Thailand Performance Based Navigation (PBN) Implementation Plan (2010 - 2020)

Executive Summary

This Thailand PBN Implementation Plan is an updated version of the first Implementation Plan developed in 2009 by a working group participated by Department of Civil Aviation, currently Civil Aviation Authority of Thailand (CAAT), representatives from Thai airline operators, Thai Pilot's Association, Airports of Thailand Public Company Limited, and Aeronautical Radio of Thailand Limited. This Plan aims to provide concerning parties with appropriate implementation guidance and timelines to allow proper preparation for Performance Based Navigation (PBN) implementations within Bangkok Flight Information Region (FIR). The Plan is aligned with the Asia/Pacific Seamless ATM Plan.

This Thailand PBN Implementation Plan provides assessments of fleet readiness status and CNS infrastructure, which results in selection of appropriate PBN navigation specifications and implementation strategies for En-route and Terminal Area operations. It also explains some tangible operational benefits, derived from actual PBN implementation.

1. Introduction

1.1 The continuing growth of aviation places increasing demands on airspace capacity and the need for optimum utilization of available airspace. With these needs and the fluctuation in fuel costs as well as higher concerns on aircraft/airport noise to the environment, aviation industry calls for new navigation technologies and operation procedures to be implemented. In responded to this call for actions, ICAO Asia/Pacific Air Navigation Planning and Implementation Regional Group, APANPIRG, adopted several conclusions to promote the uses of Performance-Based Navigation (PBN) and Global Navigation Satellite System (GNSS) as the navigation elements of CNS/ATM systems. These navigation technologies and specifications have promising potentials to provide accurate, reliable and seamless position determination and navigation capabilities to airspace users.

1.2 Introduction of PBN specifications and GNSS technology facilitate more efficient use of airspace and more flexibility for procedure design. They cooperatively result in improved safety, access, capacity, predictability, operational efficiency, fuel economy, and environmental effects.

2. Benefits of PBN

2.1 PBN offers a number of benefits over the sensor-specific navigation routes and procedures. Some of the benefits are being listed below:

- Reduced need to maintain sensor-specific routes and procedures, and their associated costs
- Avoids need for development of sensor-specific operations with each new evolution of navigation system. The present requirement of developing procedures with each new introduction is often very costly.
- Allows more efficient use of airspace in true harmony with the way in which RNAV systems are used

- Facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.
- For the pilots, the main advantage of using this system is that the navigation function is performed by highly accurate and sophisticated on-board equipment and thus allowing reduction in cock-pit workload and also increase in safety.
- For Air Traffic Controllers, the main advantage of aircraft using a RNAV system is that ATS routes can be straightened as it is not necessary for the routes to pass over locations marked by conventional navigation aids.
- RNAV based arrival and departure routes can complement and even replace radar vectoring, thereby reducing Approach and Departure Controllers' workload.

3. Global Perspectives and Needs for Harmonization

3.1 The 37th Session of the ICAO Assembly held in Montreal in September 2010 adopted Resolution A37-11 urging all the States to implement RNAV and RNP air traffic services (ATS) routes and procedures in accordance with ICAO PBN concept described in the *Performance Based Navigation Manual* (Doc 9613). The Assembly 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 5700 kg or more, according to established timelines and intermediate milestones.

3.2 The PBN concept specifies RNAV and RNP system performance requirements in terms of accuracy, integrity, availability, continuity and functionality needed for the proposed operations in the context of a particular Airspace Concept, when supported by the appropriate navigation infrastructure. In that context, the PBN concept represents a shift from sensor-based to performance-based navigation. Performance requirements are identified in navigation specifications which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements. These navigation specifications are defined at a sufficient level of detail to facilitate global harmonization by providing specific implementation guidance for States and operators.

3.3 Under the PBN concept, the generic navigation requirements are defined based on operational requirements. Thus, users may evaluate the available options. To ensure synchronization of investment and interoperability of the airborne and ground systems, the selection of the solution should be in consultation with aviation stakeholders, including international and domestic airline operators, air navigation service providers, and regulators. The solution selected should also be the most cost-effective one.

3.4 The development of PBN concept recognized that advanced aircraft RNAV systems are achieving an enhanced and 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. It also takes account of the fact that RNAV systems have developed over a 40-year period and as a result there were a large variety of differing implementations globally. Identifying navigation requirements rather than on the means of meeting the requirements will allow use of all RNAV systems meeting these requirements irrespective of the means by which these are met.

