1.2 Under PBN, generic navigation requirements are defined based on the operational requirements. Operators are then able to evaluate options in respect of available technologies and navigation services that could allow these requirements to be met. Technologies can evolve over time without requiring the operation itself to be revisited, as long as the requisite performance is provided by the RNAV system. ICAO's Performance Based Navigation (PBN) concept aims to ensure global standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use worldwide.

2.1.3 The development of the PBN concept recognized that advanced aircraft RNAV systems are achieving a predictable level of navigation performance accuracy which, together with an appropriate level of functionality, allows a more efficient use of available airspace to be realized.

2.2 BENEFITS OF PBN IMPLEMENTATION

2.2.1 The main benefits envisaged from implementing PBN in Pakistan are:

2.2.1.1 Increased safety through the implementation of runway aligned approaches and stabilized descent procedures using vertical guidance;

2.2.1.2 Enhanced access to the aerodrome which otherwise not possible under conventional navigation due to airspace limitations;

2.2.1.3 Reduced aircraft flight time due to the implementation of optimal flight paths, with the resulting savings in fuel, reduction in noise and carbon emission, and enhanced environmental protection;

2.2.1.4 Optimum use of onboard capabilities that already exist in a significant percentage of the aircraft fleet flying in Pakistan Airspace both domestic and international operations;

2.2.1.5 Improved airport and airspace arrival paths in all weather conditions, and the possibility of meeting critical obstacle clearance and environmental requirements through the application of optimized PBN paths;

2.2.1.6 Implementation of more precise approach, departure, and arrival paths that will foster smoother traffic flows;

2.2.1.7 Rationalization of ground - based sensor and their associated costs;

2.2.1.8 Decrease ATC and pilot workload by utilizing PBN procedures and airborne capability;

2.2.1.9 Increase of predictability of the flight path as PBN specifications facilitate more efficient design of airspace and procedures, which collectively result in improved safety, access, capacity, predictability, operational efficiency and environmental effects;

2.2.1.10 Possibility of implementing Continuous Climb / Descent Operations (CCO/CDO) using PBN airspace design principles;

2.2.1.11 No need for development of sensor-specific operations for each new evolution of navigation systems

2.2.1.12 Facilitation of the operational approval process by providing a limited set of global navigation specifications

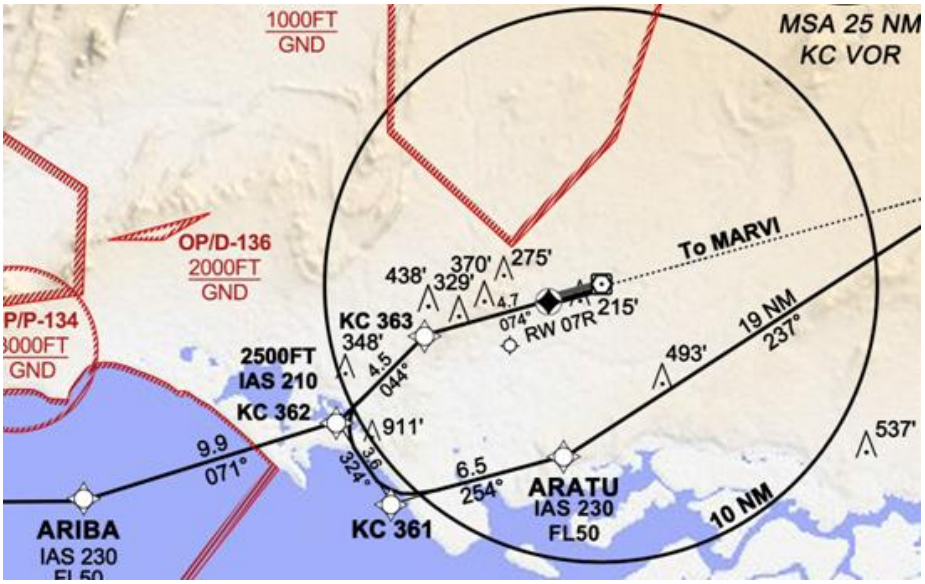
2.3 PBN IMPLEMENTATION - CURRENT STATUS

2.3.1 TERMINAL AIRSPACE

2.3.1.1 Pakistan developed its first PBN implementation plan during 2009 which was subsequently revised in 2012. Total 40 runway ends were planned for implementation of RNP APCH procedures out of which 36 were instrument runways. The other 04 runways were not having access using conventional procedures except visual circling due to airspace limitations. Starting first implementation in May 2012 for RWY12 of Benazir Bhutto Int'l Airport (BBIAP) Islamabad, Pakistan has so far implemented RNP APCH procedures at 37 runway ends which is 92.5% of the plan. RNP1 STARs have been provided for connectivity to the approaches where deemed necessary for safe aircraft operations while general T or Y bar concept have been used at smaller locations where traffic is not significant.

