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

- **C**ommunications
- **N**avigation
- **S**urveillance
- **A**ir **T**raffic **M**gt

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

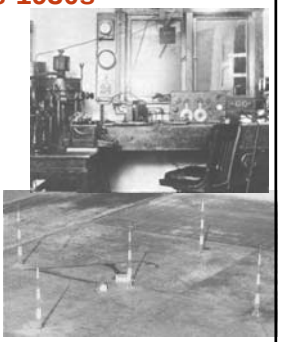
Night and Weather

- 1910s
  - ✈ First Bonfires and Beacons
- Early 1920s
  - ✈ Lighted airport boundaries
  - ✈ Spot-lit windsocks
  - ✈ Rotating lighted beacons on towers
  - ✈ Lighted Airways

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



1930s - 1940s

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

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!

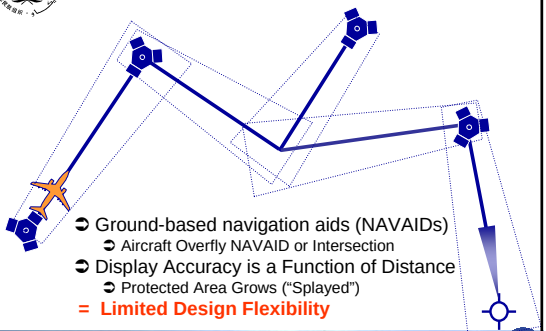
From 1950s

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

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 makes a clear distinction between *RNAV Applications* and *RNP Applications*

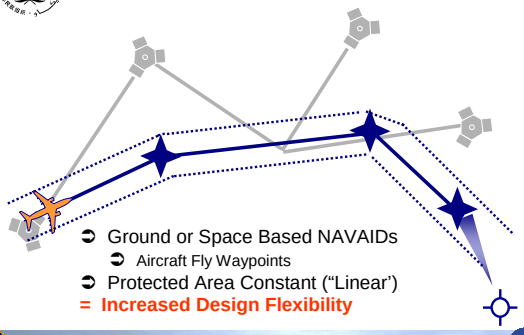
Difference between RNAV and RNP Applications

- RNAV applications assume aircraft operations on any desired flight path in the coverage of station-reference NAVAIDS or within the limits of the capability of self-contained aids, or a combination of these.
- RNP applications are RNAV applications requiring

Definition: Area Navigation

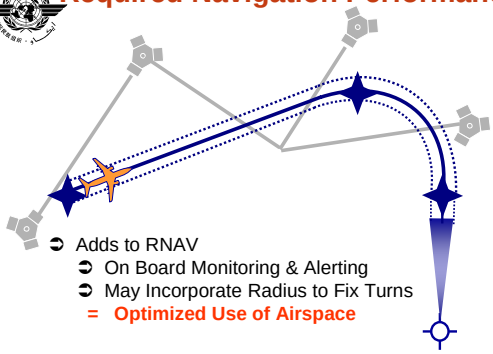
- ICAO: Area Navigation is a method of navigation enabling aircraft to fly on any desired flight path:
  - within the coverage of referenced NAVAIDS, or
  - within the limits of the capability of self-contained systems, or
  - a combination of these capabilities
- The concept of PBN relies on the use of an area navigation system

Area Navigation (RNAV)



➲ Ground or Space Based NAVAIDs
➲ Aircraft Fly Waypoints
➲ Protected Area Constant ("Linear')
= **Increased Design Flexibility**

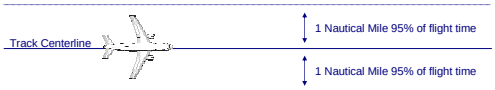
Required Navigation Performance



➲ Adds to RNAV
➲ On Board Monitoring & Alerting
➲ May Incorporate Radius to Fix Turns
= **Optimized Use of Airspace**

RNAV Application (notional)

RNAV 1



RNP Application (notional)

RNP 1 **Alert to Pilot**

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

Audience Response System Questions