3.5 APANPIRG established the PBN Implementation Coordination Group (PBNICG) to serve as the primary APAC Regional Body to support PBN implementation, harmonization and prioritization with a goal to enhance safety and efficiency of aircraft trajectories and operations. Accordingly, States are encouraged to work cooperatively bilaterally, multilaterally and with the Implementation Coordination Group to ensure regional and sub-regional harmonization of PBN implementation.

3.6 **Route Operations -** The application of RNP 2, RNP 4, and RNP 10 navigation specifications is expected for Oceanic and Remote continental routes. For Continental routes, the application of RNP 2, RNAV 2 and RNAV 5 navigation specifications is expected.

3.7 **TMA Operations** - In selected TMAs, the application of RNAV 1 in a radar environment can be supported through the use of GNSS or ground navigation infrastructure, such as DME/DME and DME/DME/IRU. In this phase, mixed operations (equipped and non-equipped) will be permitted. In a non-radar environment and/or in an environment without adequate ground navigation infrastructure, the SID/STAR application of RNP 1 is expected in selected TMAs with exclusive application of GNSS. In this phase, mixed operations (equipped and non-equipped) will be permitted.

3.8 **Instrument Approaches** - The application of RNP APCH with Baro-VNAV procedures is expected to be implemented in the maximum possible number of airports, commencing primarily with international airports. To facilitate transitional period, conventional approach procedures and conventional navigation aids should be maintained for non-equipped aircraft. The use of APV operations (Baro-VNAV or augmented GNSS) will be promoted to enhance safety and accessibility of RNP approaches. The application of RNP AR APCH procedures should be considered in selected airports, where obvious operational benefits can be obtained due to the existence of significant obstacles.

3.9 **Summary table & Implementation Plan for Asia-Pacific Region**

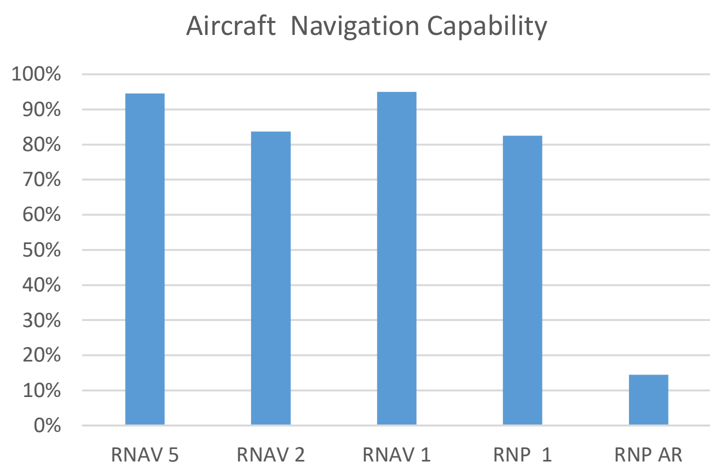
Nov 2019	
Airspace	**Preferred Nav. Specifications**
Route – Oceanic	RNP 2
Route – Remote continental	RNP 2
Route – Continental en-route	RNP 2
TMA – Arrival	RNAV 1 in radar environment and with adequate navigation infrastructure. RNP 1 in non-radar environment
TMA – Departure	RNAV 1 in radar environment and with adequate navigation infrastructure. RNP 1 in non-radar environment
Approach	RNP APCH with Baro-VNAV in possible airports RNP AR APCH in airport where there are obvious operational benefits.

4. Fleet Readiness Status

4.1 All major commercial aircraft manufacturers since the 1980's have included RNAV capabilities. The commercial aircraft currently produced incorporate an RNP capability.

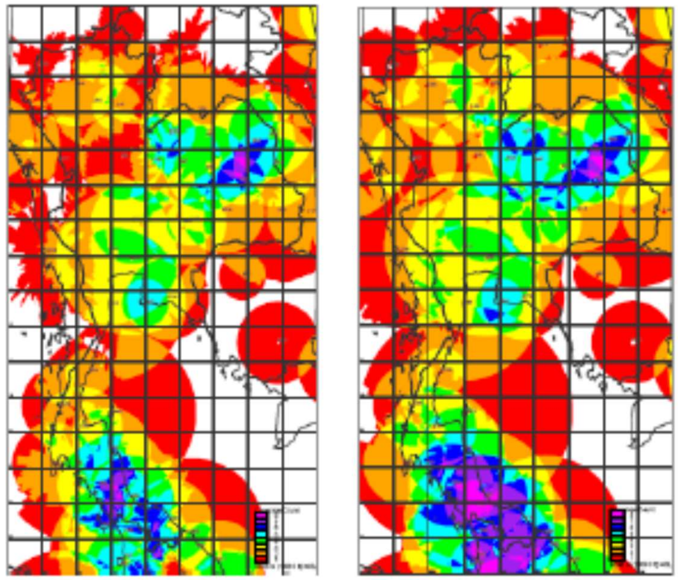
4.2 One significant issue for PBN implementation today is directly related to the multitude of FMS installations and varying degrees of capabilities associated with the current fleet of RNAV aircraft. Specifically, there are numerous FMS systems installed in today's fleets, all with varying capabilities.

