



International Civil Aviation Organization

**The Eighth Meeting of the Performance Based Navigation Task Force
(PBN TF/8)**

New Delhi, India 12 – 13 May 2011

Agenda Item 4: PBN Implementation Issues

**Progress on the Establishment of
APAC Regional RAIM Prediction System**

(Presented by Thailand)

SUMMARY

This paper presents information on the establishment of a Regional RAIM (Random Anonymity Integrity Monitoring) System. GNSS (Global Navigation Satellite Systems) is considered a main navigation infrastructure supporting PBN (Performance Based Navigation) operations. It is now also becoming a critical component of surveillance systems, such as ADS-B (Automatic Dependent Surveillance-Broadcast). Unpredicted outage of GNSS services can cause undesired interruptions on aircraft operations. ICAO Annex 10 and ICAO PBN manual require States and ANSPs (Air Navigation Service Providers) to provide timely warnings of GNSS RAIM outages. RAIM prediction results are needed daily by pilots, flight dispatchers, air traffic controllers and airspace planners.

ICAO PBN TF/7 endorsed the minimal technical and operational requirement for a regional RAIM prediction system. This working paper discusses AEROTHAI's progress on the establishment of the APAC Regional RAIM Prediction System.

This paper relates to –

Strategic Objectives:

- A: *Safety – Enhance global civil aviation safety*
- C: *Environmental Protection and Sustainable Development of Air Transport – Foster harmonized and economically viable development of international civil aviation that does not unduly harm the environment*

Global Plan Initiatives:

- GPI-5 RNAV and RNP (Performance-based navigation)
- GPI-11 RNP and RNAV SIDs and STARS
- GPI-21 Navigation systems

1. **Introduction**

1.1 Implementations of PBN and GNSS facilitate more efficient use of airspace and more flexibility for operational procedure. They cooperatively result in enhanced safety, access, capacity, predictability, operational efficiency, fuel economy, and environmental sustainability.

1.2 Implementation of PBN is strongly supported by major aviation stakeholders, including ICAO, IATA, and CANSO. On April 1, 2009, a joint industry declaration in support of PBN implementation was issued calling upon all leaders of the civil aviation community to fully support implementation of PBN into the air navigation system in accordance with the ICAO provisions and established timetable.

1.3 GNSS is considered the main navigation infrastructure supporting PBN operations. GNSS provides highly accurate and high-integrity navigation and positioning services for aircraft. GNSS also enables on-board monitoring and alerting capability which are required for Required Navigation Performance (RNP) operations.

1.4 Unpredicted outages of GNSS services can cause undesired interruptions on aircraft operations. Safety impacts may become more severe during approach phase of flights especially if pilots are not aware of such outages.

1.5 ICAO APANPIRG at its 20th meeting was reminded that GPS (Global Positioning System) prediction service was a necessary part of GNSS approvals to allow for the fluctuations in service availability. Concern was also raised over possible future GNSS outages due to satellite constellation anomalies and other factors.

1.6 GNSS is presently not only used for navigation, but is also becoming a critical component of surveillance system, such as ADS-B, plus many aviation applications that depend on accurate timing, for example SSR radar.

2. **Requirements for Receiver Autonomous Integrity Monitoring**

2.1 RAIM provides integrity monitoring of GNSS satellites for aviation applications. RAIM utilizes redundancy of satellite signal measurements combined with aircraft barometric altitude equipments to detect any faulty satellite signal based on satellite geometry and probability analysis.

2.2 ICAO Annex 10 and ICAO PBN manual require States and ANSPs to provide timely warnings of GNSS RAIM outages. A pre-flight GNSS RAIM prediction analysis is required by the FAA for flights intending to use RNAV/RNP routes and departure and arrival procedures while using GPS as the sole navigation source.

2.3 RAIM prediction results are needed daily by pilots, flight dispatchers, air traffic controllers and airspace planners. The use of appropriate RAIM prediction services is considered to be a necessary part of GNSS approvals. Pilots and air traffic controllers need such information to ensure proper flight planning during possible service unavailability.

2.4 RAIM prediction is required for en-route, terminal area, and approach operations. RAIM prediction algorithms for different types of GNSS receivers and avionics configuration are also different.

