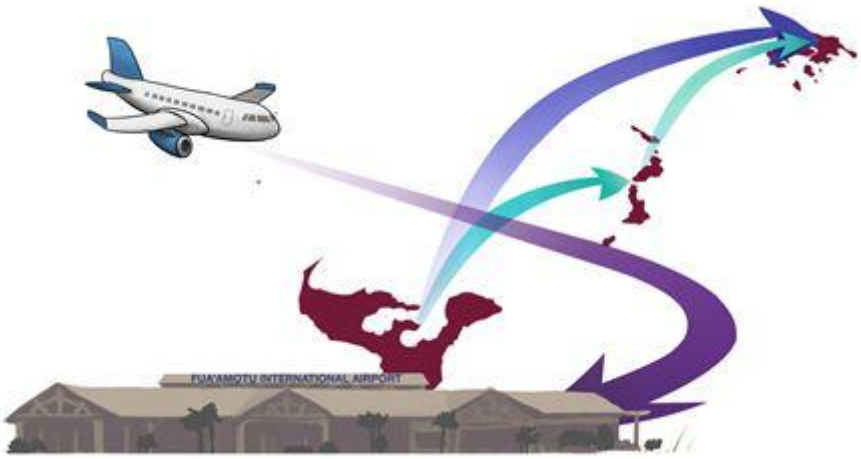
PBN Implementation Plan – Tonga



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Executive Summary

Performance Based Navigation (PBN) is a change from aircraft navigating/flying using ground based navigation aids to using satellite based navigation systems on the flight deck that compute the aircraft's position. This allows aircraft fly closer to optimal profiles producing the following benefits:

- Safety enhancements by using flight trajectories that are safer
- Efficiency improvements by using routes and approaches that minimise fuel burn.
- Environmental performance improvement by minimising both Green House Gas (GHG) emissions and the noise footprint

For the upper airspace the introduction of PBN is the responsibility of New Zealand however Tonga has responsibility to implement PBN in the lower airspace. Notably Tonga already has some Global Navigation Satellite System (GNSS) based approaches that will be reviewed to ensure consistency with current international standards.

The implementation of PBN in Tonga airspace will be delivered in phases with target implementation dates of 2012, 2017 and 2020 to harmonize with New Zealand's PBN implementation plan.

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1 Acronym list

The acronyms used in this document along with their expansions are given in the following list:

ADSB	Automatic Dependent Surveillance - Broadcast
APAC	Asia and Pacific
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APCH	Approach
ATM	Air Traffic Management
Baro VNAV	Barometric Vertical Navigation
CAD	Ministry of Infrastructure (Civil Aviation Division) Tonga
CDO	Continuous Descent Operations
CFIT	Controlled Flight into Terrain
CNS	Communication, Navigation, Surveillance
CTA	Control Area
DA	Decision Altitude A specified altitude in the *precision* approach at which a missed approach must be initiated if the required visual reference to continue the approach has not been established
DME	Distance Measuring Equipment
FIR	Flight Information Region
FMS	Flight Management System
GHG	Green House Gas
GNSS	Global Navigation Satellite System
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
INS	Inertial Navigation System
MDH	Minimum Descent Height A specified height in a *non-precision* approach or circling approach below which descent must not be made without the required visual reference
MEL	Minimum Equipment List
NDB	Non-Directional (Radio) Beacon
PAIP	Pacific Aviation Investment Project
PBN	Performance Based Navigation
RNAV	Area Navigation
RNP	Required Navigation Performance
SID	Standard Instrument Departure
STAR	Standard Instrument Arrival
TAL	Tonga Airports Limited
TMA	Terminal Control Area
VHF	Very High Frequency
VOR	VHF Omni-directional Radio-range

2 Introduction

ICAO Assembly Resolution A36-23 called for each Member State to develop a national Performance Based Navigation (PBN) implementation plan by 2009. This requirement was further reiterated in 2010 by the ICAO Assembly Resolution A37-11. The introduction of PBN must be supported by an appropriate navigation infrastructure consisting of an appropriate combination of Global Navigation Satellite System (GNSS), self-contained navigation system (inertial navigation system) and conventional ground-based navigation aids.

APANPIRG has developed a regional PBN implementation plan that addresses primarily upper airspace (Oceanic, Remote continental, and Continental en-route). States/Territories are required to develop their own national plans for the implementation of PBN in Terminal Control Areas (TMA). The plan also notes the need to meet acceptable safety risk measures.

A National steering committee is expected to be established during the first quarter of 2013 to oversee the PBN implementation in Tonga. The members of the committee will include officials from the Government Transport Policy Division, Civil Aviation Regulatory Authority, ANS Providers, Aircraft Operators, Airport Operators, other airspace users and any other entity considered relevant.