4.3 The following table displays a high level analysis of PBN aircraft capability for flights operating within Bangkok FIR. The fleet readiness status is based on sample flight plan from 2016.



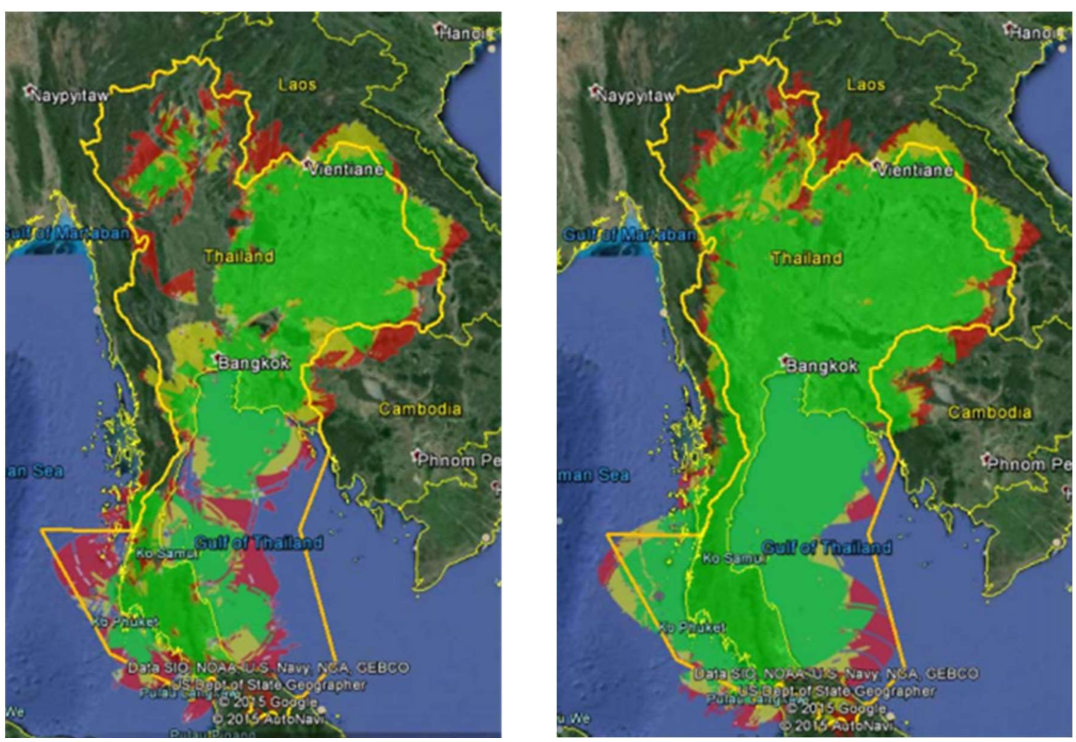
5. Assessment of CNS Infrastructure

