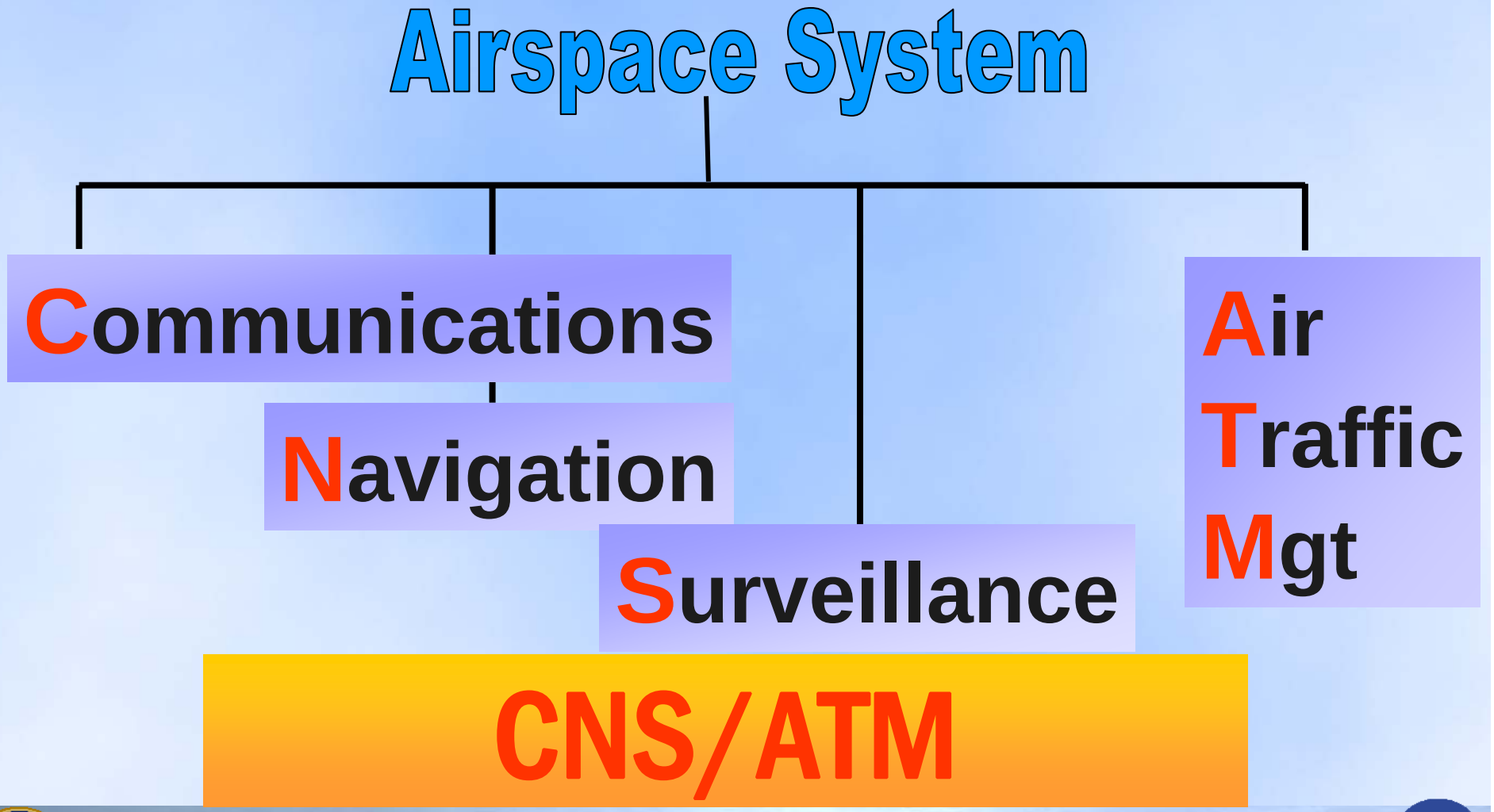
Overview of Evolution to Performance Based Navigation

