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Lufthansa Systems FMS Workshop Greater China

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Martin Zillig
Head of Navigational Data Standards - Lufthansa Systems FlightNav Inc.

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汉莎系统FMS大中华区研讨会

珠海 2013年3月6日－8日

Martin Zillig
导航数据标准室主任– 汉莎系统FlightNav公司

Agenda

RNAV/RNP Procedure Coding

- Definition and Principels
- Benefits
- Challenges

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议程

RNAV/RNP 程序编码

- 定义和原则
- 效益
- 挑战

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RNAV/RNP Procedure Coding

Definition and Principles

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RNAV/RNP Procedure Coding – Definition and Principles

Definition RNAV and RNP

- **RNAV (Area Navigation)** is a method of navigation which permits aircraft operation on **any desired flight path within the coverage of station-referenced navigation aids** or **within the limits of the capability of self-contained aids**, or a combination of these.

- RTCA: An RNAV Specification that includes **requirements for on-board performance monitoring and alerting** is known as an **RNP specification**

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RNAV/RNP 程序编码 – 定义和原则

定义RNAV和RNP

- RNAV（区域导航）是一种导航方法，允许航空器在参考台站导航设施覆盖范围内、或者自主式导航设施能力限度内、或者将其组合，按任意期望的飞行路径飞行。

- RTCA：一种RNAV规范，包括已知的RNP规范对机载性能监视和告警（OPMA）的要求。

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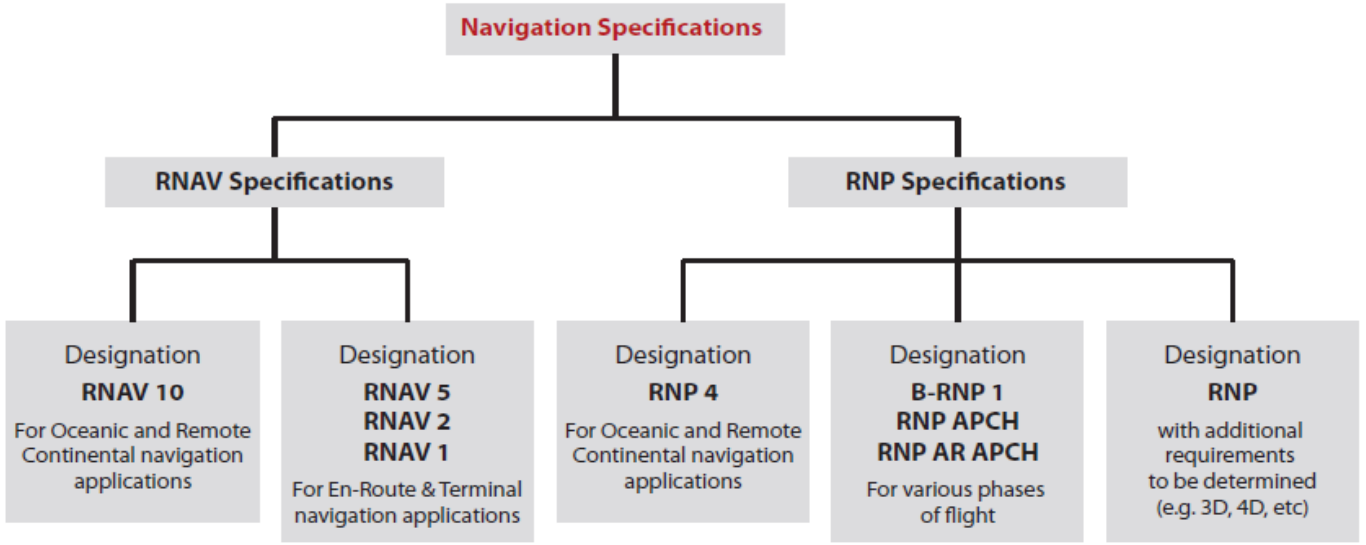
RNAV/RNP Procedure Coding – Definition and Principles

- The **Navigation Specification** is a technical and operational specification that **identifies the required functionality** of the **area navigation equipment.**

- To date, the **PBN Manual** contains **8 navigation specifications**:

  4 RNAV specifications & 4 RNP specifications



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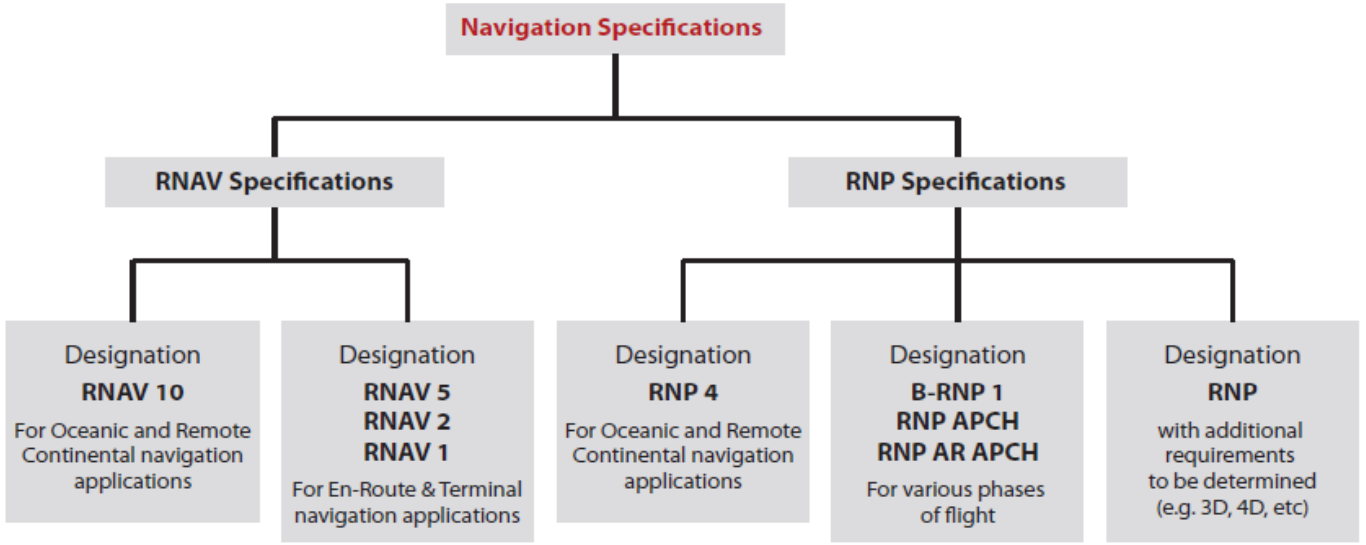
RNAV/RNP 程序编码 – 定义和原则

- 导航规范是一种技术和运行规范，用来明确区域导航设备所必备的功能。
- To date, the **PBN Manual** contains **8 navigation specifications**:
- 迄今为止，PBN手册包含8种导航规范：

  4 种RNAV 导航规范 和 4种RNP导航规范



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RNAV/RNP Procedure Coding – Definition and Principles

RNP RNAV Performance

- **Accuracy:** *Aircraft operating in RNP airspace shall have **total system error components** in the cross-track and along track directions that are **less than the RNP value 95% of the flying time**.*