5.1 VOR/DME coverage within the Bangkok FIR is as follows:



10,000 ft **20,000 ft**

5.2 DME/DME coverage within the Bangkok FIR at 20,000 ft. is as follows:

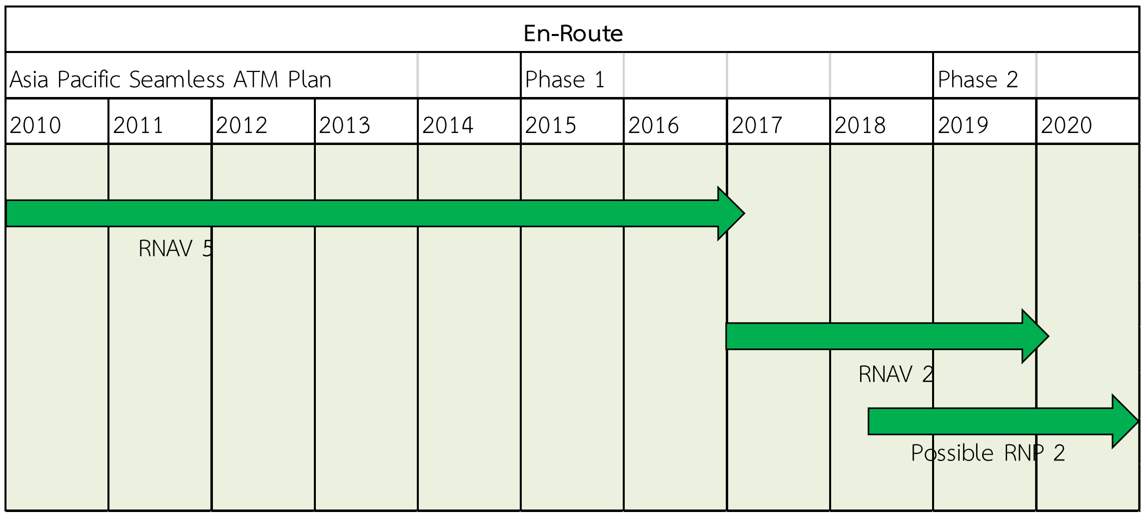


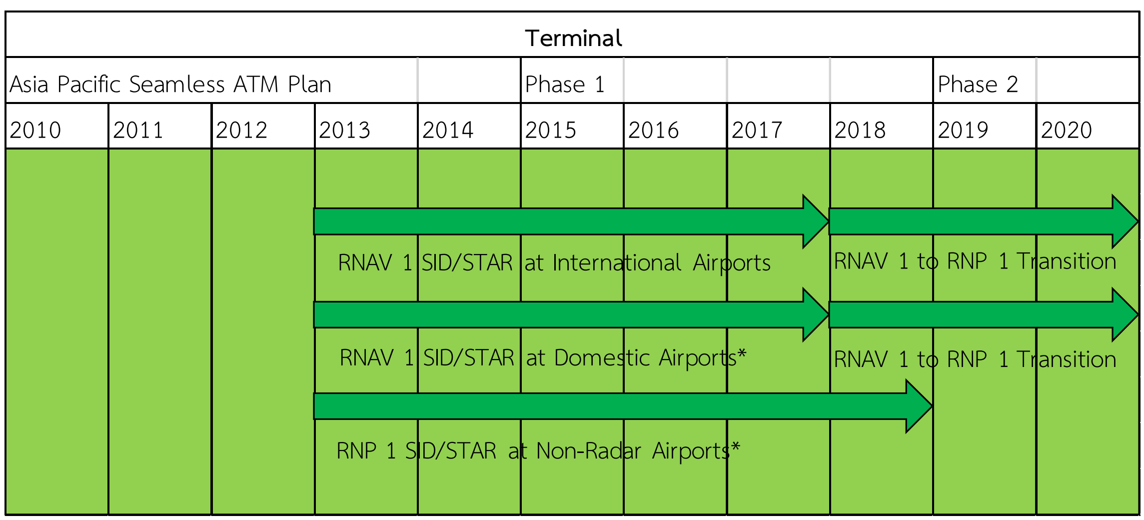
Current Coverage Expected Coverage in 5 Years