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



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

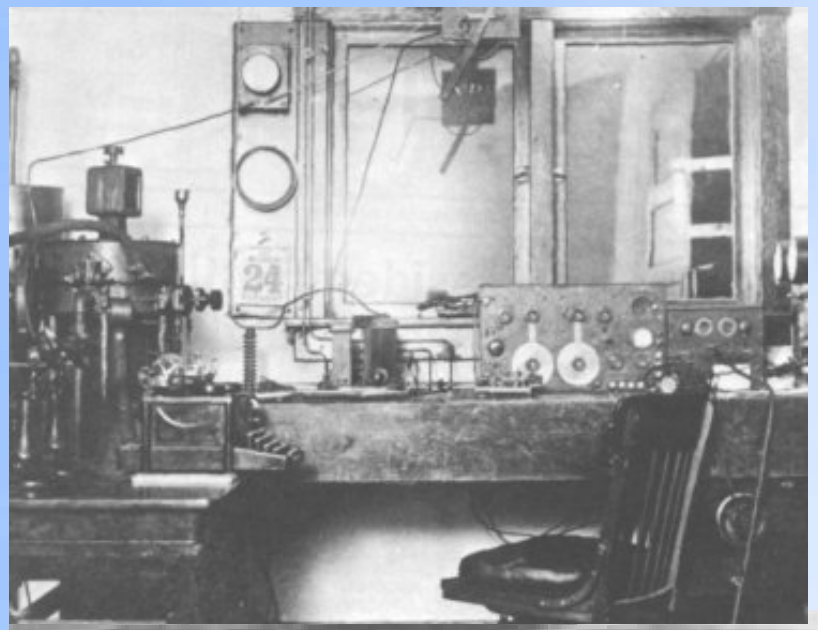
Night and Weather!

- 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



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

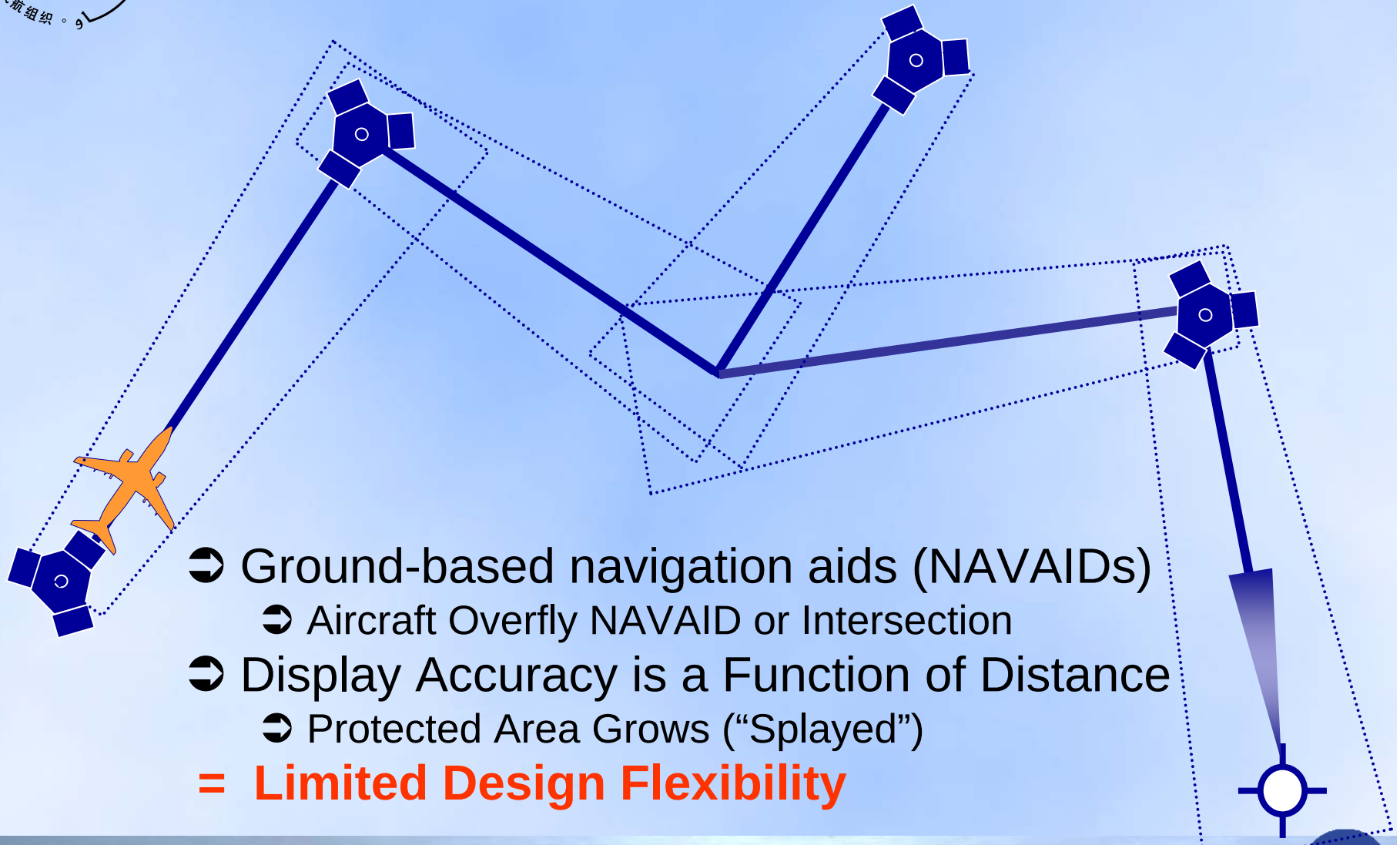
DME!