- **Integrity:** *The **probability** that the **total system error** of each aircraft operating in RNP RNAV airspace **exceeds the specified cross-track containment limit (2xRNP) without annunciation** shall be less that 1x10-5 per flight hour.*

- **Continuity:** *The **probability** of **annunciated loss of RNP RNAV capability** shall be less than 10-4 per flight hour.*

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RNAV/RNP 程序编码 — 定义和原则

RNP RNAV 性能

- 精度：*航空器在RNP空域内运行时，在侧航迹和沿航迹方向，在95％飞行时间内总系统误差（TSE）要小于RNP值。*
- 完好性：*每架航空器在RNAV空域内运行时，TSE超出指定侧航迹包容度限制值（2倍RNP值）而没有发出告警的概率要小于$1x10^{-5}$每飞行小时。*
- 连续性：*提示失去RNP RNAV能力的概率要小于10^{-4}每飞行小时。*

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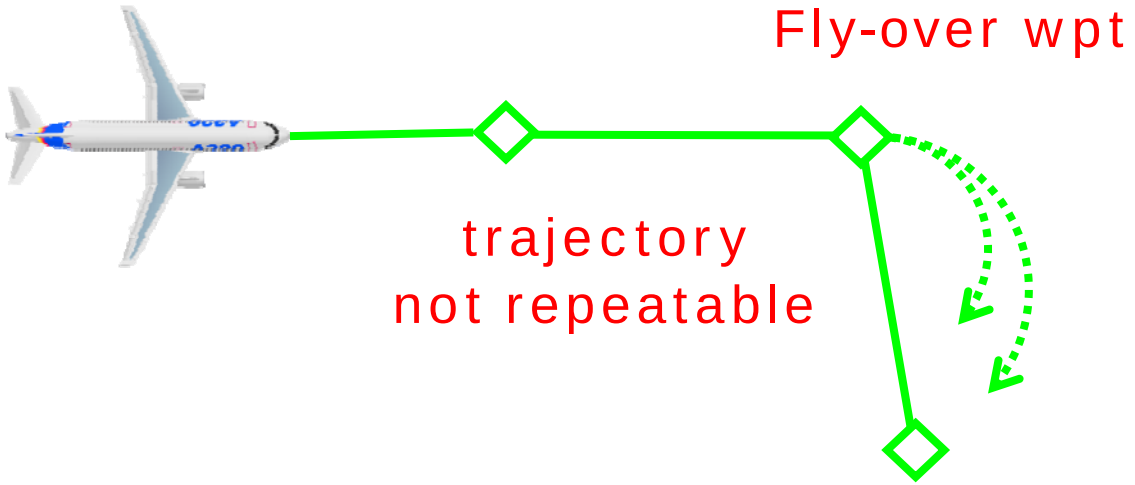
RNAV/RNP Procedure Coding – Benefits

Benefits of **Fly-by versus Fly-over** in procedure coding

- **Fly-over** waypoints: depending on **wind, aircraft speed, bank angle** limitation etc… the **FMS trajectory will be different**



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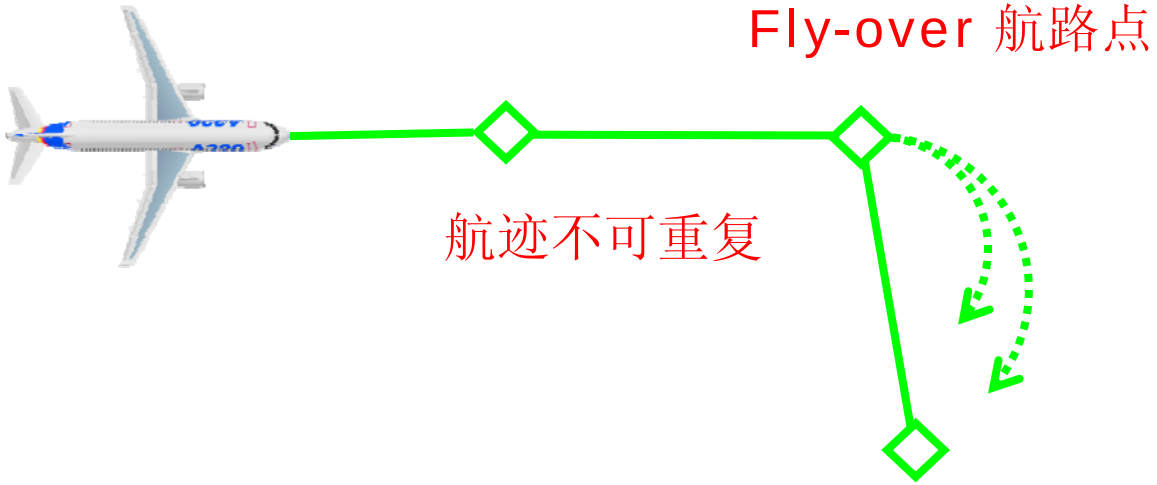
RNAV/RNP 程序编码-效益

在程序编码中Fly-by(飞越)与Fly-over(旁切)的效益

- **Fly-over航路点：风、航空器速度、坡度限制等不同，FMS航迹不同。**



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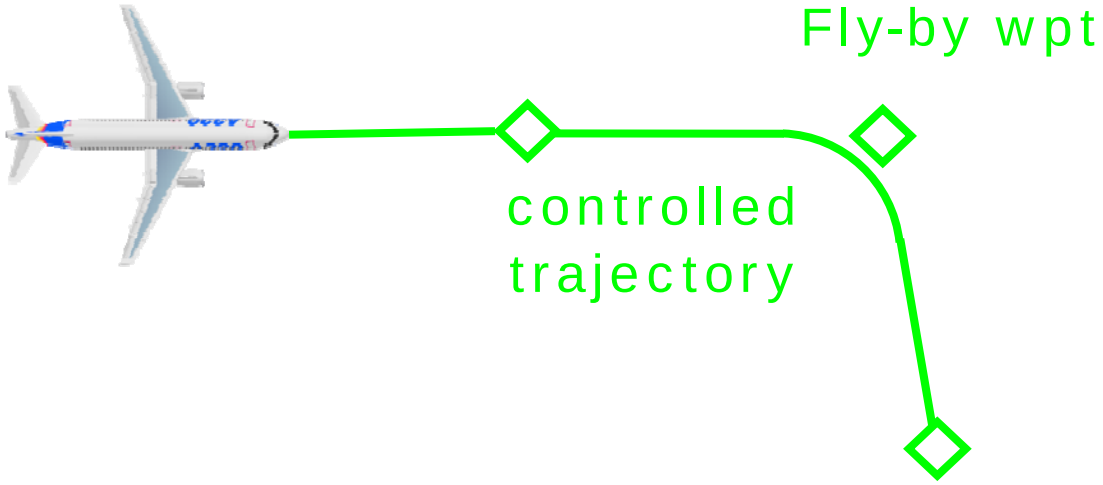
RNAV/RNP Procedure Coding – Benefits

Benefits of **Fly-by versus Fly-over** in procedure coding

- **Fly-by** waypoints: **better trajectory** control is achieved as the FMS will track a **pre-computed curve**