3. **Regional RAIM Prediction Services**

3.1 As RAIM service prediction algorithms use pre-determined satellite orbit and maintenance schedule to assess future outages, one single RAIM prediction system can technically provide a RAIM prediction service for the whole world or an entire region.

3.2 However, it is still within States' responsibilities to provide RAIM outage information to airspace users and aviation stakeholders. All safety-related information provided by a RAIM prediction service will need to be recognized and authorized by State before it can be used.

3.3 With these reasons, it is thus not cost effective for each State to invest on an individual RAIM prediction system. Moreover, various implementations of RAIM prediction services may result in inconsistency of RAIM prediction information provided by various States. This may cause operational problems especially during en-route operation over international airspace.

3.4 A common, regional RAIM prediction service for region such as South-East Asia can prove to be an effective solution. By harmonizing RAIM prediction information among States, the regional RAIM prediction service will **enhance seamless air traffic operation**, while **providing a cost-effective investment solution**. A regional RAIM project will also provide a **forum for States to share their knowledge and experiences**.

3.5 ICAO APANPIRG Decisions 20/38 and 20/39 task the ICAO PBN Task Force to examine the feasibility of establishing a regional RAIM prediction system and invite ICAO to develop guidance materials on establishing common implementation rules and technical standards for GNSS reporting and prediction requirements.

3.6 The 46th DGCA Conference encouraged States to support and place priority on the ICAO Task Forces and work programmes for the Asia-Pacific. Proposals on specific mechanisms, such as a regional RAIM prediction service, could also be looked into.

3.7 The APEC GNSS Implementation Team (GIT), a team established under the Asia-Pacific Economic Cooperation (APEC) Transportation Working Group, during its thirteenth meeting in 2009, has expressed its willingness to work cooperatively with ICAO PBN Task Force to support the establishment of a regional RAIM prediction service. This willingness to support the ICAO regional RAIM activity has been reiterated during the fourteenth meeting for the APEC GIT in June 2010 and has been reaffirmed by the adopted APEC GIT Strategy for 2010-2015.

4. **Current PBN Manual RAIM Prediction Requirements**

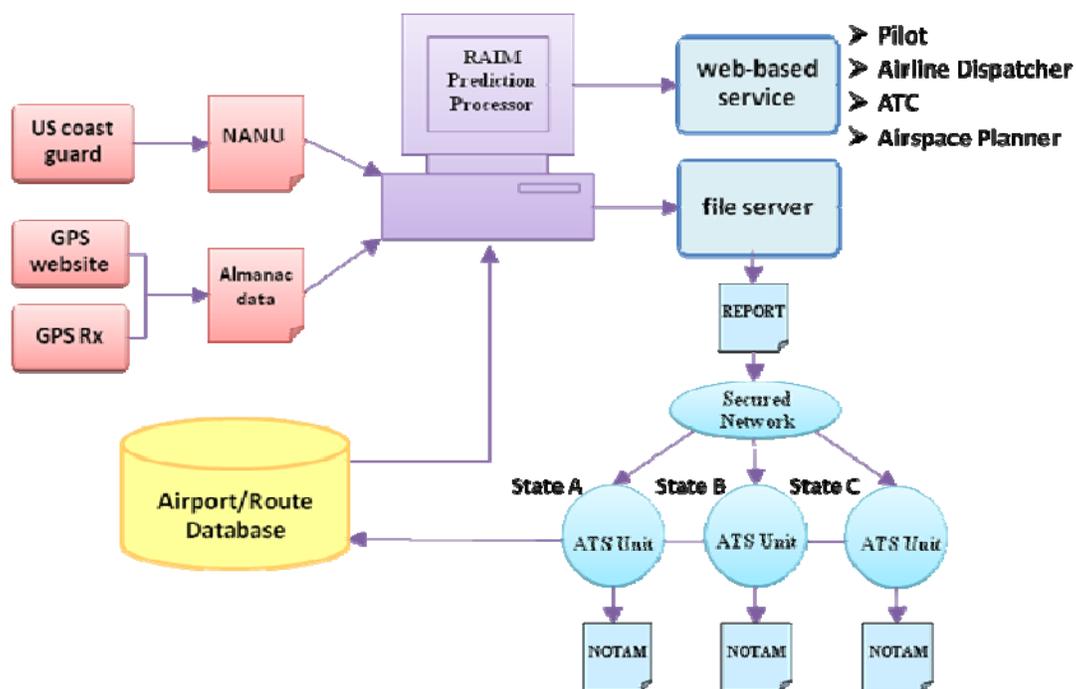
4.1 The PBN Manual contains numerous requirements for various forms of GNSS prediction plus requirements for ANSP providers to 'monitoring the status of GNSS and issue timely warnings of outages'. (Section 1.2.7). For example RNP 10 requires FDE (Fault Detection and Exclusion) availability prediction program must be used (Paragraph 1.3.4.2.1.4). For RNAV En-route RAIM levels are required and can be verified either through NOTAM (where available) or through prediction services. The operating authority may provide specific guidance on how to comply with this requirement (e.g. if sufficient satellites are available, a prediction may not be necessary). Operators should be familiar with the prediction information available for the intended route (Paragraph 2.3.4.3.1).