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

DME (on top of VOR)

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”)

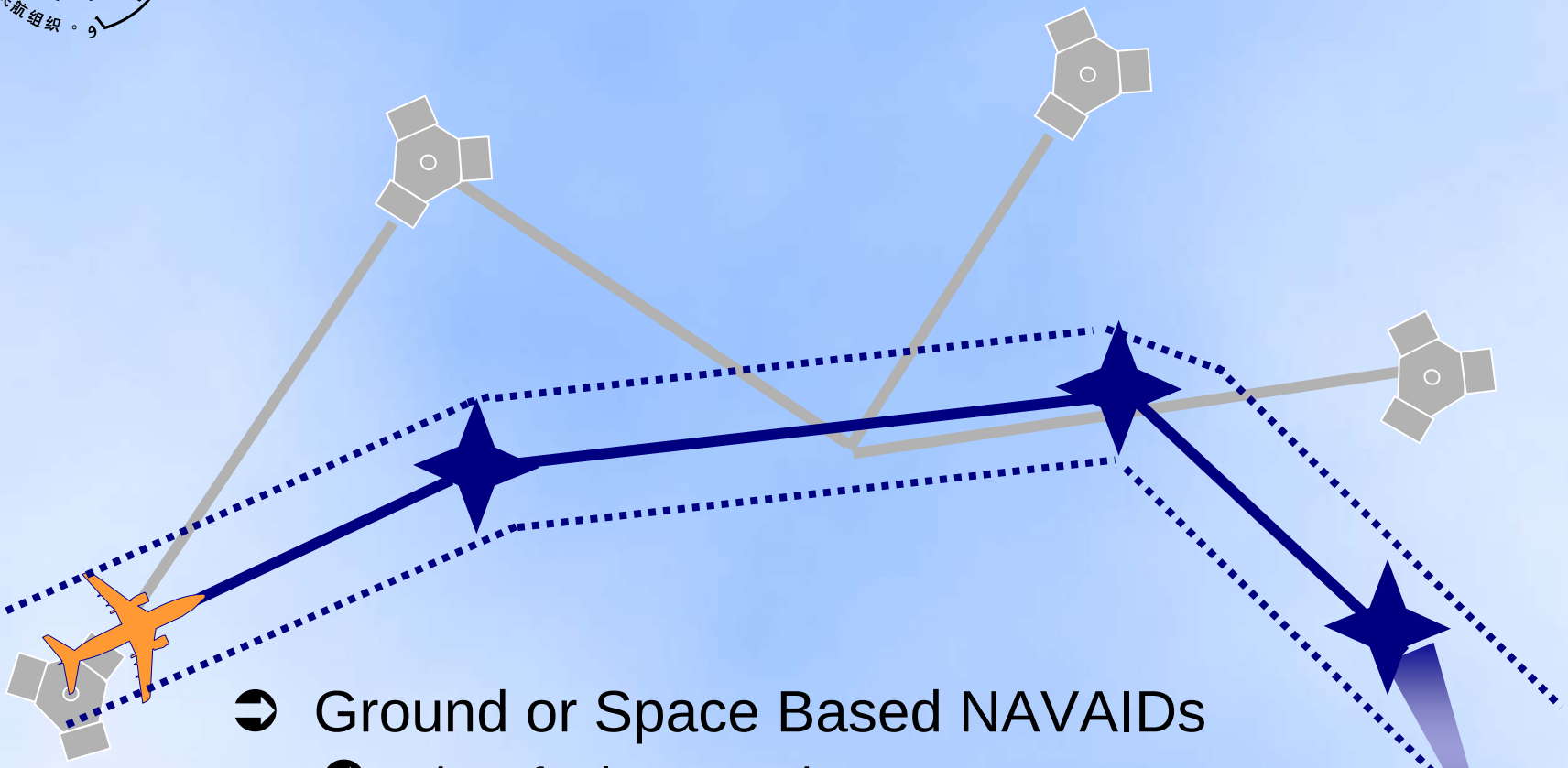