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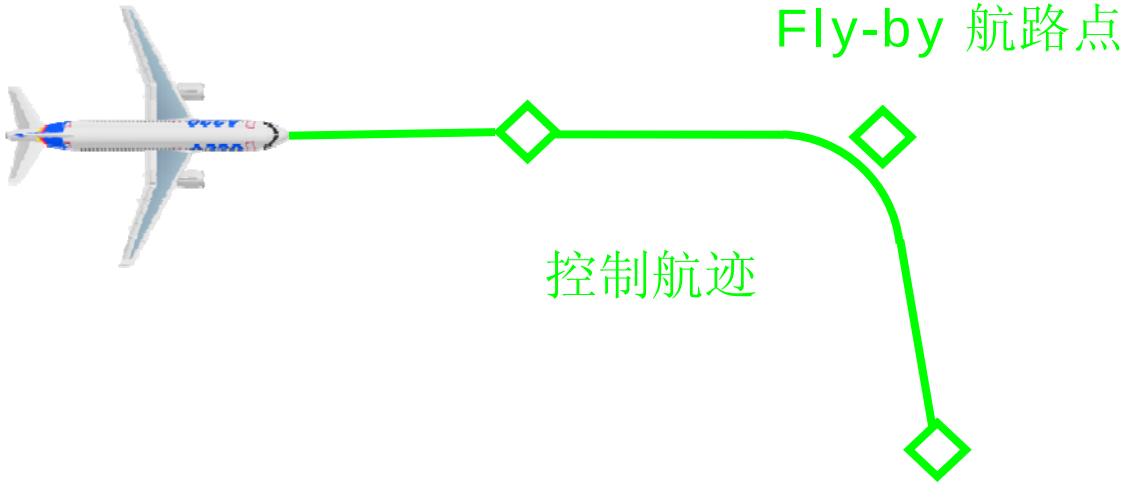
RNAV/RNP 程序编码-效益

在程序编码中Fly-by(飞越)与Fly-over(旁切)的效益

- **Fly-by** waypoints: **better trajectory** control is achieved as the FMS will track a **pre-computed curve**
- Fly-by航路点：更佳的航迹控制，FMS可跟踪预先计算的曲线航迹。



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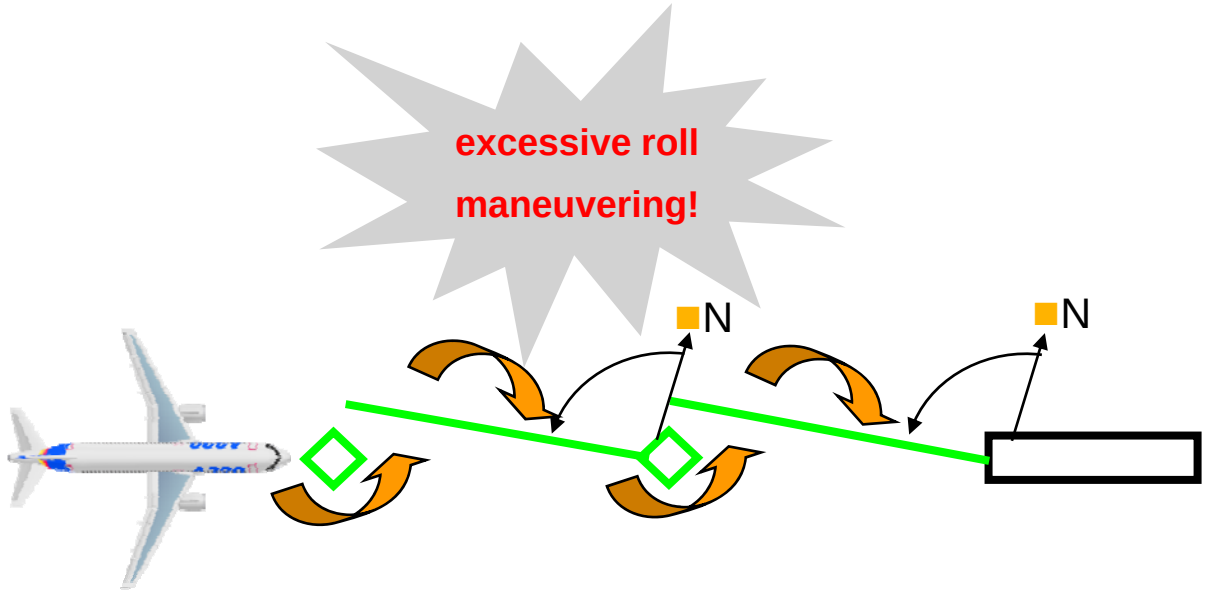
RNAV/RNP Procedure Coding – Benefits

Benefits of **TF over CF Path Terminator** in procedure coding

- **CF-leg**: Magnetic course may mismatch runway centerline course



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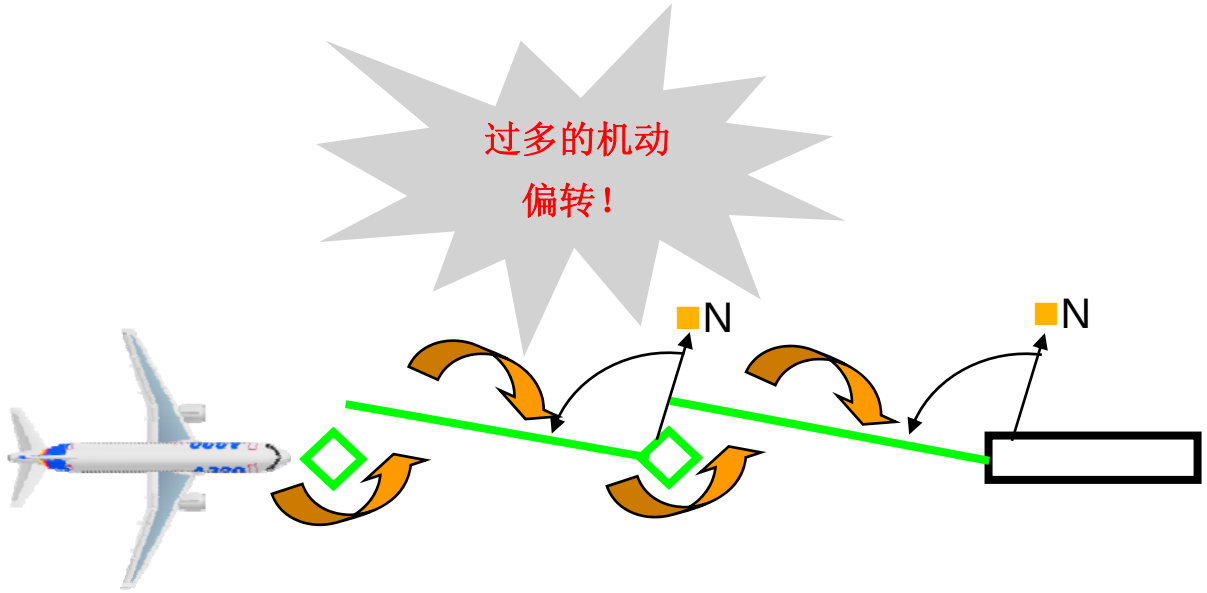
RNAV/RNP 程序编码-效益