2.3.1.2 First RNP1 departures were implemented at BBIAP Islamabad during 2016 while SIDs for major airports Karachi and Lahore are planned during 2017. The SIDs for remaining runways will subsequently be undertaken in this triennium.

2.3.1.3 As ILS is still recognized as a great facility for approach and landing, Baro-VNAV or LPV have yet to be improved to reach that performance. The new amendment in PANS-OPS regarding RNAV-ILS integration is an important step for real benefits of PBN as PBN capability can be used prior to ILS interception and during missed approach. Pakistan has started implementation of such procedures and presently such connectivity exists at Islamabad, Multan, Faisalabad and Peshawar Airports.



RNP APCH RWY07R JIAP Karachi

2.3.2 ENROUTE AIRSPACE

2.3.2.1 Pakistan is at the western boundary of the ICAO Asia/Pacific Region interfacing with ICAO MID Region. It has adjoining airspace of Oman and Iran towards west where RNAV 5 is being used.

2.3.2.2 India and Afghanistan have implemented RNP10 in their airspaces. Accordingly, Pakistan transformed number of ATS Routes serving major traffic flows into PBN ATS routes with navigation specification of RNP10 to support regional harmonization. The transformation of some more international ATS routes into PBN routes having regional traffic flows will be completed by 31st December, 2017.

2.3.2.3 The work on segregation of arrival and departure trajectories from major airports of Karachi and Lahore is also ongoing which will support CCO / CDO operations.

2.3.2.4 Pakistan is also looking forward towards APAC seamless ATM implementation plan and will review navigation specifications of ATS Routes in harmony with the adjacent states as and when required to achieve PBN goals in line with ICAO GANP and APAC seamless ATM Plan.

2.4 AIRCRAFT FLEET CAPABILITIES

2.4.1 While the onboard GNSS equipage was limited during early phase of PBN implementation, such aircraft are phasing out with the passage of time. B747, A310 and B737 Classics owned by the national carrier were the major non-compliant aircraft which have now completed their airframe life. Presently there are 04 Regular Public Transport (RPT) License holder in Pakistan with majority of the fleet have the capability for RNP1 / RNP APCH operations. With regard to the foreign carriers, almost all regular operators have the capability to fly RNP1 / RNP APCH. However, mixed mode operations still exist due to limited non-compliant and general aviation operations in terminal airspace.

2.4.2 As far as the enroute operation is concerned, the majority of the fleet is compliant with the requirements of current RNP10/RNAV5 operations. However, no aircraft within Pakistani fleet has the endorsement of RNP2 planned to be future navigation specification for enroute operations as per APAC seamless ATM Plan. The case is similar for number of foreign operators and ICAO APAC office has already endorsed the Australian strategy for consideration of RNP2 equipage.

2.5 STATE CNS/ATM CAPABILITIES

2.5.1 The NAV-AIDs infrastructure within Pakistan airspace does not support terminal operations using DME/DME sensors for PBN navigation specification of RNP1 or RNAV1. RNP1 using GNSS as primary sensor is therefore possible option for terminal applications.

2.4.1 Controller Pilot Direct Communication using a network of VHF stations is available over entire airspace except for some portions of airspace towards North along Pak – China border. New VHF station is already plan to address the problem which is likely to be operational during 2017.

2.4.2 Sufficient surveillance coverage is available within TMAs established around major international airports of Karachi, Lahore and Islamabad. These radars along with remote SSRs provide coverage over entire Pakistan airspace except for some grey areas towards North and West. These radars are under replacement with new Mode S radars and enhanced coverage of 250NM. In the first phase the radars at Karachi, Lahore and Islamabad radars have been made operational. The remote SSRs serving the enroute operations are also planned to be replaced with new Mode S radars by June 2018. Additionally, ADS-B coverage is planned as backup for entire airspace for enroute operations. These initiatives will provide redundant surveillance coverage over Pakistan airspace for enroute as well as terminal operations at 03 major international airports.

2.6 APPLICABLE PBN NAVIGATION SPECIFICATIONS

2.6.1 Based on above considerations, RNP1 is envisioned as primary navigation specification for terminal operations in Pakistan utilizing GNSS as primary sensor while RNP APCH will be the navigation specification for approach phase of flight. Pakistan may consider RNP AR APCH in future for some of the runway ends where instrument operation using RNP APCH is not practicable to enhance access to the aerodrome.

2.6.2 RNAV5 is currently envisioned as primary navigation specification for enroute operations in Pakistan utilizing any allowable sensor. However, some of the ATS routes with major flow from East to West and vice versa has been designated as RNP10 for regional harmonization. A study to assess the transition requirements to RNP2 as required vide APAC seamless ATM plan is also in hand.