= Limited Design Flexibility

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

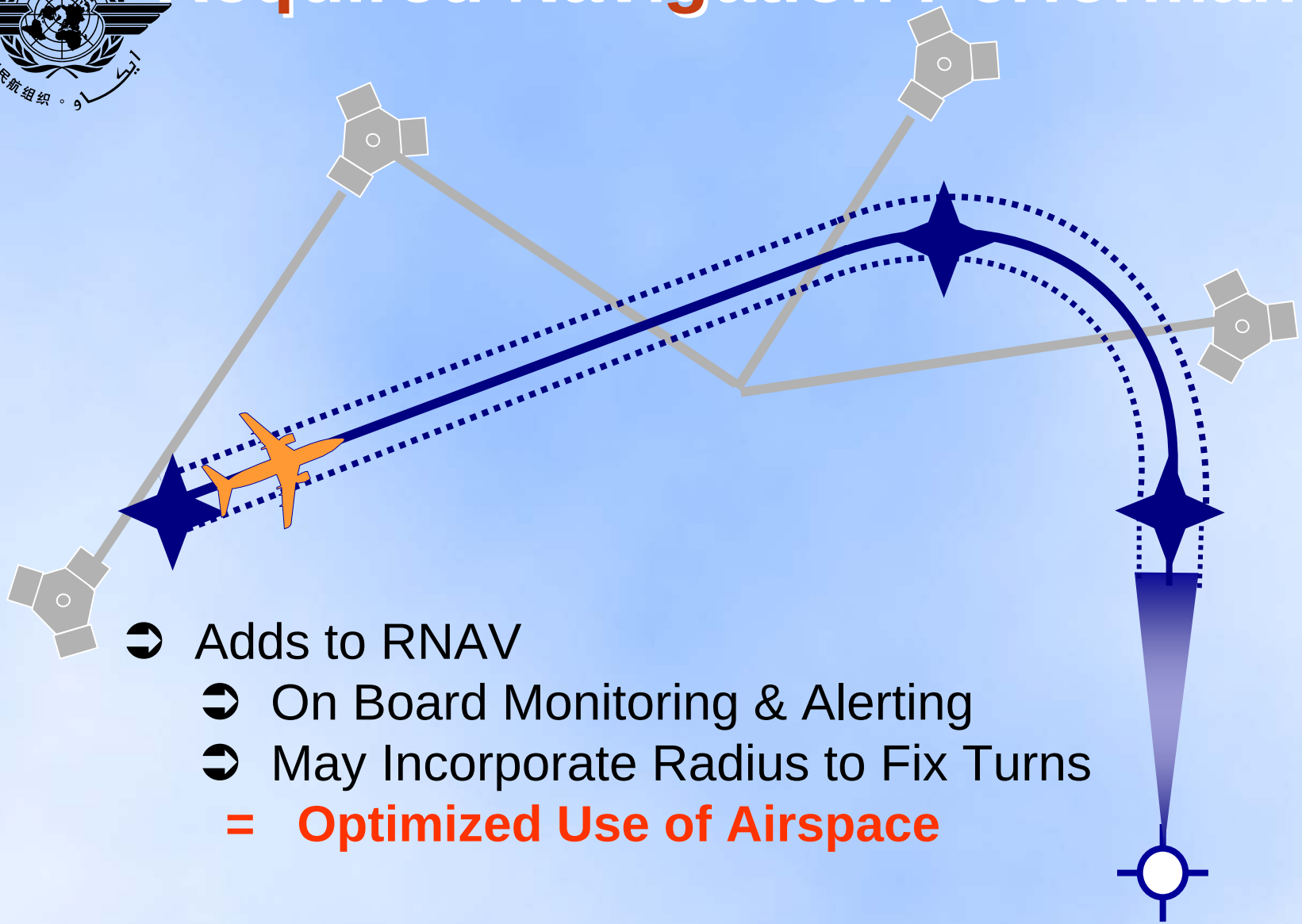
Evolution of Required Navigation Performance (RNP)