在程序编码中TF与CF航迹终结码效益

- **CF航段**: 磁航线角可能与跑道中线航道不匹配



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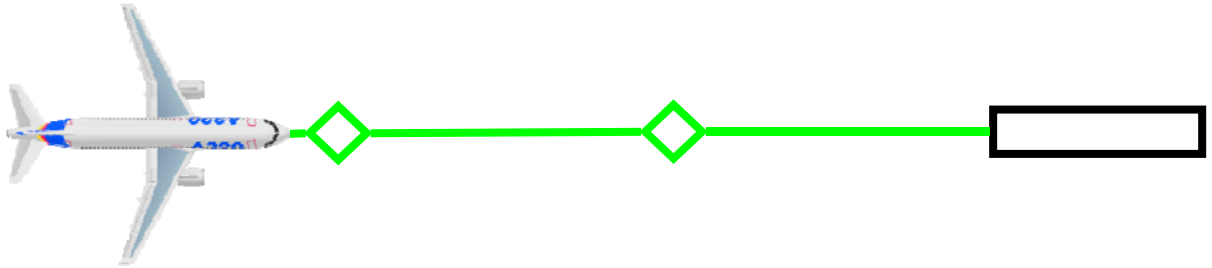
RNAV/RNP Procedure Coding – Benefits

Benefits of **TF over CF Path Terminator** in procedure coding

- **TF-leg**: not influenced by magnetic variation, always creates a smooth path



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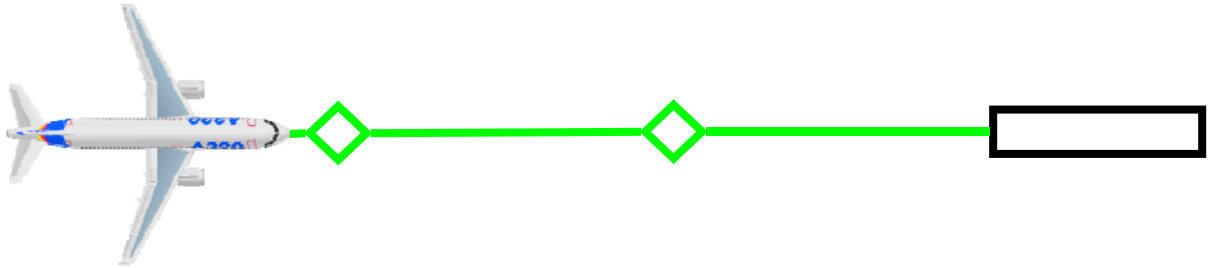
RNAV/RNP 程序编码-效益

在程序编码中TF与CF航迹终结码效益

- **TF航段**: 不受磁差影响，总是建立一个平滑的航径



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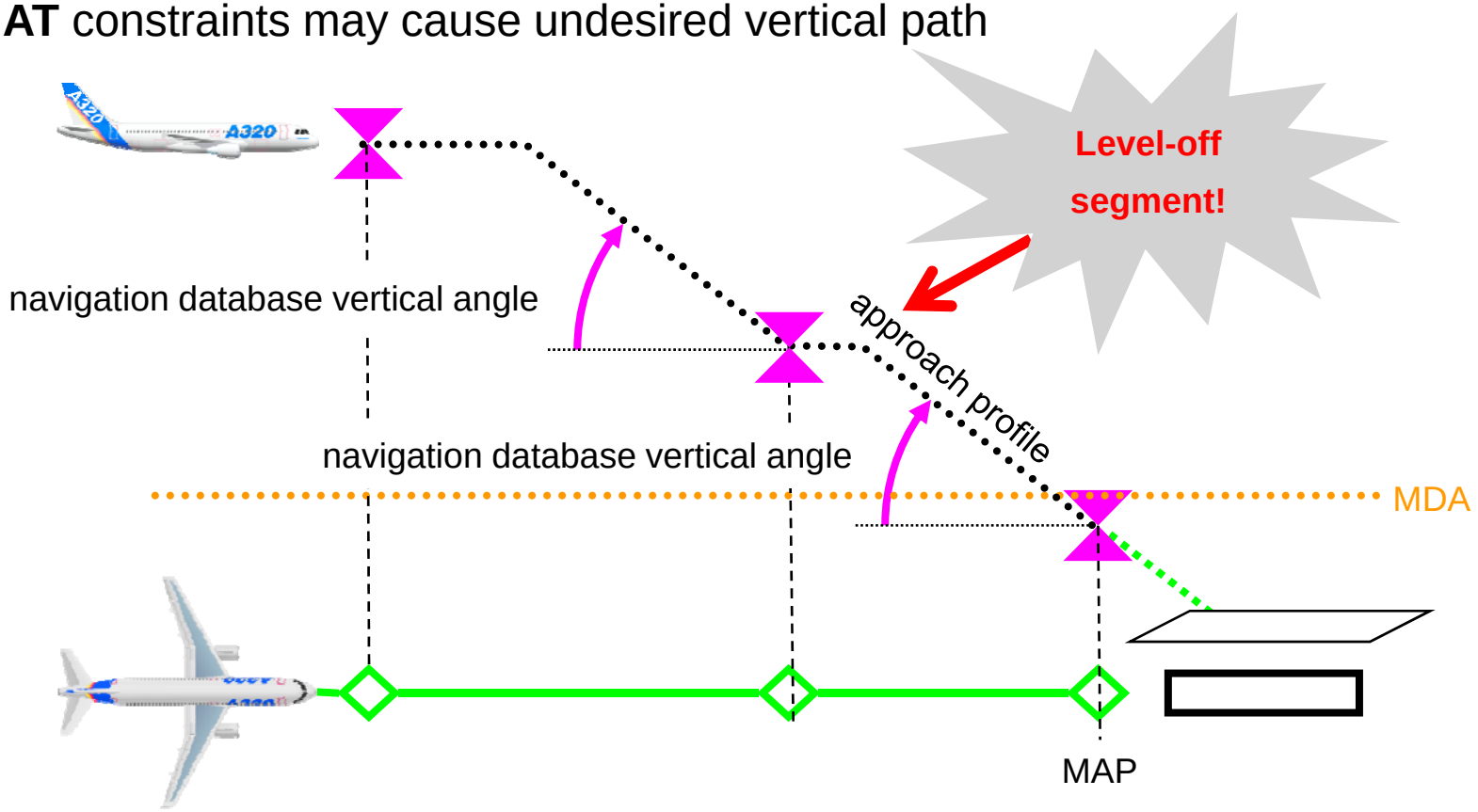
RNAV/RNP Procedure Coding – Benefits