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Chapter 3

IMPLEMENTATION CONSIDERATIONS

3.1 SAFETY

3.1.1 Safety challenges revolve largely around the safe operation of the ATM system during the transition to PBN operations. Gaps will necessarily occur within the CNS/ATM system noting that PBN addresses only the navigation tenet of the system and advances in navigation may outpace advances in communication and/or surveillance. Safety challenges therefore include:

3.1.1.1 Integration into the ATM system including software enhancement to support PBN.

3.1.1.2 Safety monitoring of ATM system.

3.1.1.3 Mixed fleet/system operations.

3.1.1.4 Development of supporting rule set.

3.1.1.5 Education and training of stakeholders.

3.1.1.6 Approach naming and charting conventions.

3.1.1.7 Database integrity control (Pakistan CAA is working on transformation from AIS to AIM).

3.1.1.8 GNSS system performance and availability of prediction service.

3.1.2 Pakistan CAA has already acquired AIRCON2100 ATM system which is operational at Karachi and Lahore Area Control Centers. Si-ATM system has been procured and installed at new international airport - Islamabad. Both these systems have the capability for integration to support PBN operations. Safety monitoring and procedures for mixed fleet operations is already in place.

3.1.3 Transformation of AIS to AIM is in process and will be finalized by 31st December, 2017 and subsequently digitalized aeronautical data will be available for PBN operations.

3.2 AIRCRAFT OPERATIONS

3.2.1 In the past, the National aircraft operators have limited onboard GNSS equipage which was major obstacle in PBN implementation. Now such aircraft are being phased out on completion of their operational life. Presently majority of fleet of 04 Regular Public Transport (RPT) License holders in Pakistan are compliant for RNP1 / RNP APCH operations. The foreign carriers have almost acquired the capability to fly on RNP1 / RNP APCH specifications. However, mixed mode of operations still exists due to limited non-compliant aircraft and general aviation operations.

3.2.2 The majority of the aircraft overflying Pakistan airspace are compliant with the requirements of current RNP10/RNAV5 operations. However, no aircraft holding Pakistani Regular Public Transport (RPT) License has the endorsement of RNP2 planned to be future navigation specification for enroute operations to support APAC seamless ATM Plan. Similar is the situation for number of foreign operators. As ICAO APAC office has already endorsed the Australian strategy for consideration of RNP2 equipage for en-route operations, Pakistan has planned to implement PBN specification of RNP2 by 2019 to enable operators for meeting the equipage requirement.

3.3 INFRASTRUCTURE

3.3.1 ICAO has allowed different navigational references for PBN operations which include GNSS, terrestrial radio navigation aids i.e. DME/DME & VOR/DME and aircraft self contained navigation systems (INS and/or IRS). Pakistan plan is based to implement PBN as prescribed in PBN Manual Doc-9613 for different phases of flight.

3.3.2 En-Route Operations: The current infrastructure can support the ongoing RNAV5 and RNAV10 operations using GNSS or a combination of VOR/DME and self contained. However, infrastructure of ground based navigation aids is considered insufficient for RNAV2 operations using DME/DME. While Pakistan is looking forward for RNP2 implementation, the sole reliance will be on the use of GNSS.

3.3.3 Terminal Operations: The terrestrial navigation aids in Pakistan are insufficient to support PBN operations in terminal areas using RNAV1 or RNP1. As such GNSS is envisaged as main navigational reference for PBN operations in terminal areas. However, INS or IRS may also be utilized where applicable as per ICAO provisions.

3.3.4 Approach Operations: Pakistan has planned RNP APCH for approach operations as per ICAO plan. As Pakistan has not acquired SBAS capability, therefore APV through Baro VNAV will be implemented where required.

3.3.5 Pakistan will maintain a reduced network ("the backup network") of terrestrial radio navigation aids to provide an alternative means of navigation for terminal operations in reversionary mode and Non-Precision Approach (NPA) using conventional navigation procedures.

3.4 EFFICIENCY AND CAPACITY

3.4.1 Performance-based flight operations are based on the ability to assure reliable operations. The implementation of performance-based flight operations requires not only the functions traditionally provided by the RNAV or RNP system, but may also require specific functions to improve procedures, airspace and air traffic operations allowing more efficient use of airspace (route placement, fuel efficiency and noise abatement) to enhance the efficiency of aviation operations.

3.4.2 Due to the global nature of aviation operations, GNSS-centered navigation delivers globally interoperable navigational infrastructure that provide benefits in safety, efficiency and capacity. In order to achieve these benefits performance based navigation must be supported by an appropriate navigation infrastructure for standardized positioning information to the aircraft system to support precise globally. This would help in airspace capacity enhancement.