DME/DME Redundancy Double DME/DME Redundancy Triple DME/DME Redundancy

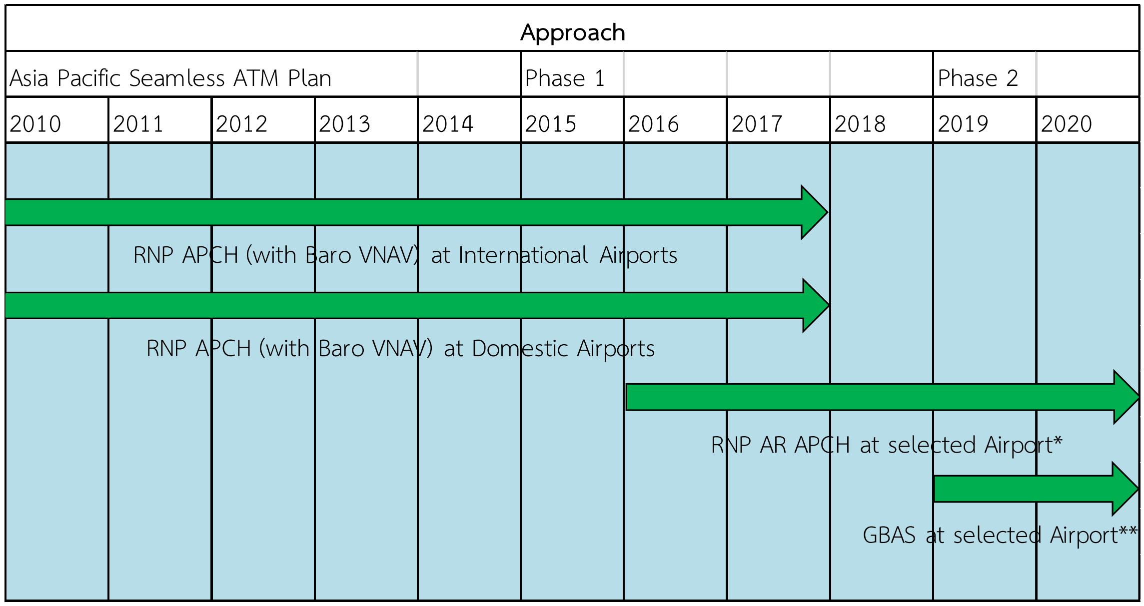
6. Thailand PBN & GNSS Navigation Specification Roadmap

6.1 To assist planning and to assure proper equipages by aircraft operators, the following Navigation Specification Roadmap for PBN & GNSS should be used for implementation planning over Bangkok FIR. The Roadmap is consistent with Asia/Pacific ATM Seamless Plan adopted by ICAO APANPIRG/19.





* RNAV/RNP SID is planned for all domestic airports while STARs will be implemented at selected airport taking into consideration traffic, environment and other restrictions.



* Planned for Krabi, Hat Yai, Phuket and Don Mueang Airport.
** Planned for Suvarnabhumi International Airport where benefits can be realized and most operators are anticipated to have aircraft capability.

7. Current PBN Status

7.1 Approach and Terminal

7.1.1 The following table shows a list of PBN implementations in terminal airspaces of international[1] and major airports in Thailand already in operation. In line with Asia and Pacific Seamless ATM Plan, APV procedures are expected to replace straight-in LNAV procedures at the rest of international airports by 2019.

Airport Name	Runway End	LNAV	LNAV/ VNAV	RNAV/RNP 1 SID	RNAV/RNP 1 STAR
Chiang Mai	18	✓			
	36	✓		✓	✓
Chiang Rai	03	✓			✓
	21	✓			
Don Mueang	03L*	N/A	N/A	✓	✓
	03R*	N/A	N/A	✓	✓
	21L	✓	✓	✓	✓
	21R	✓	✓	✓	✓
Hat Yai	08*	✓			
	26*	✓			
Khon Kaen	03	✓		✓	
	21	✓		✓	
Krabi	14*	N/A	N/A	✓	
	32*	✓		✓	✓
Phitsanulok	14	✓	✓	✓	
	32	✓	✓	✓	
Phuket	09*	✓	✓	✓	✓
	27*	✓	✓	✓	✓
Surat Thani	04	✓			
	22	✓			
Suvarnabhumi	01L	✓	✓	✓	✓
	01R	✓	✓	✓	✓
	19L	✓	✓	✓	✓
	19R	✓	✓	✓	✓
Ubon Ratchathani	05	✓	✓	✓	
	23	✓	✓	✓	
U-Tapao	18	✓	✓		
	36	✓	✓		

7.1.2 RNP-AR procedures are currently being designed for four airports namely Hat Yai, Phuket, Krabi and Don Mueang Airport. (Denoted with * in the table) The implementation of RNP-AR procedures at these airports are subject to further regulatory approval process with the expectation of the first procedures being published in 2017.

[1] International Airports as listed in APAC Regional Air Navigation Plan and could be revised in the future as appropriate.

7.1.3 A GBAS system is currently being considered for Suvarnabhumi International Airport to serve as the backups for ILS at four runway ends with installation tentatively planned for 2020. Subject to further study on signal interference and approval process, GLS implementation is expected to follow shortly after.

7.1.4 The following table shows a current PBN implementation status in other instrument airports in Thailand. RNP APCH with Baro-VNAV procedures are expected to be implemented at the remaining four low-traffic airports in 2017.