Benefits of **AT OR ABOVE** versus **AT** altitude in approach coding

- **AT** constraints may cause undesired vertical path



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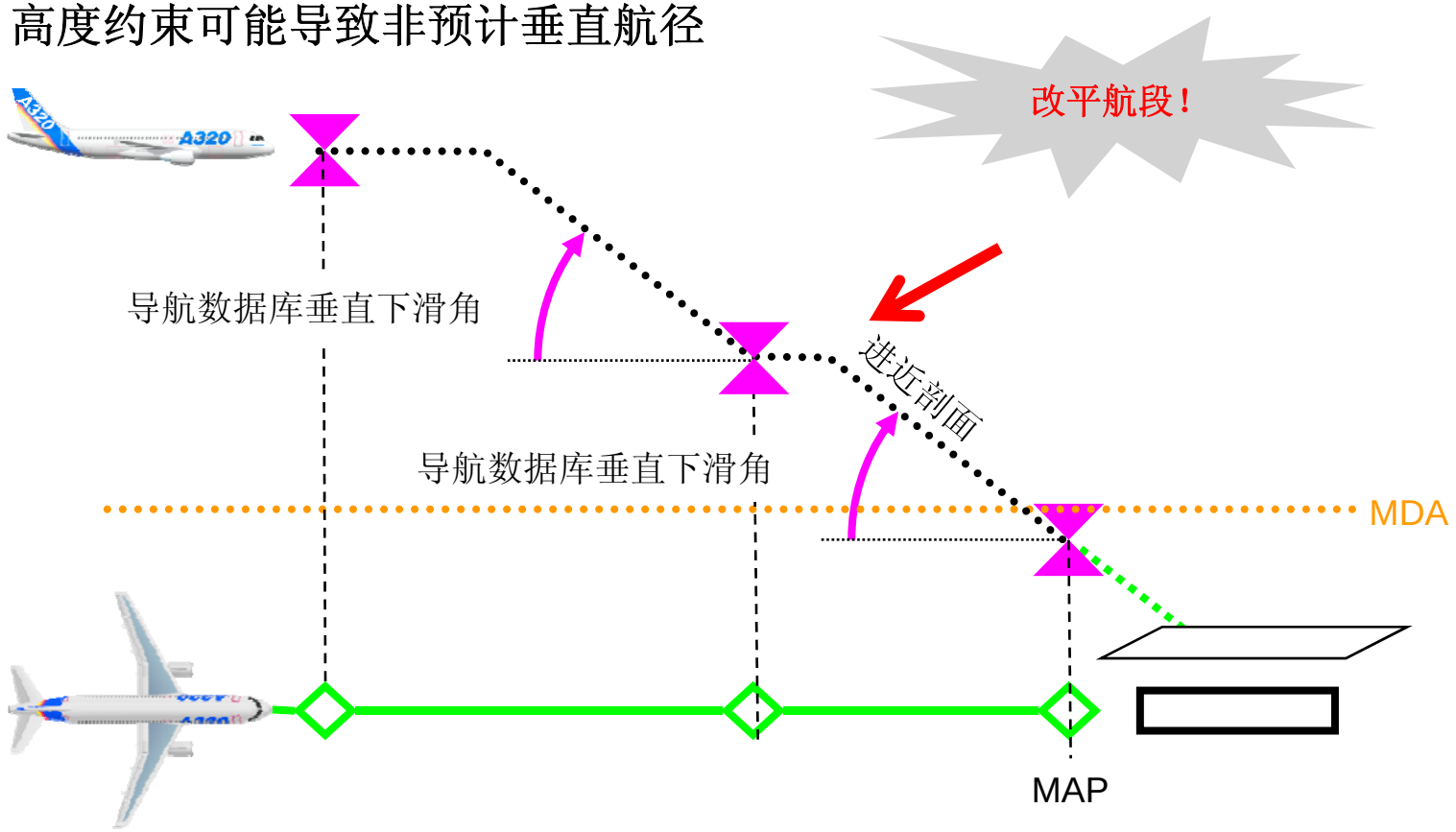
RNAV/RNP 程序编码-效益

进近编码中，AT（在）或ABOVE（高于） vs. AT（在）高度

- **AT 高度约束可能导致非预计垂直航径**



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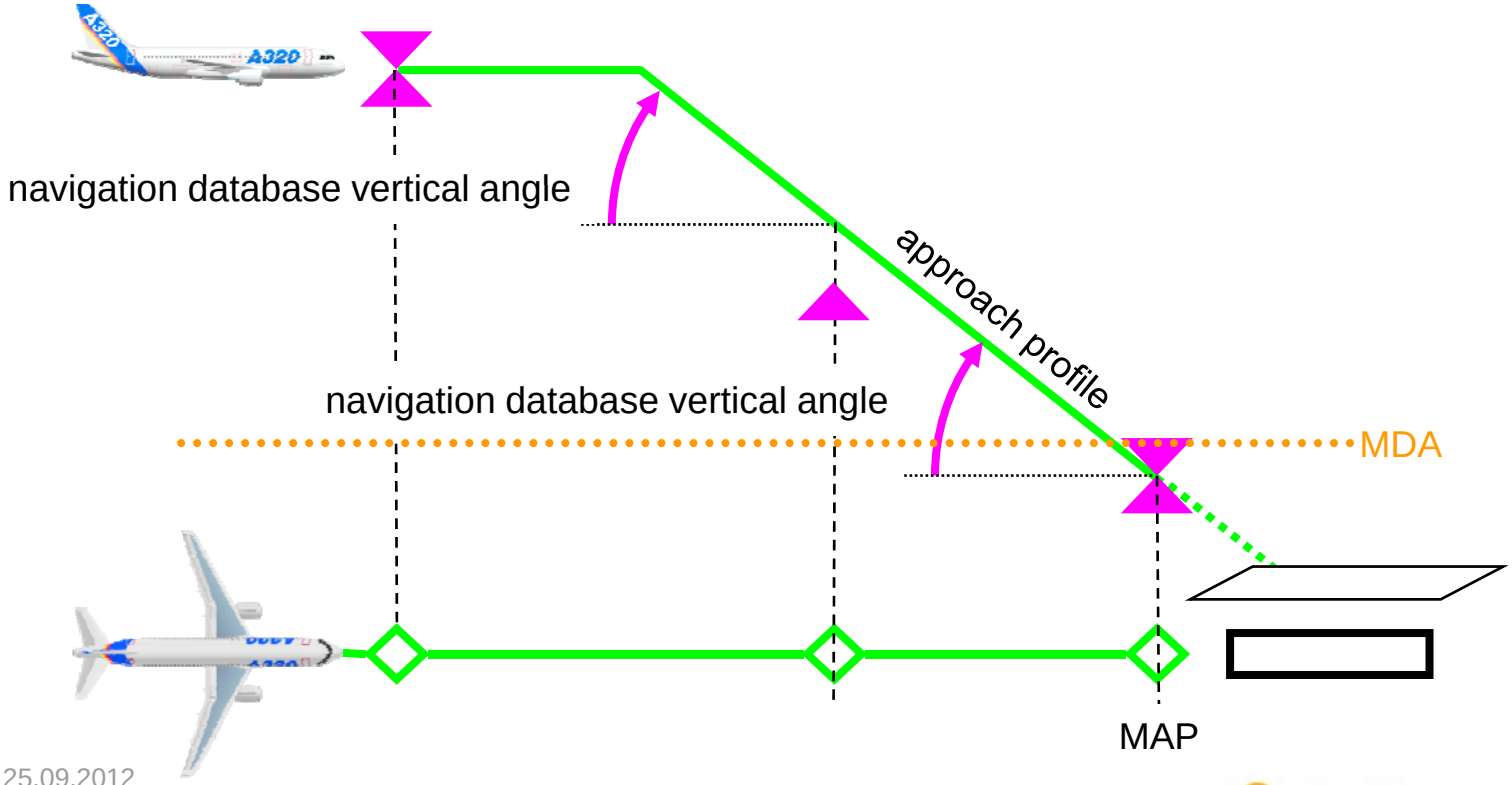