3.4.3 GNSS based PBN operations enables seamless, harmonized and cost effective navigational service from departure to final approach that will provide benefits in terms of safety, efficiency and capacity.

3.4.4 Medium / longer term GNSS applications will make use of existing and future satellite navigation systems with some type of augmentation, or a combination of augmentations required for operation in a particular phase of flight.

3.5 ENVIRONMENT (NOISE AND EMISSIONS)

3.5.1 Environmental challenges include minimizing the impact of noise and emissions on both the communities in the proximity of aerodromes and the global environment. PBN will support the achievement of these goals while preserving aviation safety and efficiencies in the ATM system, but a collaborative approach will be essential to deliver all these objectives. Environmental challenges therefore include:

3.5.1.1 Increased ATM system capacity due to PBN efficiency gains;

3.5.1.2 Emission control / management, including demonstrated efficiencies associated with PBN operations;

3.5.1.3 Noise control/management

3.5.2 The development of the PBN concept recognized that advanced aircraft RNAV systems are achieving a predictable level of navigation performance accuracy which, together with an appropriate level of functionality, allows a more efficient use of available airspace to be realized.

3.5.3 Environmental challenges are significant, not least through the political sphere of influence for aircraft noise at major aerodromes and aircraft emissions (carbon footprint). PBN will provide significant efficiencies in the ATM system which will simultaneously increase system efficiency and reduce total carbon emission and aircraft noise levels. The introduction of a global Emission Trading Scheme (ETS) could provide aircraft operators with significant commercial advantage, particularly those operating to RNP specifications. Environmental challenges therefore include:

3.5.3.1 Political developments/considerations

3.5.3.2 Increased capacity due PBN efficiency gains

3.5.3.3 Emission control/management

3.5.3.4 Noise control/management

3.5.4 Environment requirements for reduced emissions, noise preferential routes or CDO/CCO are environmental motivators for change. Airspace concepts are being developed to satisfy strategic objective of providing more accurate flight paths and to mitigate the environmental impact by reducing the fuel burns.

3.5.5 The importance of knowing the fleet's characteristics lies in the fact that the placement of ATS routes, SIDs/STARs or IAPs is decided with a view to ensuring maximum flight efficiency, maximum capacity and minimum environmental impact.

3.5.6 PBN makes it possible to place routes in the most optimum locations for significant advantages i.e. shorter route length or vertical windows supporting continuous descent or climb operations enabling more fuel efficient profiles with reduced environmental affects (noise, CO2, etc.).

3.6 REGULATORY

3.6.1 ICAO vide PBN Operational Approval Manual Doc-9997 requires that individual States must develop national regulatory material which addresses the PBN applications relevant to their airspace or relevant to operations conducted in another State by the operators and aircraft registered in their State.

3.6.2 PBN is the international regulatory framework to standardize the implementation of Area Navigation worldwide.

3.6.3 PBN regulations and standards encompass onboard equipment standards, aircraft airworthiness qualifications, navigational standards, training of personnel (flight,

maintenance, dispatch and air traffic control), operation procedures, certification and approval, monitoring and inspection, CNS/ATM and flight procedure design criteria etc. Pakistan CAA will establish a complete regulation system conforming to ICAO PBN standards by December, 2017.

3.6.4 To implement PBN operations, the air operators must ensure that their aircraft are properly equipped to meet the requirements as specified in the applicable PBN navigation specification, establish operational procedures, complete the training of personnel as specified, and apply for and obtain PCAA operational approval. The air operators shall, in accordance with PCAA PBN implementation planning and operational need, gradually establish operational capabilities and obtain their PBN operational approvals in accordance with PBN implementation time lines.

3.7 RESOURCES

3.7.1 Pakistan CAA has acquired necessary resources for the development / implementation of instrument flight procedures based on PBN criteria. It includes a team of authorized Flight Procedure Designers to undertake design of terminal and approach procedures using applicable PBN navigation specifications. Pakistan CAA has also acquired automation tool to assure the quality in procedures designing and reducing human errors, gaining the capability to develop “what-if” scenarios, and standardized application of the ICAO PANS-OPS criteria. The design tool being used is integrated with the Aeronautical database of Pakistan maintained by AIM Branch with the objective of maintaining the integrity of the source data throughout the design process.

3.7.2 During the process of PBN implementation, Pakistan CAA has provided training and educational information about its PBN implementation program. Few PBN seminars were arranged earlier with the help of M/s Integra and ICAO APAC FPP during early implementation phase. A similar seminar has been planned in the year 2017 for the education of personnel from the regulatory authorities, air traffic management, aviation agencies, and aircraft operators etc.

3.8 AIR NAVIGATION SERVICE PROVIDER (ANSP)

3.8.1 For the PBN implementation, an airspace concept is being designed based upon future operation al requirements taking in to account the expected environmental issues when the new airspace operation is intended. ATS surveillance and communication system is being up-graded. The first phase of upgradation has been completed by June, 2017. Subsequently the remaining radars will be replaced with Mode S SSRs in 2018.