- 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)
  - ICAO Doc 9163 *Manual on Required Navigation Performance* (First Edition 1993)
    - **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
  - RTCA DO 236/EUROCAE ED-75 *Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation* (2003)
    - **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

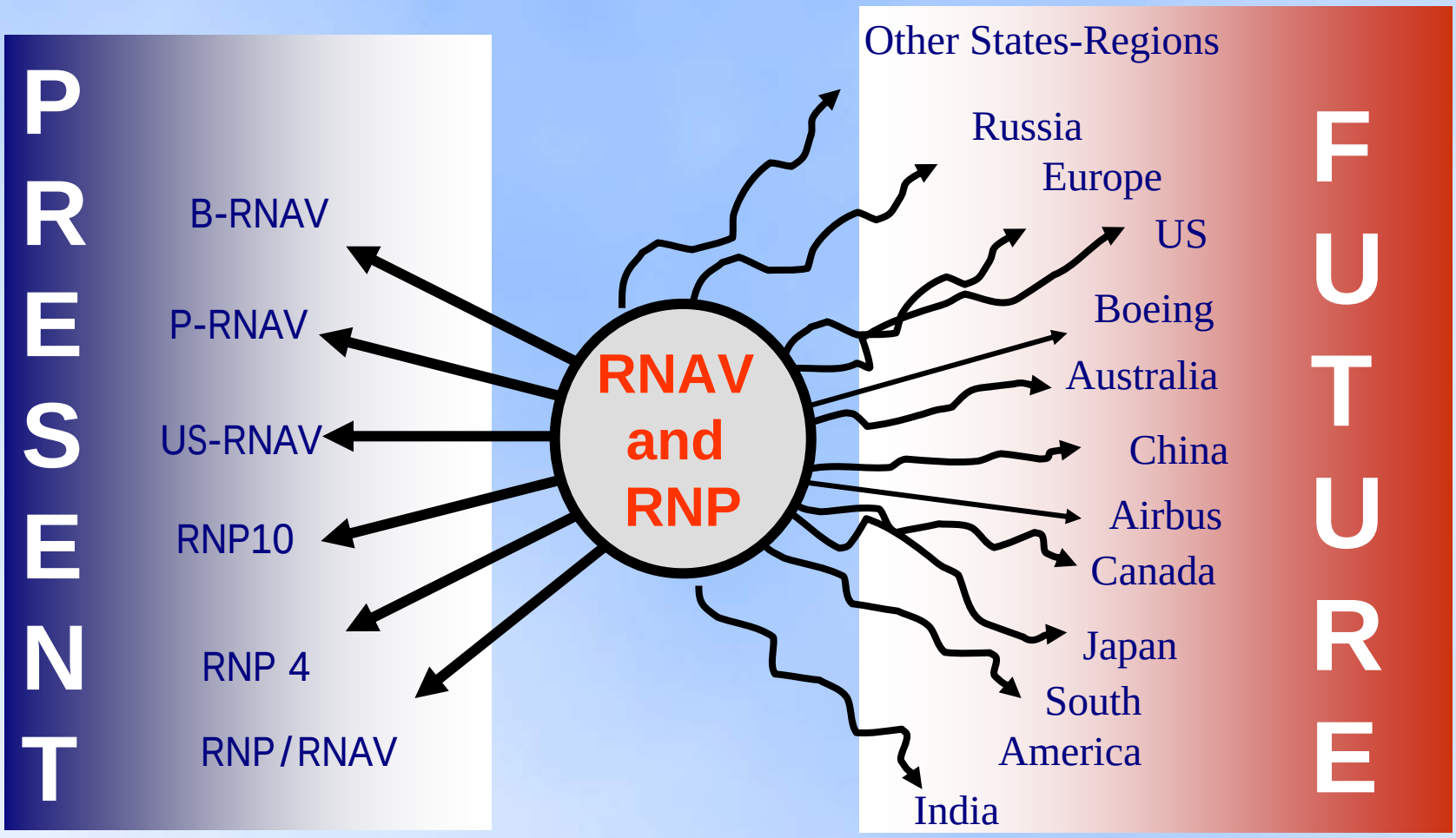
Required Navigation Performance



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