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RNAV/RNP 程序编码-效益

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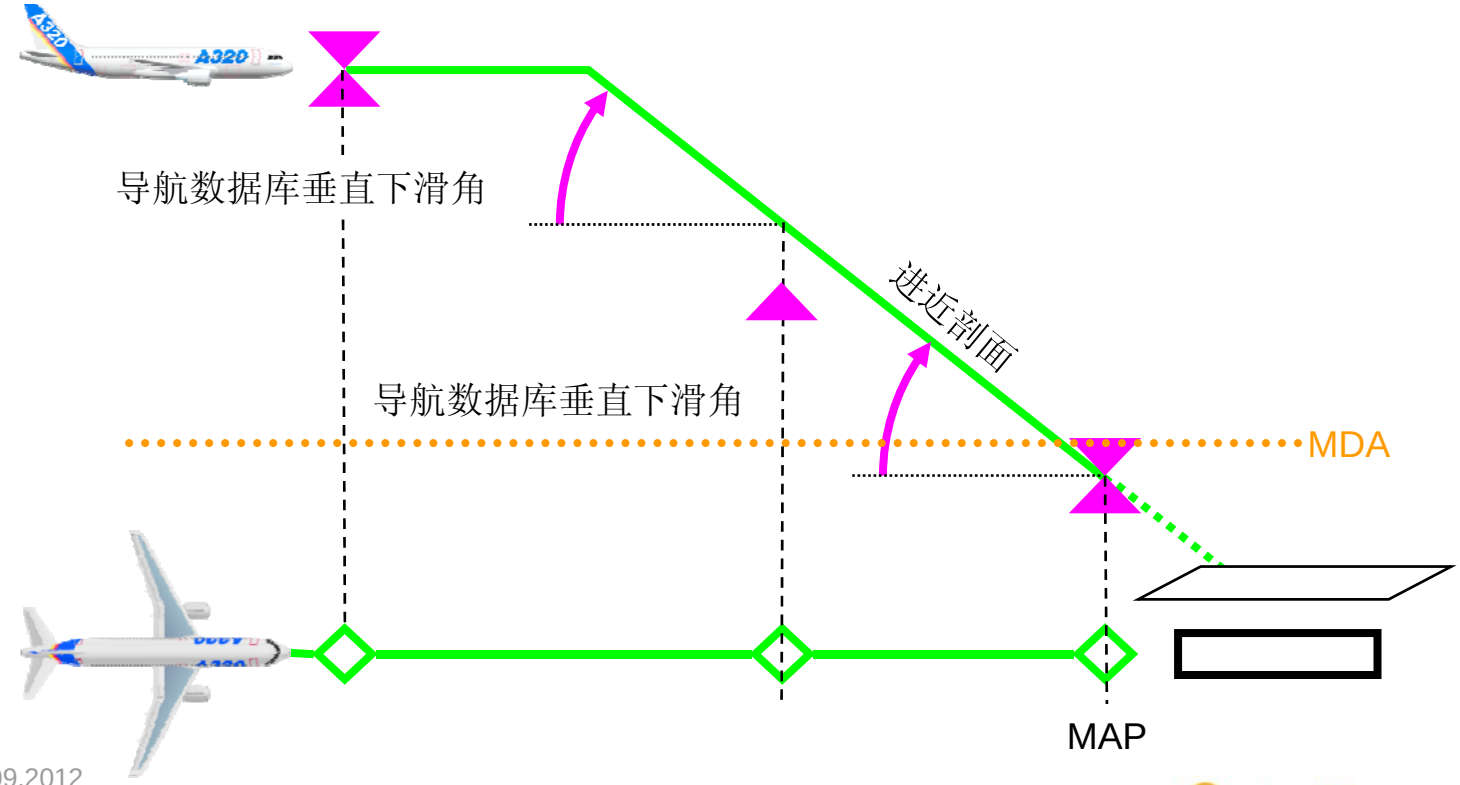

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RNAV/RNP Procedure Coding – Benefits…

… for Procedure Design:

- increased flexibility in airspace usage
- IFR procedures for previously non-IFR runways
- quicker implementation of changes

… for Data Houses:

- less complex procedures (fewer Path Terminator)
- procedure originally intended for NavDB usage

… for OEMs:

- procedure design criteria compatible with todays avionics

… for Airlines:

- access to previously inaccessible runway ends
- lower minima hence less diversions, cancellations
- reduced track miles resulting in reduced fuel costs and less emissions
- inherently safer with constant angle approach than typical “dive and drive” NPAs
- ILS-like indications means quick pilot familiarization

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RNAV/RNP 程序编码-效益…

… 对程序设计:	• 增加空域利用的稳定性 • 为先前非IFR跑道设计IFR程序 • 程序变更能更快实施
… 对导航数据仓库:	• 复杂程序更少（航径终结码更少） • 程序最初目的在于导航数据库使用
… 对OEM:	• 程序设计准则与当前航电匹配
… 对航空公司:	• 可飞至先前难以到达的跑道端 • 着陆标准更低，减少备降和航班取消 • 减少航段里程，减少燃油消耗和排放 • 恒定下滑角进近比典型的梯级下降非精密进近（NPA）安全性更高 • 类ILS指示，能让飞行员快速熟悉

