ICAO APAC FPP

EoR Research and Experimental Operation in TMA Airspace of China

Air Traffic Management Bureau of CAAC

2026.4.3 Beijing, China

About me

- 2001-2005
- Civil Aviation University of China

- 2006-2010
- Air Traffic Controller, Beijing TMA

- 2011-2013
- Flight Procedure Designer, North China ATMB

- 2013-
- Senior Engineer, Airspace Management Center, ATMB of CAAC

Contents

目录

01 Basic Concept of EoR

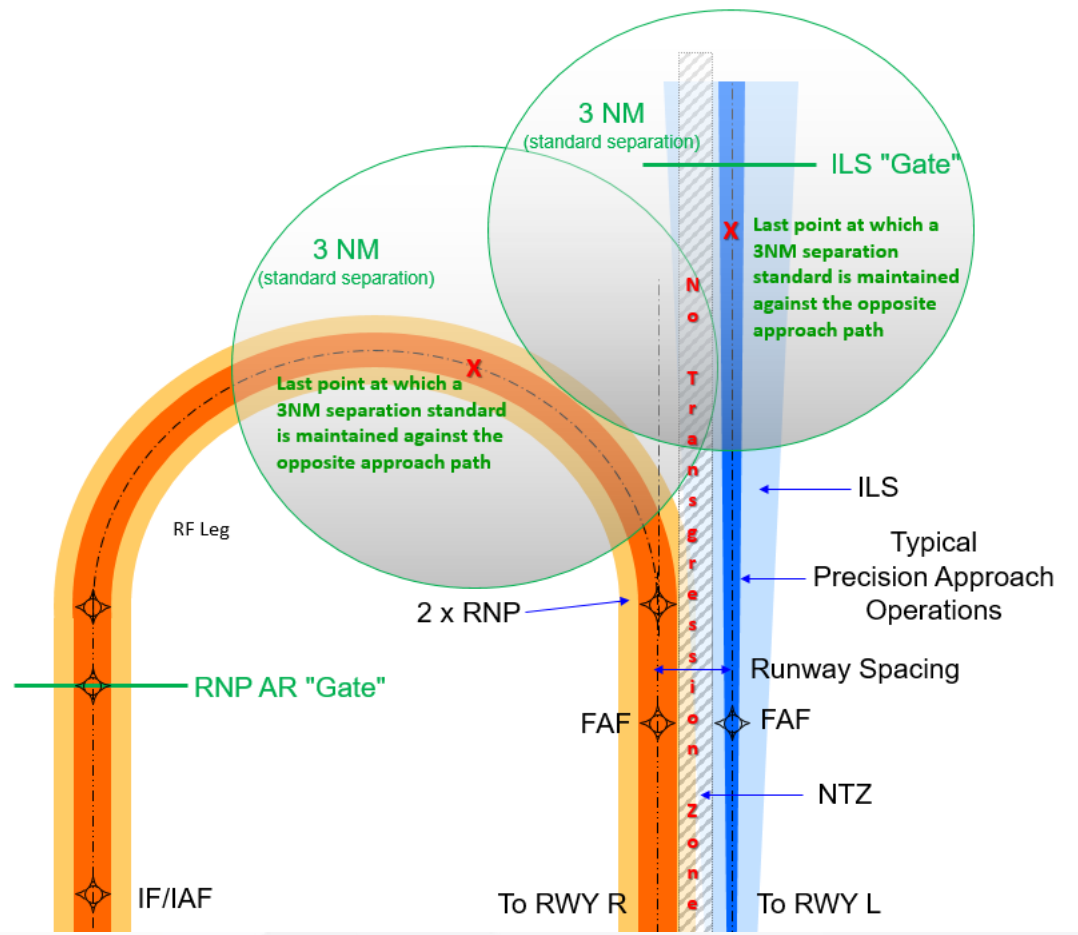
What is EoR?

EoR stands for "Established on RNP-AR Approach"

ICAO Doc 9643 – Manual on Simultaneous Operations on Parallel or Near Parallel Instrument Runways (SOIR)

Established on RNP AR APCH is an **operation for simultaneous approaches** that considers aircraft conducting an RNP AR APCH procedure eligible for SOIR.