3.8.2 An air traffic system is the integrated of the CNS/ATM capabilities available. PBN is only the navigation component of CNS/ATM and should not be viewed as the only component. It cannot be safely and successfully implemented without due consideration of the communications and ATS surveillance infrastructure available to support the operation.

3.8.3 The following specific ATS system assumptions have been given due considerations;

3.8.3.1 Fleet capabilities are of crucial importance to the new airspace concept and are being thoroughly analyzed. The evaluation mix aircraft navigational performance and navigation capabilities of the fleet will be completed by 31st December, 2017.

3.8.3.2 What are projected equipage rates (for instance, in the next three years)?

3.8.3.3 Can failures of GNSS be mitigated by other means of navigation including self contained sensors or conventional navigation or ATS surveillance and/or ATS procedural service?

3.8.3.4 When there are insufficient Nav-aids available to provide adequate signal coverage, can the gaps in coverage be accommodated by reliance on aircraft inertial systems?

3.8.3.5 Due consideration is being given to accommodating users with varying levels of navigation equipage i.e. a mixed PBN environment or mixed PBN and conventional environment etc.

3.8.3.6 The Nav-Aid infrastructure is being assessed in order to ensure that it is sufficient for the proposed operations, including reversionary modes. The route spacing and obstacle clearance is also being taken in to account for expected increase in lateral track-keeping errors.

3.8.3.7 Availability of navigation database containing the routes and procedures;

3.8.4 AIR TRAFFIC CONTROLLERS TRAINING

It is also essential that air traffic controllers providing control services in airspace where PBN is implemented should have completed training in the following areas:

3.8.4.1 How area navigation systems works (in the context of the specific navigation specification):

3.8.4.2 Functional capabilities and limitations of the navigation specification;

3.8.4.3 Accuracy, integrity, availability and continuity; and

3.8.4.4 GPS receiver, RAIM, FDE, and integrity alerts functions;

3.8.4.5 Flight plan requirements;

3.8.4.6 ATC procedures:

3.8.4.7 ATC contingency procedures;

3.8.4.8 Separation minima;

3.8.4.9 Mixed equipage environment (impact of manual VOR tuning);

3.8.4.10 Transition between different operating environments; and

3.8.4.11 Phraseology

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Chapter 4

IMPLEMENTATION TARGETS

4.1 GENERAL

4.1.1 . Pakistan is already on the road for PBN implementation from 2009 onwards and has endeavored to implement PBN Approach Procedures on instrument runway ends for which about 92.5% work has already completed.

4.1.2 The first priority is therefore to accomplish the target of 100% instrument runway ends as required vide Assembly Resolution A37-11 with minimal delay. Pakistan is also looking for implementation of PBN related ASBU modules at major international airports on priority. Accordingly, these targets have been prioritized over a short period of time reducing the short term to only 01-year time.

4.1.3 Implementation of terminal procedures (Arrival/departure) at all airports having IFR aircraft operation is planned during this triennium and has been reflected as medium term. It is anticipated that by 2019, PBN based procedures would have been implemented in all phases of flights and Pakistan will look forward for further improvement and development consistent with the industry and global air navigation plan. This has been placed in long term which is 2020 and beyond.

4.2 SHORT TERM (2017)

4.2.1 The highest priority task for Pakistan is the implementation of RNP APCH procedures at planned 40 runway ends to achieve the milestone set by Assembly Resolution A37-11 with minimum delay. The target date for accomplishment of this task is set as December, 2017 for which the required actions are in hand. The list of target runway ends with current status is placed as Appendix B.

4.2.2 New civil airport to serve the capital city of Islamabad is about completion and is planned to be commissioned during 2017. Design of complete IFP package including RNP APCH Procedures, STARs and SIDs for all 04 runway ends have also completed awaiting operationalization of new airport.

4.2.3 RNP1 SIDs for major airports of Karachi and Lahore are planned for 3rd and 4th quarter of 2017 with a study to look into possibility for implementation of PBN airspace design concept with separation between arrival and departure trajectories.

4.2.4 The provision of RNAV-ILS connectivity at major airports of Karachi (JIAP) and Lahore (AIIAP) are also planned during the year.

4.2.5 Some of the international and domestic routes are planned to be transformed to RNAV5 during 2017.

4.3 MEDIUM TERM (2018-19)

4.3.1 The implementation of SIDs at remaining airport is planned during 2018-19. Periodic review of implemented procedure is also planned task during this period. The target is to ensure availability of terminal and approach procedures for all instrument runways within Pakistan. PBN initials availability will also be ensured at all ILS equipped runway ends for real benefits of PBN systems.