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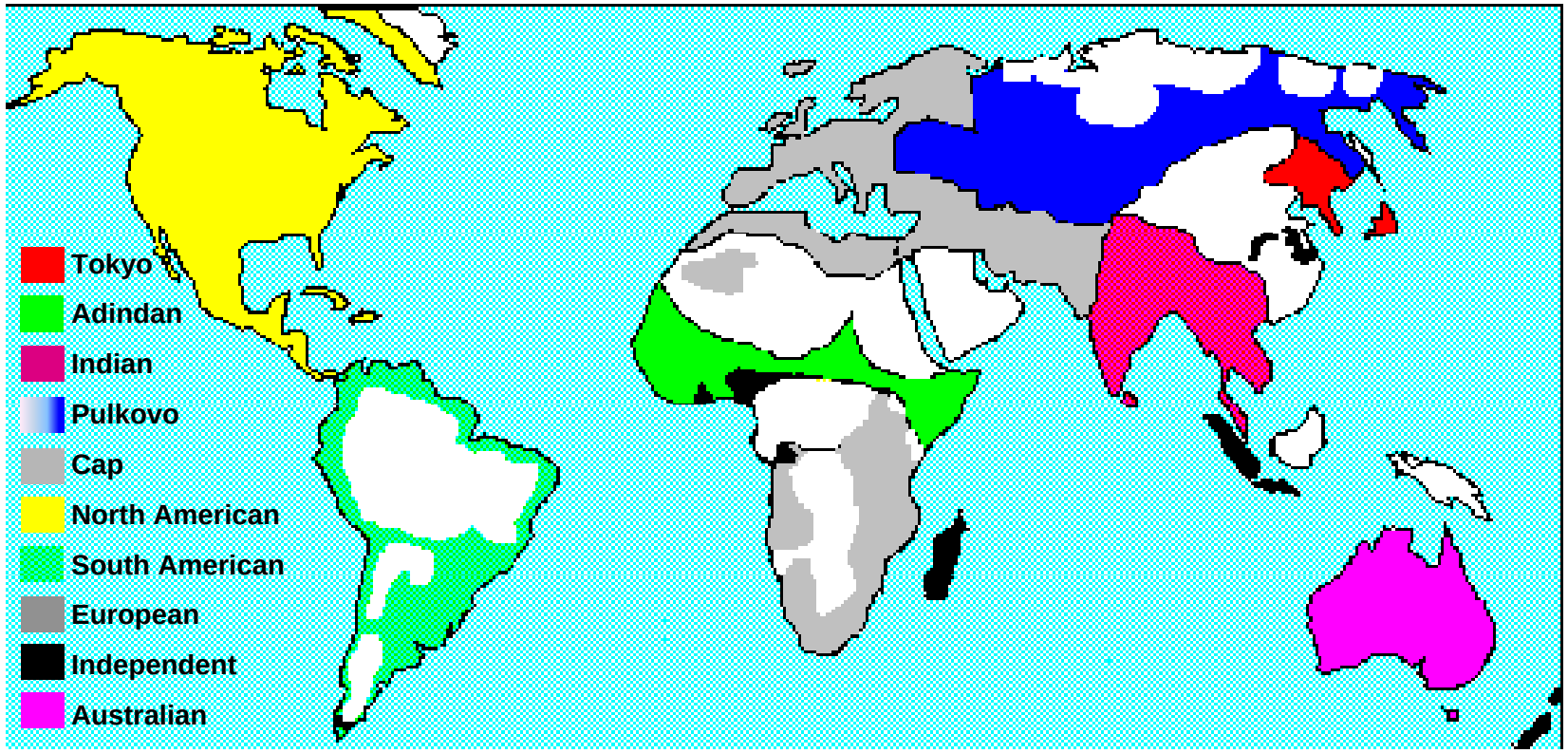
RNAV/RNP Procedure Coding – Challenges – Datum Issues (1)

Different Datum Systems in the World

(must not necessarily match todays datum system used in local AIP)



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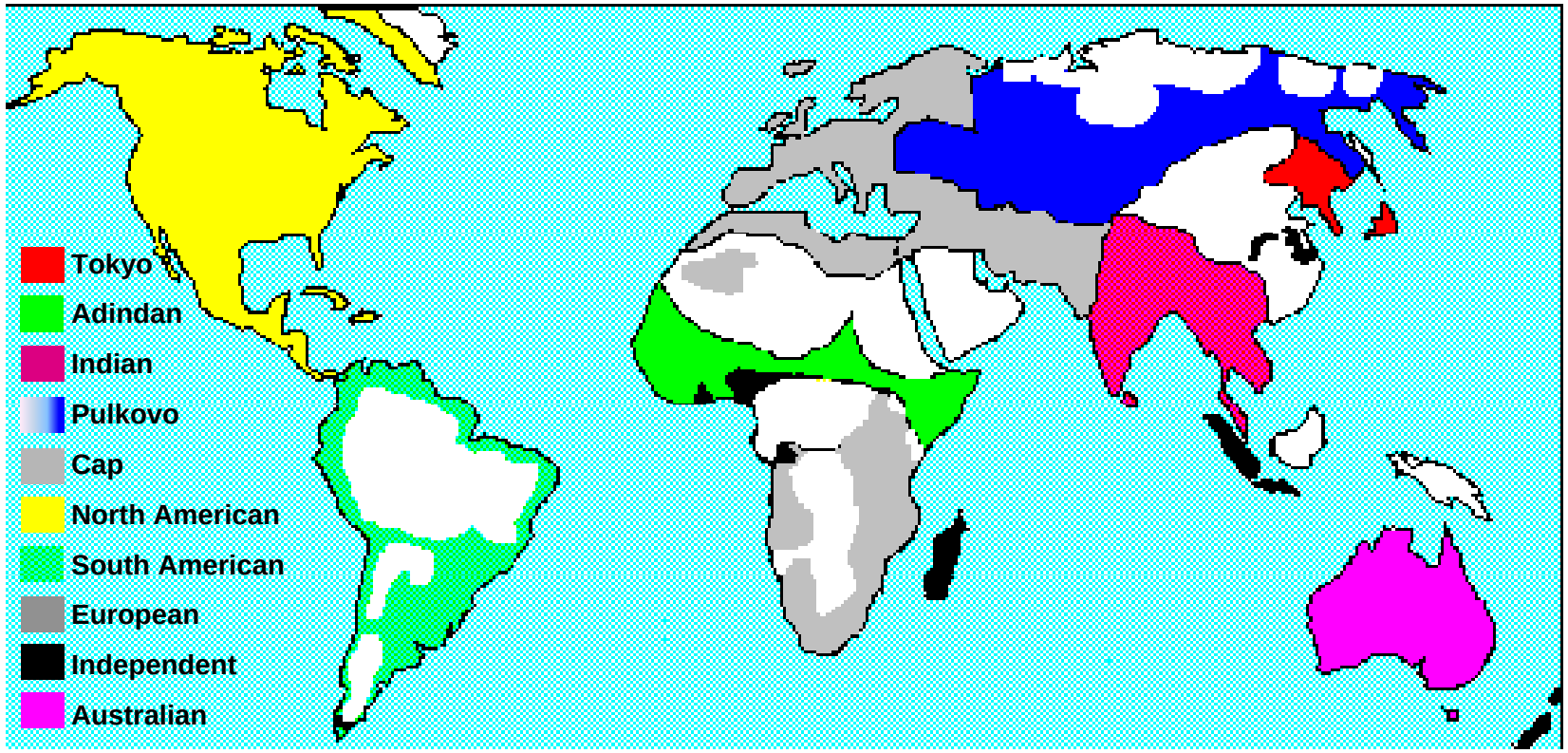
RNAV/RNP 程序编码 – 挑战 – 数据问题(1)