= Optimized Use of Airspace

RNAV and RNP Divergence



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)

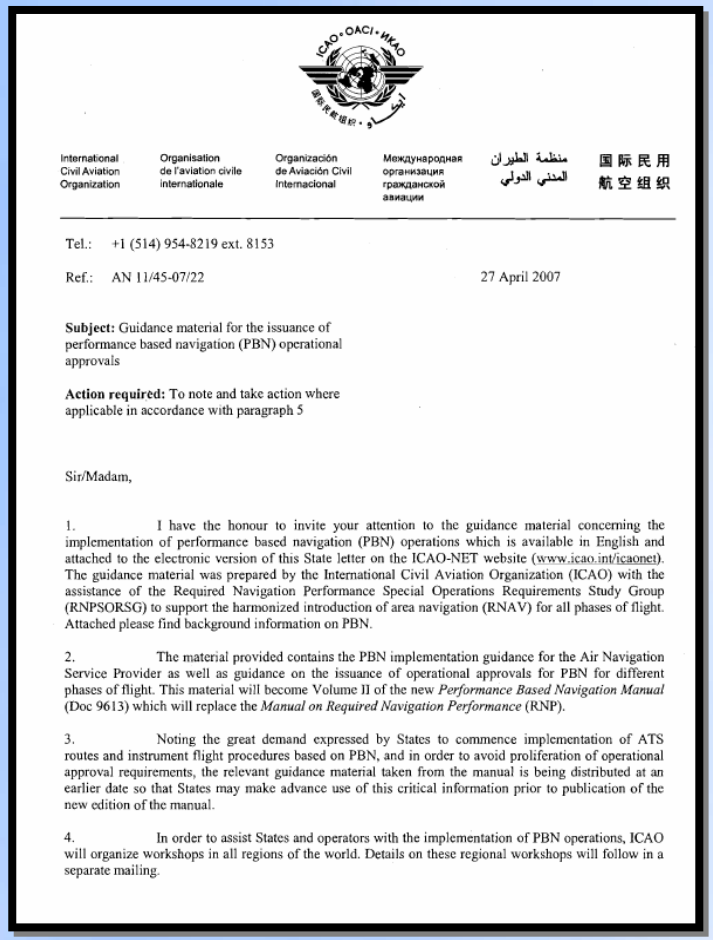
RNP SORSG
Main Goals

- 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



International Civil Aviation Organization | Organisation de l'aviation civile internationale | Organización de Aviación Civil Internacional | Международная организация гражданской авиации | منظمة الطيران المدني الدولي | 国际民用航空组织