4.3.2 APAC Seamless ATM Plan prescribes RNAV2/RNP2 as the preferred navigation specification for ATS Routes in Phase I while RNP2 is envisaged as preferred navigation specification for Phase II. It is also expected that implementation of RNP2 will be started soon. Pakistan is planning to transform the navigation specification for enroute ATS routes to RNP2 in line with Regional Seamless ATM Plan and the transition from existing navigation specification of RNAV5/RNP10 is planned during the period.

4.4 LONG TERM (2020 & BEYOND)

4.4.1 A fully-harmonized global air navigation system built on modern performance-based procedures and technologies will provide a viable solution to meet future air traffic growth. The 37th Session of the International Civil Aviation Organization (ICAO) General Assembly (2010) directed the Organization to double its efforts to meet the

global needs for airspace interoperability while maintaining its focus on safety. ICAO therefore initiated the “Aviation System Block Upgrades” initiative as a programmatic framework that;

4.4.1.1 Develops a set of air traffic management (ATM) solutions or upgrades,

4.4.1.2 Takes advantage of current equipage,

4.4.1.3 Establishes a transition plan, and

4.4.1.4 Enables global interoperability.

4.4.2 In the long term, PCAA has planned to step ahead in ASBU Block-1 for set of improvements that can be implemented globally to enhance the performance of the ATM System and support regional harmonization as per ASBU concept. Accordingly, the following three ASBU modules have been earmarked as performance improvement areas;

4.4.2.1 **Optimized Airport Accessibility:** This is the next step in the universal implementation of GNSS-based approaches. As more PBN and GBAS procedures become available, and as more aircraft are equipped with the required avionics, application of this module will result in some rationalization of the navigation infrastructure. Increased aerodrome accessibility via lower approach minima to more runways, which will result in fewer fight disruptions, reduced fuel burn and reduced greenhouse gas emissions. The more widespread availability of SBAS and GBAS procedures will enhance safety via vertical guidance.

4.4.2.2 **Improved Operations through Free Routing:** Introduction of free routing in define airspace, where the flight plan is not defined as segments of a published route **network** or track system to facilitate adherence to the user-preferred profile. It will provide the opportunity to exploit further PBN capabilities in order to continue eliminating design constraints and operating more flexibly. The module is made of the following elements:

4.4.2.2.1 Free routing;

4.4.2.2.2 Reduced route spacing;

4.4.2.2.3 Dynamic sectorisation.

4.4.2.3 **Improved Flexibility and Efficiency in Descent Profiles (OPDs):** Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Optimized Profile Descents (OPDs). Vertical RNP contributes to Terminal airspace design and efficiency due to an aircraft’s ability to maintain a vertical path during descent. Other benefits include reduced aircraft level-offs, enhanced vertical precision in the terminal airspace, de-confliction of arrival and departure procedures and adjacent airport traffic flows, and the ability of an aircraft to fly an approach procedure not reliant upon ground based equipment for vertical navigation. This ultimately leads to higher utilization of airports and runways lacking vertical approach guidance

Chapter 5

PLAN COORDINATION

5.1 COORDINATION AND CONSULTATION

Pakistan Performance Based Navigation plan is based on consultation between relevant aviation agencies and representatives of the industry. It has the involvement of Civil Aviation Authority as a regulatory body and Air Navigation Service Provider as well as the aircraft operators both Pakistani and foreign operating through the Pakistan airspace.

5.2 PLAN RESPONSIBILITY

5.2.1 The responsibility of Regulatory Division of Pakistan CAA is to provide a framework to accord approvals to National operators based on PBN navigation specifications and approval for implementation of PBN based flight procedures.

5.2.2 ANS Division of Pakistan CAA will develop PBN airspace concept based on PBN navigation specifications, navigational infrastructure and ANS operational procedures as per timelines established in the plan for PBN implementation. The responsibility of the operators is to ensure aircraft equipage for the airspace concept agreed in the PBN Plan in harmony with ICAO global and Regional implementation strategy.

5.2.3 Although the plan has involvement of all stakeholders to accrue its real benefits, the main responsibility for implementation of PBN plan rest with ANS Division of Pakistan CAA as majority of foreign operators will be the beneficiary even if there is some delay on part of National operators.

5.3 PLAN REVIEW

The version of the plan has been issued when majority of the work for RNP APCH implementation has already been undertaken. It is planned that the PBN operations including arrival / departures and approaches will be implemented at all instrument runways during next triennium for qualifying aircraft under mixed mode operation. No obligatory mandate has been decided so far for any terminal airspace. The plan will be reviewed during 2019 to align with APAC Seamless ATM Plan strategy after due consultation with all stakeholders.

