Overview of Evolution to Performance Based Navigation
Overview

• Learning Objectives: at the end of this presentation you should:
  – Understand what are the two main elements of Performance Based Navigation
  – Understand the key difference between the two elements

• This presentation will discuss
  – Navigation in Context
  – Evolution to Performance Based Navigation
  – Performance Based Navigation
    ➢ What Is It?
    ➢ What is Area Navigation (RNAV)?
    ➢ What is Required Navigation Performance?
    ➢ What is the Key Difference?
Navigation in Context

Airspace System

- Communications
- Navigation
- Surveillance

CNS/ATM
Navigation: The Beginning

IFR

I Fly Roads!
- And Rivers
- And Railroads
- And Buildings
- And Telephone Lines
- And Whatever Else I Can See
The Early Days

Night and Weather!

- 1910s
  - First Bonfires and Beacons

- Early 1920s
  - Lighted airport boundaries
  - Spot-lit windsocks
  - Rotating lighted beacons on towers
  - Lighted Airways
    - 1923 Dayton to Columbus, Ohio (USA) – 72 km
Late 1920s-1930s

Radio!

- Radio for Two-Way Communications
  - Weather Updates
  - Request Help With Navigation

- Radio for Navigation
  - Radio Marker Beacons
  - 4-Course Radio Range System

- Pilots Listen for Navigation Signals
VOR!

- Static-Free VHF Omni-directional Radio Range
  - Pilots Navigate by Instrument
- VOR (with improvements) becomes a primary NAVAID for decades
  - Defines Routes
  - Supports Approach Procedures

1930s - 1940s

VOR Has Done a Great Job For Decades!
1940s-1950s

**ILS!**

- 1929: First system tested
- 1946: (Provisional) ICAO selects ILS as primary landing air for international “trunk” airports
- Today: ILS Cat I, Cat II, Cat III

ILS Still Does a Great Job!
From 1950s

**DME!**

- 1961: first regular civil use (pilot tuned)
- In PBN, DME use is based on automatic tuning

DME is incorporated into PBN
Conventional Navigation

- Ground-based navigation aids (NAVAIDs)
  - Aircraft Overfly NAVAID or Intersection
  - Display Accuracy is a Function of Distance
    - Protected Area Grows (“Splayed”)

= Limited Design Flexibility
Evolution of RNAV

- Long RAnge Navigation (LORAN)
- Omega Radio Navigation System*
- Inertial Navigation
- VOR/VOR and VOR/DME
- Multi-sensor Flight Management System (FMS)
- GPS, GLONASS, and Augmentations

*terminated in 1997
Area Navigation (RNAV)

- Ground or Space Based NAVAIDs
- Aircraft Fly Waypoints
- Protected Area Constant ("Linear")

= Increased Design Flexibility
Evolution of Required Navigation Performance (RNP)

- ICAO: Developed RNP concepts
  - Initially defined by ICAO Special Committee on Future Air Navigation Services (FANS) for “Required Navigation Performance Capability” (RNPC)
  - ICAO Review of the General Concept of Separation Panel refined to “Required Navigation Performance” (RNP)

  ➢ **RNP**: “A statement of the navigation performance necessary for operation within a defined airspace”
Evolution of RNP (2)

- RTCA/EUROCAE: Defined performance and functional requirements
    - **RNP**: “A Statement of the navigation performance accuracy necessary for operation within a defined airspace”
    - **RNP RNAV**: “An area navigation capability that meets all of the requirements of this document”
    - **RNP Type**: ”RNP Types are established according to navigational performance accuracy in the lateral plane…”
    - **RNP (x) RNAV**: “A designator used to indicate the minimum navigation system requirements needed to operate in an area, on a route or a procedure”

- Manufacturers: Delivered “RNP” based on different versions of requirements
Required Navigation Performance

- Adds to RNAV
  - On Board Monitoring & Alerting
  - May Incorporate Radius to Fix Turns

= Optimized Use of Airspace
RNAV and RNP Divergence

RNAV and RNP

Present

B-RNAV
P-RNAV
US-RNAV
RNP10
RNP 4
RNP/RNAV

Future

Other States-Regions
Russia
Europe
US
Boeing
Australia
China
Airbus
Canada
Japan
South America
India
The Problem Addressed: ICAO Action

- Need for focal point in ICAO to address problems experienced with RNP Concept
  - GNSSP/4 recommendation 1/1
  - 11th Air Navigation Conference
- Individual Air Navigation Commission Panels not suitable to address the problem
- ANC (163/9) approves establishment of Required Navigation Performance Special Operations Requirements Study Group (RNPSORSG) as coordinating group
  - "ICAO RNP Study Group"
RNP SORSG Members

- Subject Matter Experts from
  - States
    - Australia, Brazil, Canada, France, Japan, United Kingdom, United States
  - Agencies
    - EUROCONTROL
    - ICAO Secretariat
  - Industry Stakeholder Groups
    - IATA (International Air Transport Association)
    - IFALPA (International Federation of Airline Pilots Associations)
    - ICCAIA (International Coordinating Council of Aerospace Industries Associations)
RNP SORSG
Main Goals

• Achieve and document a common understanding of RNP and RNAV and associated concepts and functionalities
  – Define RNAV and RNP
  – How do they relate to each other?
  – What is the essential distinction?
• Harmonize use of RNP and RNAV on global basis, for benefit of operators and service providers
  – Identify operational and airworthiness requirements for RNP and RNAV
RNP SORSG
April 2004 – April 2007

- Completely revised ICAO Doc 9613
  - Draft *Manual on Performance Based Navigation*
    - Vol I – PBN Concept and Implementation Guidance
    - Vol II – Implementing RNAV and RNP
  - Navigation Specifications
- ICAO State Letter AN 1 1145-07122 (27 April 2007)
  - Vol II Navigation Specifications can be used now
Transition to Performance Based Navigation

- Navigation based on specified system performance requirements for aircraft operating on a air traffic route, instrument approach procedure, or in a designated airspace
  - Potential for aircraft to demonstrate requirements compliance through a mix of capabilities, rather than only specific equipment
  - Regulators will not always need to write new compliance documents for new capabilities

PBN’s 2 Key Elements: **RNAV** and **RNP**
Definition: RNAV

- RNAV is a method of navigation enabling aircraft to fly on any desired flight path:
  - within the coverage of referenced NAVAIDS, or
  - within the limits of the capability of self-contained systems, or
  - a combination of these capabilities

Blue line shows RNAV route without constraints of ground-based NAVAIDs
Definition: RNP (System)

- An area navigation system which supports on-board navigation performance monitoring and alerting.

RNP isn’t “fundamentally different” from RNAV: RNP is MORE Than RNAV.
RNAV and RNP
(Notional)

RNAV 1

Track Centerline

1 Nautical Mile 95% of flight time

1 Nautical Mile 95% of flight time
RNAV and RNP (Notional)

RNP 1

Alert to Pilot

Track Centerline

1 Nautical Mile 95% of flight time

The Key Difference:

On-Board Performance Monitoring and Alerting
Summary

• Navigation is one element in the CNS/ATM infrastructure that enables an Airspace System
• Evolution to Performance Based Navigation (PBN)
• Learning Objectives were
  – Understand what are the two main elements of Performance Based Navigation
    ➢ RNAV and RNP
  – Understand the key difference between the two elements
    ➢ On-Board Performance Monitoring and Alerting
Feedback and Questions

Bearing in mind the target audience in ICAO Regions