Airport Name	**Runway End**	**LNAV**	**LNAV/VNAV**
Samui	17	✓	
	35	✓	
Udon Thani	12	✓	
	30	✓	
Narathiwat	02	✓	
	20	✓	
Nakhon Si Thammarat	01	✓	✓
	19	✓	✓
Ranong	02	✓	
	20	N/A	N/A
Nakhon Ratchasima	06	✓	
	24	✓	
Roi Et	18		
	36		
Chumphon	06		
	24		
Buriram	04		
	22		
Phetchabun	18		
	36		

7.1.5 RNP approach procedures have also been implemented at other smaller airports and are summarized in the table below. Additional procedures will be implemented where practicable, in order of priority set according to benefits and other constraints.

Airport Name	**Runway End**	**LNAV**	**LNAV/VNAV**
Trat	05	N/A	N/A
	23	✓	
Lampang	18	✓	
	36	✓	
Phrae	01	✓	
	19	N/A	N/A
Hua Hin	16	✓	
	34	N/A	N/A
Mae Sot	09	N/A	N/A
	27	✓	
Pattani	08	✓	
	26	✓	

Airport Name	Runway End	LNAV	LNAV/VNAV
Trang	08	✓	
	26	N/A	N/A
Sakon Nakhon	05	N/A	N/A
	23	✓	
Nakhon Phanom	15	✓	✓
	33	✓	✓

7.2 En-route

7.2.1 For en-route airspace, in 2013 Thailand has established unidirectional RNAV 5 routes connecting from Phuket to Bangkok (Y5 Route) and between Bangkok and Chiang Mai (Y6 and Y7 Routes). The unidirectional routes are designed to increase airspace efficiency based on the PBN concept and the Flexible Use of Airspace (FUA) concept. Moreover these routes are created to reduce aircraft fuel consumption and green gas emission and to enhance safety and improve flow capacity of air traffic operations.

7.2.2 For en-route airspace, in 2014, Thailand has established five additional unidirectional RNAV 5 routes connecting Bangkok with southern destinations, as depicted in the following figure and table:

Route Designator	Direction	Main City Pairs Served
Y8	Southbound	Bangkok to Phuket/Surat Thani/Krabi/Trang
Y9 / M769	Northbound	Hat Yai/Samui/Kuala Lumpur/Penang to Bangkok
Y10 / M757	Southbound	Bangkok to Hat Yai/Samui/Kuala Lumpur/Penang
Y11	Southbound	Bangkok to Singapore/Jakarta
Y12	Northbound	Singapore/Jakarta to Bangkok

These routes are designed based on the PBN concept and the flexible use of airspace (FUA) concept to enhance safety and improve flow capacity of air traffic operations between Bangkok and major cities in the southern part of Thailand, as well as other international destinations south of Thailand.

7.2.3 The routes Y9 and Y10, later in 2015, have been upgraded from domestic to international routes, M769 and M757 respectively, connecting between Bangkok FIR and Kuala Lumpur. The upgrade is aimed at improving flow capacity between Bangkok and Malaysia.

7.2.4 In 2016, five additional domestic RNAV 5 routes were established. Four unidirectional routes, Y13, Y14, Y15 and Y16, are designed to enhance flow of traffic between Bangkok and its eastbound international destinations and lessen the congestion of the existing routes A1 and A202.

8. Tangible Benefits of PBN

8.1 **Phuket International Airport (VTSP)** The following table summarizes benefits of PBN implementation at Phuket International Airport.

	Conventional	PBN
Runway 27	1.4-degree ILS offset	Runway aligned approach
Runway 09	6-degree VOR offset	Runway aligned approach
	No vertical guidance	Vertical guidance
	OCA at 850 feet	OCA at 750 feet

8.2 **Samui International Airport (VTSM)** The following table summarizes benefits of PBN implementation at Samui International Airport.

	Conventional	PBN
Runway 17	Runway aligned, yet pass through unstable weather area	Runway aligned approach, using side-step to avoid the unstable weather area

8.3 **Hat Yai International Airport (VTSS)** The following table summarizes benefits of PBN implementation at Hat Yai International Airport.

	Conventional	PBN
Runway 08	Unavailable due to mountainous terrain	Runway aligned approach

8.4 **Chiang Mai International Airport (VTCC)** The following table summarizes benefits of PBN implementation at Chiang Mai International Airport.

	Conventional	PBN
Runway 18	VOR circling approach with high OCA/H	Runway aligned approach

8.5 **Udon Thani International Airport (VTUD)** The following table summarizes benefits of PBN implementation at Udonthani International Airport.

	Conventional	PBN
Runway 12	12-degree VOR offset	Runway aligned approach