5.4 STAKEHOLDER COMMITMENT

Pakistan CAA has so far not documented any commitment from the aircraft operators. However, based on the operational benefits envisaged from PBN operations, fleet equipage for PBN operations is growing with fast pace. Some of the old equipment used by the national operators has already completed airframe life and are not in operation. Stakeholder commitment will be obtained during next triennium to decide mandate for terminal airspace for transition from mixed mode to a full PBN based environment.

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Chapter 6

SAFETY

6.1 PRELIMINARY SAFETY ASSESSMENT

6.1.1 State safety management requirements provide specifications for performance, personnel and processes necessary for the safety of aircraft operation. These requirements include the collection, analysis and exchange of safety data.

6.1.2 Though the airspace is reviewed and is verified of having an acceptable level of safety, a review and pre-implementation assessment will be held to see if every corner of operational environment is safe, reflecting changes introduced by the new concept of navigation specification. If this process find risks the actions for risk mitigation have been completed and the level of safety is considered sufficient to meet Target Level of Safety (TLS), the PBN operation will be started followed by post implementation assessment.

6.1.3 Due to limitations in conventional infrastructure and fleet capabilities, operations based on conventional navigation will coexist with PBN operations within a certain period in the future. The PCAA will mandate PBN operations at certain airports and to expedite the replacement of conventional operations. Pakistan CAA is also aware that there are certain risks in PBN operations, such as mixed operations by aircraft with and without RNP capabilities; Design and update of routes and flight procedures to satisfy operational requirements; and the reliability and availability of satellite-based navigation. To ensure a smooth transition to PBN, PCAA will take the following safety principles into consideration during its implementation.

6.1.4 During the mixed operation environment, sufficient conventional navigations systems will be retained to provide services for aircraft without PBN equipage. The requirements of the State aircraft will also be taken into consideration, but will segregate traffic according to the navigation capability of the aircraft, and will grant preferred route access to aircraft with PBN capability.

6.1.5 Operators will be given enough transition time to update their equipment. All airspace users are encouraged to install PBN avionics to become PBN-capable.

6.1.6 PCAA will conduct safety assessments and periodic safety inspections, and will formulate contingency plans to ensure continuous operational safety.

6.1.7 Thorough operations monitoring will be implemented that will include operator qualifications, aircraft navigation performance, navigation error, etc., and corrective measures will be formulated as required.

6.1.8 Harmonized conventional procedures and PBN flight procedures shall be considered in flight procedure design to reduce the risk of procedure conflict while conventional operations and PBN operations coexist.

6.1.9 The ANSP will enhance training of controllers, and will have control plans and safety measures in place for a blended operational environment to ensure safe separation.

6.1.10 Operators shall be informed as early as possible before PBN operations are to be implemented at airports or en route, and airworthiness and operational approvals shall be actively pursued.

6.2 IMPLEMENTATION SAFETY ASSESSMENT

6.2.1 To demonstrate that the system is safe, ongoing monitoring of the PBN en-route. TMA and Approach implementation would be undertaken through appropriate post implementation review mechanism. In this regard close coordination will also be maintained with Regional Airspace Safety Monitoring Advisory Group (RASMAG) formed by APANPIRG to ensure en-route implementation in regional harmonization. Necessary support to RASMAG would be extended though provision of relevant data.

6.2.2 In undertaking a safety assessment and ongoing monitoring to enable en-route implementation of PBN the following strategy would be adopted on regular basis;

6.2.2.1 Establishment and maintenance of PBN approval database;

6.2.2.2 Monitor aircraft horizontal-plane navigation performance and the occurrence of large navigation errors and report results appropriately to the RASMAG;

6.2.2.3 Conduct of safety and readiness assessments and report results appropriately to the RASMAG;

6.2.2.4 Monitoring of operator's compliance with State approval requirements after PBN implementation;

6.2.2.5 Initiation of necessary remedial actions if PBN requirements are not met.

6.2.3 It is necessary to analyze flight track data after the implementation of the PBN procedure to see if Target Level of Safety (TLS) is met. As a source of flight track, the radar track data will be used at the initial stage. Also a system that utilizes ADS-B track data as another source of flight track data will be developed in the near future. The recorded source data for specific months of the year will be collected for deviation analysis. The magnitude of deviation from collected flight track will be developed and safety assessment experts will evaluate the level of safety through deviation analysis and collision risk

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APPENDICES

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APPENDIX – "A"

ASSEMBLY RESOLUTION A37-11

(PERFORMANCE BASED NAVIGATION GLOBAL GOALS)

Note: Resolution A37-11 is a result of the 11th Air Navigation Conference recommendations on area navigation implementation and Resolution A33-16 that requested Council to develop a program to encourage States to implement approach procedures with vertical guidance. The main points of Resolution A37-11 are as follows:

The Assembly

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

2. Resolves that:

   a. States complete a PBN implementation plan as a matter of urgency to achieve:

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

      ii. Implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS), including LNAV–only minima, 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% by 2010, 70% by 2014; and

      iii. Implementation of straight-in LNAV-only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5700 kg or more;

   b. ICAO develop a coordinated action plan to assist States in the implementation of PBN and to ensure development and/or maintenance of globally harmonized SARPs, Procedures for Air Navigation Services (PANS) and guidance material including a global harmonized safety assessment methodology to keep pace with operational demands;

3. Urges 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;

4. Instructs the Council to provide a progress report on PBN implementation to the next ordinary session of the Assembly, as necessary;

5. Requests the Planning and Implementation Regional Groups (PIRGs) to include in their work programme, the review of status of implementation of PBNB by States according to the defined implementation plans and report annually to ICAO any deficiencies that may occur; and

6. Declare that this resolution supersedes Resolution A36-23

APPENDIX – "B"

TARGET RNP APCH RUNWAY ENDS

S. No.	AIRPORT NAME	RUNWAY END	MINIMA	STATUS	REMARKS
ANP Aerodromes					
01	AIIAP Lahore	18L	LNAV/VNAV	Implemented	
02		18R	LNAV/VNAV	Implemented	
03		36L	LNAV/VNAV	Implemented	
04		36R	LNAV/VNAV	Implemented	
05	BBIAP Islamabad	12	LNAV	Implemented	Offset intermediate
06		30	LNAV/VNAV	Implemented	
07	BKIAP Peshawar	17	LNAV/VNAV	Implemented	
08		35	LNAV/VNAV	Implemented	
09	Faisalabad Int'l	03	LNAV/VNAV	Implemented	
10		21	LNAV/VNAV	Implemented	
11	Gwadar Int'l	06	LNAV*	Implemented	
12		24	LNAV*	Implemented	
13	JIAP Karachi	07L	LNAV*	Implemented	Offset intermediate
14		07R	LNAV*	Implemented	Offset intermediate
15		25L	LNAV/VNAV	Implemented	
16		25R	LNAV/VNAV	Implemented	
17	Multan Int'l	18	LNAV/VNAV	Implemented	
18		36	LNAV/VNAV	Implemented	
19	Nawabshah Airport	02	LNAV/VNAV	Implemented	
20		20	LNAV/VNAV	Implemented	
21	Quetta Int'l	13L	LNAV/VNAV	Planned	Dec 2017
Other International Aerodromes					
22	Bahawalpur Int'l	08	LNAV/VNAV	Implemented	
23		26	LNAV/VNAV	Implemented	
24	Dera Ghazi Khan Int'l	18	LNAV*	Implemented	
25		36	LNAV*	Implemented	
26	Rahim Yar Khan Int'l	01	LNAV/VNAV	Implemented	
27		19	LNAV/VNAV	Implemented	
28	Sialkot Int'l	22	LNAV/VNAV	Implemented	
29	Turbat Int'l	08	LNAV*	Implemented	
30		26	LNAV*	Implemented	

Domestic Airports					
31	Dalbandin	13	LNAV*	Planned	Dec 2017
32		31	LNAV*	Planned	Dec 2017
33	Dera Ismail Khan	12	LNAV*	Implemented	
34		30	LNAV*	Implemented	

35	Moenjodaro	08	LNAV*	Implemented	
36		26	LNAV*	Implemented	
37	Panjgur	13	LNAV*	Implemented	
38		31	LNAV*	Implemented	
39	Sukkur	14	LNAV/VNAV	Implemented	
40		32	LNAV/VNAV	Implemented	

* Target Aircraft operating at aerodrome ATR42/72-500 not certified for VNAV operations

APPENDIX – "C"

PBN IMPLEMENTATION SCHEDULE FOR EN-ROUTE, TERMINAL AND APPROACH PROCEDURES

PBN Specification	En-route (Oceanic, Remote, Continental)	Terminal Airspace SIDs. STARs	Approach Procedures
RNAV 10	Implemented	N/A	N/A
RNAV 5	Implemented	N/A	N/A
RNAV 2	N/A	N/A	N/A
RNAV 1	N/A	N/A	N/A
RNP 4	N/A	N/A	N/A
RNP 2	2018 - 2020	N/A	N/A
RNP 1	N/A	Implemented	N/A
Advanced RNP*	N/A	N/A	N/A
RNP APCH	N/A	N/A	Implemented
RNP AR APCH*	N/A	N/A	N/A
RNP 0.3	N/A	N/A	N/A

- [For each box indicate timeframe for implementation and where specifications will be used (if applicable. For example, indicate the airports, terminal airspace or en-route airspace). If some are not to be used or are not applicable, indicate N/A.]

* May be considered during long term subject to aircraft equipage and operational benefits.