全世界不同数据系统

(（在本地AIP中，必须但未必匹配当前在用的数据系统）



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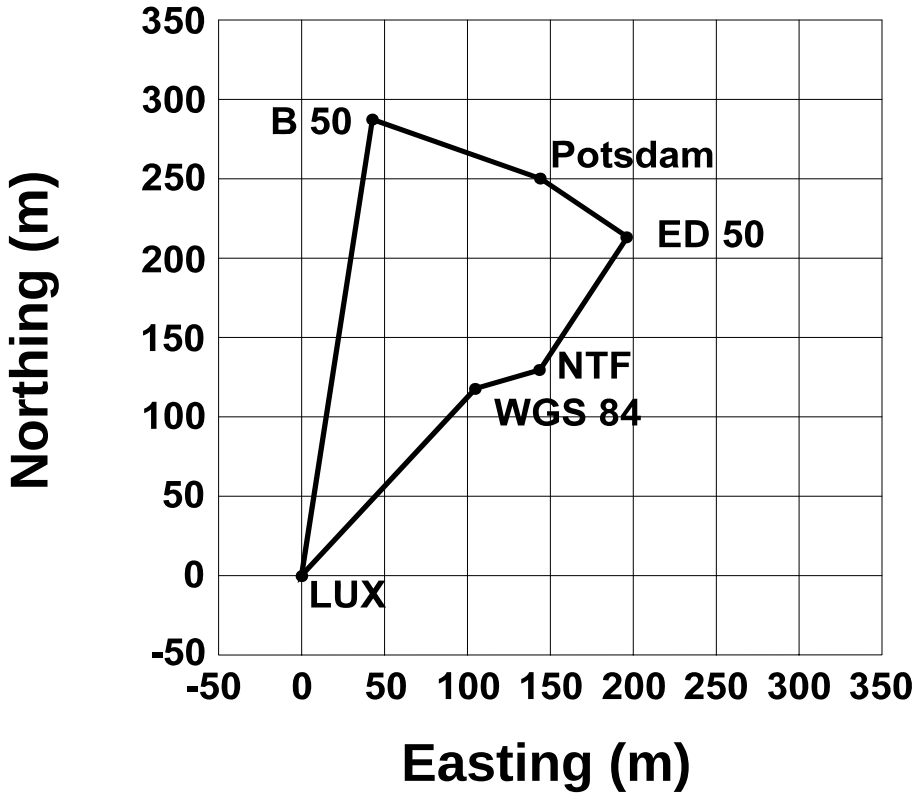
RNAV/RNP Procedure Coding – Challenges – Datum Issues (2)



- ***Coordinates of DIEKIRCH VOR (Luxembourg) in different reference frames***

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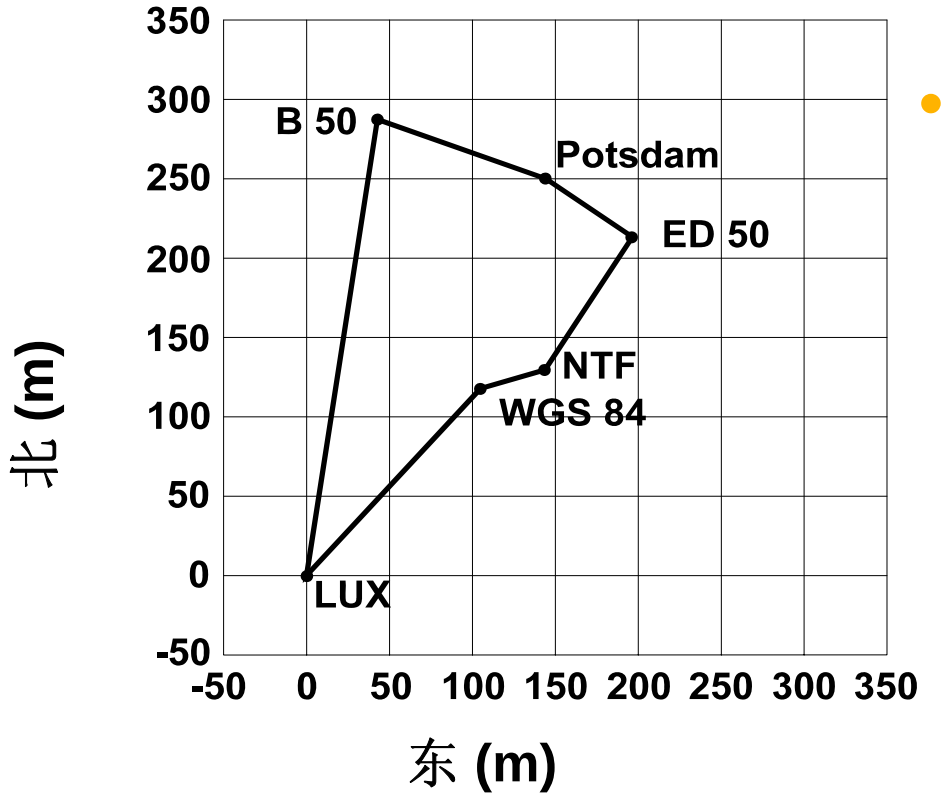
RNAV/RNP 程序编码 – 挑战 – 数据问题(2)



- *在不同参考框架内的 **DIEKIRCH VOR (Luxembourg)** 台坐标*

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RNAV/RNP Procedure Coding – Challenges – Datum Issues (3)

- ***In the past:*** Differences between reference frames could be accepted

- ***Today:*** The navigation accuracy improvement and the **RNAV introduction lead to the need of a common reference frame**

  Use of the GNSS (based upon **WGS-84)** in air navigation

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RNAV/RNP 程序编码 – 挑战 – 数据问题(3)

- *过去:* 参考框架的差异可以接受

- *现在:* 导航精度的改善和RNAV的引入，GNSS空中导航由此需要一个公共的参考框架（基于WGS-84）。

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RNAV/RNP Procedure Coding – Challenges - Datum Issues (4)

Datum Issues – Conclusions

- A **common geodetic reference system is required** in the RNAV context
- The RNAV procedures rely on the **quality of the waypoint and runway coordinates**, as **expressed in WGS-84**
- WGS-84 **implementation through data conversion** is feasible but **supposes a very accurate knowledge** of the **previously used reference system**, and high quality initial data
- WGS-84 implementation through **new surveys** is one of the keys for **high quality aeronautical data**

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RNAV/RNP 程序编码 – 挑战 – 数据问题(4)

数据问题– 总结

- 在RNAV环境下需要一个公共的地理参考系统
- RNAV程序依赖WGS-84中航路点和跑道坐标的质量，
- 如果先前使用的参考系统精确已知，并且初始数据质量高，实现WGS-84数据转换是可行的
- 对高质量航空数据，通过新的测量实现WGS-84转换是关键问题之一

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RNAV/RNP Procedure Coding – Challenges – Other Issues

Other factors impacting RNAV/RNP procedure coding

- RNAV/RNP operation **requires high accuracy and resolution of coordinates for all data elements** that are used for aircraft guidance – including, but not limited to **waypoints** and **runway thresholds**

- A perfectly designed RNAV approach **without accurate runway threshold coordinates** is of questionable value - the **most critical part of an approach is the final approach** when the runway becomes the active « TO » waypoint

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RNAV/RNP 程序编码 – 挑战 – 其他问题

影响RNAV/RNP程序编码的其他因素

- RNAV/RNP运行，对所有用于航空器引导数据元素，需要高精度和高分辨率的坐标-包括、但不限于航路点和跑道入口。

- 如果没有精确跑道入口坐标，一个完美设计的RNVA进近程序是值得怀疑的-当跑道变成有效的“向台”（“TO”）航路点时，进近最重要部分是最后进近。

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