4.2 The following factors influence both status monitoring and RAIM prediction and these can differ between aircraft:

- the receiver RAIM algorithms of different receivers;
- the satellites in view can be a different set;
- the receiver mask angle can vary; and
- integration with other sensors/aids (DME/DME, baro, inertial) may or may not be available to the navigation system.

4.3 The current approvals for the use of GPS as a primary means of oceanic and remote navigation require the operator to have a separate (to the receiver) receiver specific prediction system that takes into account the requirements of the flight.

5. Possible System Architecture for a Regional RAIM Prediction System



6. Minimal Technical and Operational Requirements for a Regional RAIM Prediction System

6.1 At its 7th meeting, the PBNTF agreed in principle the establishment of a regional RAIM prediction system and cooperation between the ICAO PBN TF and the APEC GIT. The PBNTF also endorsed the **Minimal Technical and Operational Requirements for a Regional RAIM Prediction System** as followings:

6.2 *Basic Common Denominator* - Noting the differences among different RAIM algorithms on-board different aircraft, a regional RAIM prediction system provided by a service provider, such as an ANSP, should provide a “basic common denominator” RAIM prediction service for “basic” GNSS receivers, such TSO-129 (Fault Detection) and TSO-145/146 (Fault Detection and Exclusion).

6.3 *Prediction Period* – A regional RAIM prediction system shall provide prediction for RAIM outage and number of GNSS-satellite availability for a 72 hour period using the latest available GPS NANU.

6.4 *Approach Operations* - A regional RAIM prediction system shall support aircraft approach operations based on RNP APCH (with/without Baro-VNAV) navigation specification. The system shall calculate the predicted RAIM availability for a 72 hour period for specific Aerodromes. The algorithms shall address the RAIM requirements for GNSS receivers operating in Approach operations ($\pm 0.3\text{NM}$). Both the Fault Detection (FD) and Fault Detection and Exclusion (FDE) algorithms shall be provided. The system shall calculate the predicted RAIM availability at the Aerodrome Reference Point (ARP) for baro (pressure altitude) aided and non-baro aided GNSS user equipment at 1 minute intervals or better.

7. Progress of APAC Regional RAIM Prediction System

7.1 AEROTHAI has allocated internal budget for initial investment for the establishment of the APAC Regional RAIM Prediction System. The procurement process for the system has been started. Initial operation for Bangkok FIR is expected to be ready near the end of 2011. The system will be capable to provide RAIM prediction services for all participating States within the Asia/Pacific Region within 2012.

7.2 Since its 6th meeting in 2010, ICAO Asia/Pacific PBN TF has encouraged States in the Asia-Pacific Region to take part in the Regional RAIM Prediction System for the APAC Region. To ensure financial sustainability of the project, participating States are expected to provide financial contribution to sustain the system’s operation and maintenance. For the purpose of assisting interested States in budget preparation and allocation, AEROTHAI has estimated the level of financial contribution for each participating State to be at a monthly fee of less than 1,500 USD with a one-time database set-up cost of less than 3,500 USD per State. As more States participate in the project, the monthly fee is expected to decrease.

8. Actions by the Meeting

The Meeting is invited to:

- a) note the importance and requirements for RAIM prediction services for GNSS and PBN operations;
- b) note the progress on the establishment of the APAC Regional RAIM Prediction System as presented in this Working Paper; and
- c) encourage States to participate in the APAC Regional RAIM Prediction System project.

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