Tel.: +1 (514) 954-8219 ext. 8153

Ref.: AN 11/45-07/22 27 April 2007

Subject: Guidance material for the issuance of performance based navigation (PBN) operational approvals

Action required: To note and take action where applicable in accordance with paragraph 5

Sir/Madam,

1. I have the honour to invite your attention to the guidance material concerning the implementation of performance based navigation (PBN) operations which is available in English and attached to the electronic version of this State letter on the ICAO-NET website (www.icao.int/icaonet). The guidance material was prepared by the International Civil Aviation Organization (ICAO) with the assistance of the Required Navigation Performance Special Operations Requirements Study Group (RNPSORSG) to support the harmonized introduction of area navigation (RNAV) for all phases of flight. Attached please find background information on PBN.

2. The material provided contains the PBN implementation guidance for the Air Navigation Service Provider as well as guidance on the issuance of operational approvals for PBN for different phases of flight. This material will become Volume II of the new *Performance Based Navigation Manual* (Doc 9613) which will replace the *Manual on Required Navigation Performance* (RNP).

3. Noting the great demand expressed by States to commence implementation of ATS routes and instrument flight procedures based on PBN, and in order to avoid proliferation of operational approval requirements, the relevant guidance material taken from the manual is being distributed at an earlier date so that States may make advance use of this critical information prior to publication of the new edition of the manual.

4. In order to assist States and operators with the implementation of PBN operations, ICAO will organize workshops in all regions of the world. Details on these regional workshops will follow in a separate mailing.

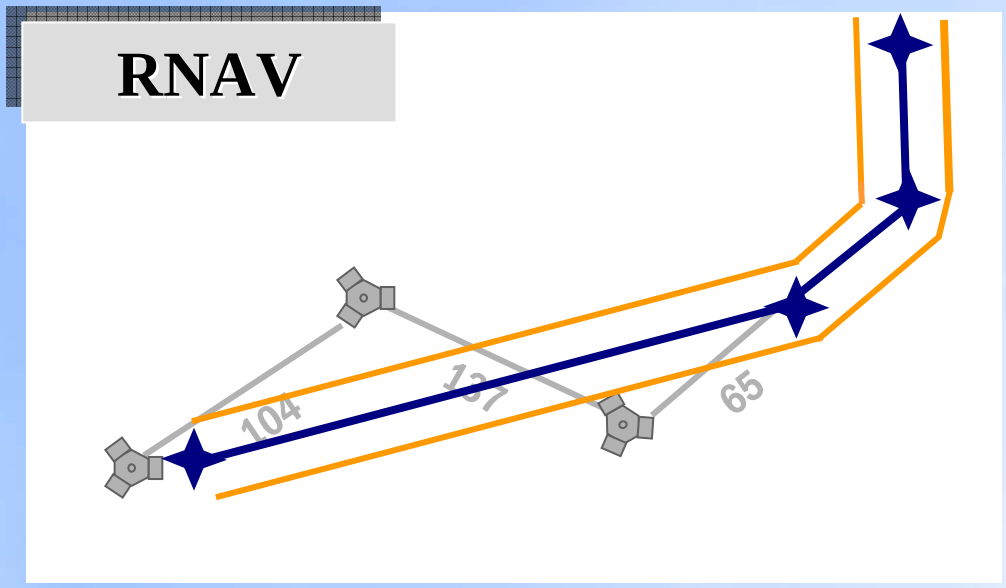
Transition to Performance Based Navigation