Communication between these stakeholders and other agencies will be achieved through regular meetings and communications when and as required.

3 PBN Description

PBN represents a shift from aircraft navigating/flying using ground based navigation aids to relying on satellite based area navigation systems on the flight deck that compute the aircraft's position. The results of PBN are:

- En-route
    - More direct flight paths that no longer need aircraft to "zigzag" between beacons on the ground.
- Terminal
    - Efficient curved tracks that take into account terrain and environmental sensitivities (noise etc….)
    - Continuous climb/descents avoiding the need for unnecessary aircraft thrust changes.

PBN essentially consists of:

- Area Navigation (RNAV) – which enables aircraft to fly independent of ground-based navigation aids using satellite based systems or a combination of both.
- Required Navigation Performance (RNP) – is RNAV with the addition of an on-board performance monitoring and alerting capability. It allows an aircraft to fly a specific path between 3-dimensionally defined points in space.
- A defining characteristic of more precise RNP operations is the ability of the aircraft navigation system to monitor the navigation performance it achieves and inform the crew if the requirement is not met during an operation. Certain RNP operations require these advanced monitoring features and approved training and crew procedures.

Navigation performance specification defines the performance required of the system together with any aircraft and crew requirements.

Examples:

- RNP 2 – en route
- RNP 1 – for Standard Instrument Departures (SIDs), and Standard Terminal Arrival Routes (STARs)
  RNP 10 is the minimum capability in the Tonga upper airspace within the Auckland Oceanic FIR and RNP 4 procedures are applied to aircraft with that capability.
- RNP APCH – RNP Approach, accuracy of 0.3 NM.
  RNP AR APCH – RNP Approval Required (from Regulator) Approach, accuracy of better than 0.3 down to 0.1 NM.
  RNP approaches to 0.3 NM and 0.1 NM at Queenstown Airport in New Zealand are the

primary approaches used by Qantas and Air New Zealand for both international and domestic services.

- RNP APCH with Baro VNAV
  Modern aircraft (737-3/A320 and larger) have on-board capability of flying the above RNP 0.3 and RNP AR APCH with Baro VNAV which provides an accurate vertical fly up/down profile similar to the ground based Instrument Landing System (ILS).

Globally PBN aims to ensure standardization of RNAV and RNP specifications and to limit the proliferation of navigation specifications in use world-wide. Locally PBN reduces the need to retain and maintain ground-based routes, procedures and navigation aids.

4 Scope

This plan addresses PBN implementation in Tonga lower airspace, namely below FL245. It focusses primarily on the Fua'amotu TMA.

For the upper airspace the introduction of PBN is the responsibility of New Zealand and has largely been implemented throughout the South Pacific for oceanic en-route flight operations.

5 Stakeholders

The prime stakeholders and role in this plan are:

- Ministry of Infrastructure (Civil Aviation Division) Tonga
  To ensure that CAA processes, Civil Aviation Rules and guidance material aligns with both international and regional PBN standards
- Tonga Airports Ltd
  To ensure that
  - The CNS/ATM infrastructure will support each phase of PBN implementation
  - The relevant Safety Cases are conducted and align with internationally accepted practices
  - Sufficient trained and qualified personnel are available to support the implementation of PBN
- Airlines and airspace users
  To ensure aircraft fleet capabilities harmonize with this plan

6 Strategic objectives

The strategic objectives of this plan are to:

- Provide for the transition to PBN in Tonga lower airspace in accordance with the implementation goals of the Assembly resolution A37-11, short term (prior to December 2012), medium term (2013-2017) and long term (beyond 2018)
- Ensure the implementation of PBN concepts meet
  - Internationally accepted safety risk criteria
  - Established operational requirements

- Harmonize with adjacent states and Regional PBN implementation plans to avoid;
    - Multiple equipment requirements on aircraft
    - Multiple airworthiness and operational approvals for operators
- Outline the PBN concepts (including RNAV and RNP specifications), that will be applied to IFR aircraft operations using instrument approaches, and ATS routes including Standard Instrument Departures (SIDs) and Standard Instrument Arrivals (STARs)
- Ensure the communications, navigation, surveillance and ATM infrastructure is capable of supporting PBN
- Accommodate mixed-equipage aircraft operations

7 Current Status of Navigation Infrastructure

Tonga has 1 international airport and 5 domestic airports. The table below indicates their capabilities and airline services.