- 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

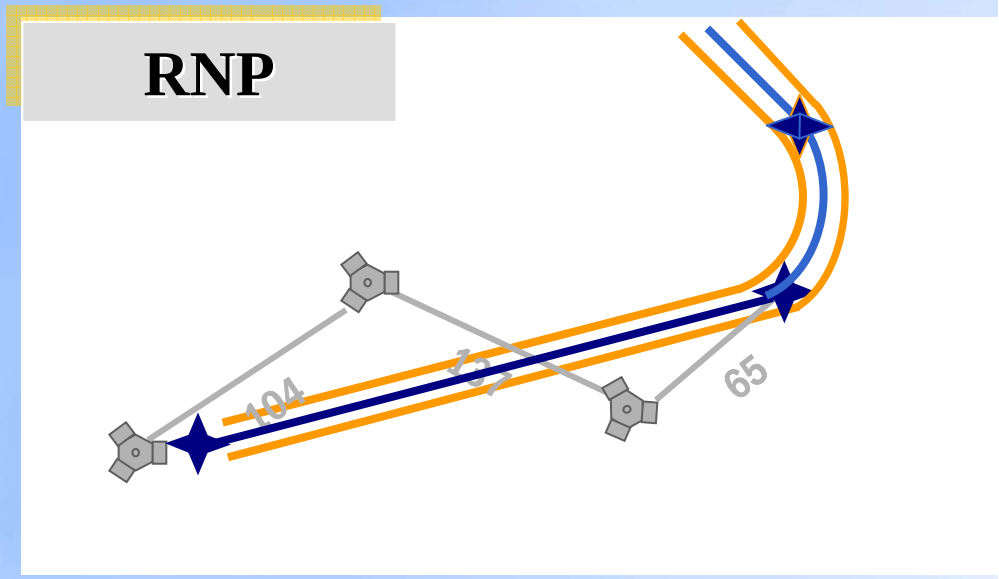
- RNAV is a method of navigation enabling aircraft to fly on any desired flight path:
  - within the coverage of referenced NAVAIDS, or
  - within the limits of the capability of self-contained systems, or
  - a combination of these capabilities



Blue line shows RNAV route without constraints of ground-based NAVAIDs

Definition: RNP (System)

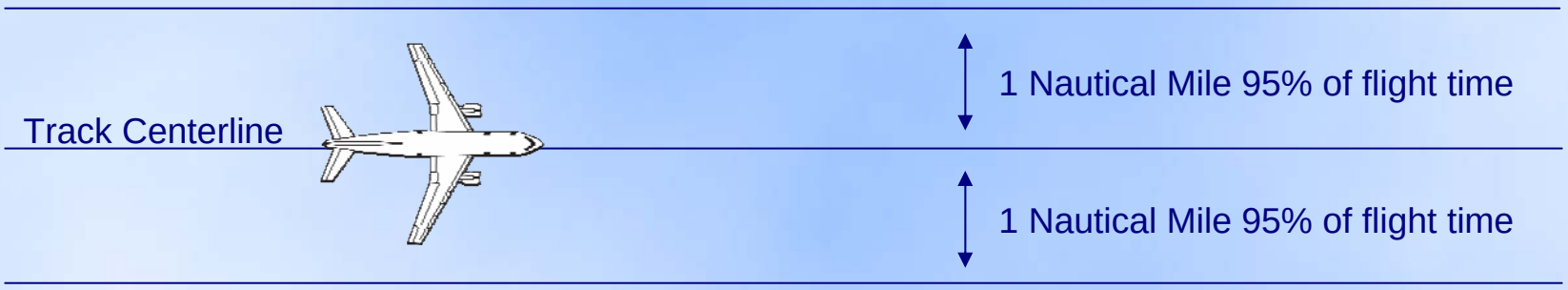
- An area navigation system which supports on-board navigation performance monitoring and alerting



RNP isn't "fundamentally different" from RNAV:
RNP is *MORE* Than RNAV

RNAV and RNP
(Notional)

RNAV 1



RNAV and RNP
(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

Bearing in mind the target audience in ICAO Regions

Feedback and Questions