Airport	*Approach / Navigation Aid*	*Non-precision approach*	*Communications*	*Surveillance*
Fua'amotu	VOR / DME NDB	RNAV (GNSS)	HF, VHF	NIL
Eua	Visual only		VHF	NIL
Ha'apai	NDB*	RNAV (GNSS)	HF, VHF	NIL
Niuafo'ou		RNAV (GNSS)	HF, VHF	NIL
Niuatoputapu	NDB*	RNAV (GNSS)	HF, VHF	NIL
Vava'u	NDB	RNAV (GNSS)	HF, VHF	NIL

*NDB currently NOTAM unserviceable

To date there has been no operational need for dedicated domestic RNAV routes.

International flights fly conventional (ground based navigation aid) departure and arrival procedures joining RNAV routes.

The existing RNAV (GNSS) APCH's above were designed over 10 years ago for use by aircraft with GNSS stand-alone TSO 129 equipment although these approaches can also be flown by RNP 0.3 aircraft.

As stated earlier, flights in the upper airspace within the Auckland Oceanic FIR fly to RNP 10 or 4 capabilities.

8 Aircraft Fleet Equipage

As at December 1, 2012 all aircraft that fly in to Tonga are either registered in New Zealand or Fiji and have PBN capability. This is a significant proportion of the IFR capable fleet. The

following table indicates the estimated state of PBN technical capability of major scheduled carriers in Tonga as of December 2012:

Current Estimated Airline Fleet PBN Capability

Aircraft Type	RNAV 2/ 1	RNP APCH Basic RNP 1	RNP AR APCH	APV (Baro-VNAV)
A320	100%	100%	100%	100%
B733	100%	40%	40%	40%
B738	100%	100%	100%	100%
B763	100%	0%	0%	0%
ATR42	100%	100%	0%	0%
CVLT	100%			
SW4B	100%			

9 Airspace Concept

An airspace concept may be viewed as a general vision or a master plan for a particular airspace. Each airspace concept is based on an agreed set of principles that support the achievement of specific objectives. The strategic objectives which most commonly drive airspace concepts are safety, capacity, efficiency, access and the environment.

9.1 Key Airspace Concepts

The agreed concepts for Tonga will be implemented through a three-phase process that will deliver incremental improvements to:

- Safety improvements (through more precise trajectory management & CDO that support the ICAO strategy to address CFIT accidents)
- Predictability and repeatability
- Efficiency (minimal air distance / optimum aircraft determined profile)
- Minimising environmental impact (e.g. from carbon dioxide, oxides of nitrogen and noise)
- Maximising capacity utilisation (aerodrome & airspace)
- Higher aircraft utilisation (sectors flown per day)
- Schedule reliability
- Cost effective investment
- Minimised quantity of CTA and optimised design

All ATS routes (including SIDs and STARs) will be enabled by RNAV (or RNP, where required): All runway ends with instrument approach procedures will be enabled by RNP (with APV where possible based on Baro-VNAV).

10 Operational concept

This plan calls for implementation of PBN within the Fua'amotu TMA to take advantage of international operators PBN capabilities, and to offer PBN departure, arrival and approach procedures.

For domestic routes and airports, namely between Fua'amotu, Eua, Ha'apai, Niuafo'ou

Niuatoputapu, and Vava'u, the existing RNAV (GNSS) procedures will be updated to be fully capable PBN procedures when the operational need or capability exists.

While safety and operator efficiency will be enhanced by introducing PBN it should be noted that, as part of the World Bank Pacific Aviation Investment Project (PAIP), it is planned that safety enhancement will also be augmented by the introduction of ADS-B at Fua'amotu and Vava'u providing surveillance capability throughout the lower airspace.

Safety risk assessments will be conducted to identify issues that need to be addressed such as system redundancy, training, adequate regulations etc.

The decommissioning of terrestrial navigation systems will be assessed from time to time and are expected to be completed during Phase 3 as described below.

10.1 Operational Concept for Phase One

During Phase One the operational concept will be a mixed-mode navigation environment that allows continued use of legacy navigation applications while PBN capability is progressively implemented in aircraft fleets and the supporting infrastructure. The benefits to operators will be limited by the diversity of navigation performance and the ATM system's ability to manage this diversity. The ground infrastructure associated with legacy navigation systems will be reviewed and progressively adapted to reflect the progress made on implementation of PBN. General aviation VFR flight access to CTA will not be subject to any additional restrictions during this phase.

10.2 Operational Concept for Phase Two

During Phase Two the operational concept will move to a more exclusive PBN environment that places greater reliance on the level of PBN capability in the national fleet and infrastructure. This change will enable further realisation of the goals outlined above. The ATM system will be managing a more homogeneous navigation capability and have greater ability to minimise the negative impact of aircraft that the lack required navigation performance capability. General aviation VFR flight access to CTA may be restricted during periods of capacity constraint but only to the extent needed to ensure that the flight paths of PBN capable flights are not restricted.

10.3 Operational Concept for Phase Three

During Phase Three the operational concept will be a mature PBN environment with a comprehensive fleet and infrastructure capability that delivers the fullest expression of the airspace concept and goals outlined above. A mature set of ATM tools will complement the airborne systems and will also enable the effective management of those aircraft that may experience a temporary loss of PBN capability without significantly impacting other airspace users. General aviation VFR flight access to CTA may be restricted during periods of capacity constraint but only to the extent needed to ensure that the flight paths of PBN capable flights are not restricted.

11 Safety - Risks Associated with Major System Change

During the transition to a mature PBN environment the government and industry will face significant challenges. The government challenges will include support of Civil Aviation Rule changes and associated preparatory work. The industry challenges will involve resourcing and managing a diverse range of navigation systems with equally diverse requirements. Some of the key identified challenges are:

- Adoption of supporting Civil Aviation Regulations
    - Regulatory and policy changes needed to enable PBN operations
    - Requirements to establish an airworthiness and operational approval process
- PBN capability register and aircraft minimum equipment lists (MEL)
- Integration of PBN capability into the ATM system (Flight Plan data fields) Mixed fleet/system operations
- Safety monitoring of ATM system
- Approach naming and charting conventions
- Navigation database integrity and control
- GNSS system performance and prediction of availability service
- Continued involvement in CNS/ATM and PBN development
- Availability and coordination of resources in CAD, TAL and industry to implement PBN
- Periodic safety reviews of PBN system
- Education and training of personnel employed by CAD, TAL and aircraft operators

12 Operational Efficiency Benefits

a) Efficiency gains enabled through PBN include:

- Lower MDH/DA specifications for approaches
- Greater flexibility of airspace design in terminal area airspace
- Reduced track distance, noise and fuel consumption through PBN enabled ATS routes and approach procedures
- Reduced environmental impact.

b) The synchronised integration of PBN and non-PBN air routes, airspace and aircraft will be vital if these efficiency gains are to be fully realised.

13 Approaches with Vertical Guidance

PBN approaches with vertical guidance in Tonga will be based on Baro-VNAV specifications for the foreseeable future. The development of a GNSS enabled precision approach application will be monitored closely but early adoption is considered unlikely due to the lack of suitable GNSS augmentation systems within Tonga airspace.

14 Implementation Schedule

14.1 Short term (2008-2012)

- Oceanic En route
  Current capability

Refer to the PBN Implementation Plan – New Zealand

- Terminal Areas (Departures and Arrivals)
  Current capability

- Approach
  Current capability

14.2 Medium term (2013-2017)

- Oceanic En route
  Refer to the PBN Implementation Plan – New Zealand

- Fua'amotu TMA (Departures and Arrivals)
  De-conflicted SIDs and STARs will be implemented to be consistent with airline PBN capabilities subject to operational need and safety assessments
  STARs will facilitate aircraft tracking from an en-route waypoint to the initial approach fix.

- Fua'amotu Approach
  The existing RNAV GNSS approaches will to be reviewed and updated to reflect the latest procedure design criteria and updated runway coordinates and obstacle survey data and to facilitate Baro VNAV operations for the regular international jet operations.

- Domestic airports
  The existing RNAV GNSS approaches will to be reviewed and updated to reflect the latest procedure design criteria and updated runway coordinates and obstacle survey data.

- Surveillance
  ADSB surveillance will be implemented (Refer to the PAIP project)

14.3 Far term (2018-2022)

Any further introduction will be subject to a review of safety and operational need, and aircraft fleet capability.

15 Technology Recommendations

Aircraft equipment and ATM requirements will change as PBN is implemented with new technology needing to be utilised in the aviation system. These include the following which will be reviewed by the PBN technical groups to set specific timeframes and requirements.

16 GNSS Equipment

These requirements will be determined based on new equipment availability and industry developments. There will be a transition from single GPS to multi-constellation GNSS equipment.
This may include requirement for TSO C145/146 from 2020.

17 ATC Transponder

Possibly by 2015 the Transponder requirements will need to become Mode-S Elementary (minimum) and Mode-S Enhanced (recommended). Additionally ADS-B using Modes-S 1090Mhz extended squitter (DO260A or later) will be implemented toward the final phase in 2015.

18 List of organisations consulted

Air New Zealand
Air Pacific
Airways New Zealand
Chathams Pacific
Ministry of Transport Tonga
Virgin Australia (NZL Ltd)

Useful links
The following links are provided further reference:

www.caa.govt.nz/PBN/pbn.htm
PBN Implementation Plan – New Zealand

www.icao.or.th/edocs/index.html
PBN Implementation Plan – APAC Region

www.icao.int/safety/pbn
ICAO PBN website provides information on what other states have included in their plans