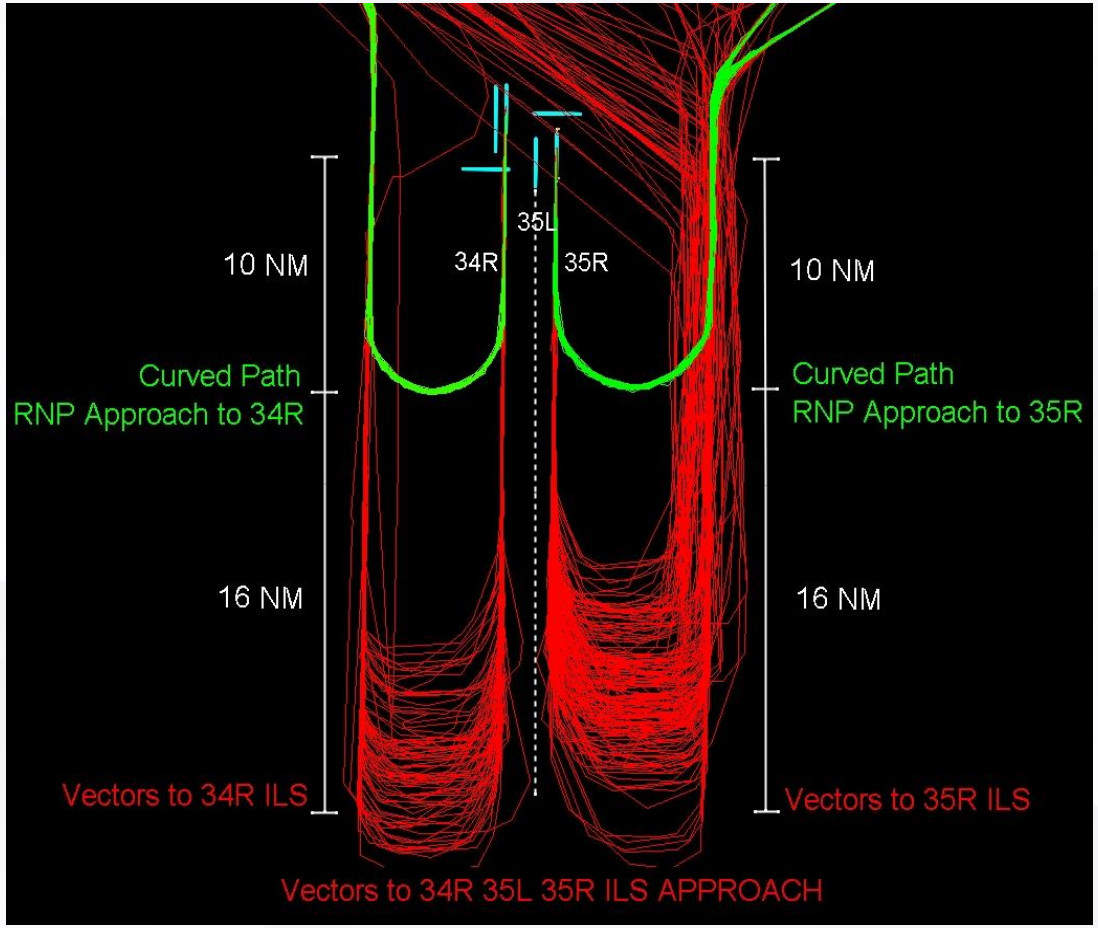
EoR allows for two aircraft, one on an RNP-AR and the other on an ILS, to make approaches simultaneously, side-by-side, to two different parallel runways.



Why EoR?

EoR can provide substantial **flexibility** in the design of simultaneous approach operations.

Many RNP designs will provide **shorter track miles and optimized descent profiles** compared to traditional SOIR, resulting in **increased operational efficiency** whilst providing environmental benefits such as a **reduction in noise and greenhouse gas emissions**.



Example Benefits in KSEA

Efficient:

- 297 – 746 lbs* fuel saved per arrival
- Up to 23 fewer track miles flown

Clean:

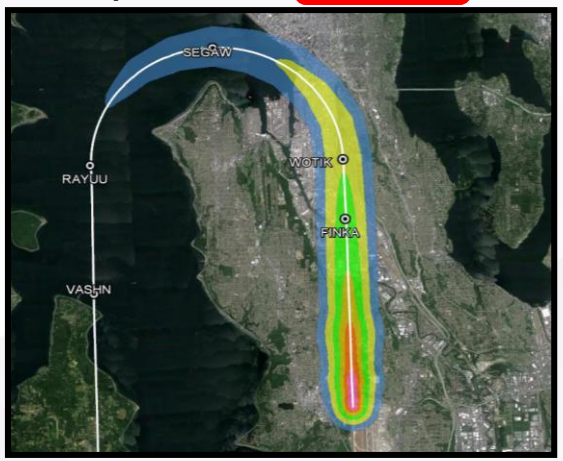
- 937 – 2,354 lbs less CO_2 per arrival
- Overall fuel reduction: >2.7 million gallons
- Emissions reduced by 25,600 metric tons (e.g. taking 5,400 cars off the road)

Quiet:

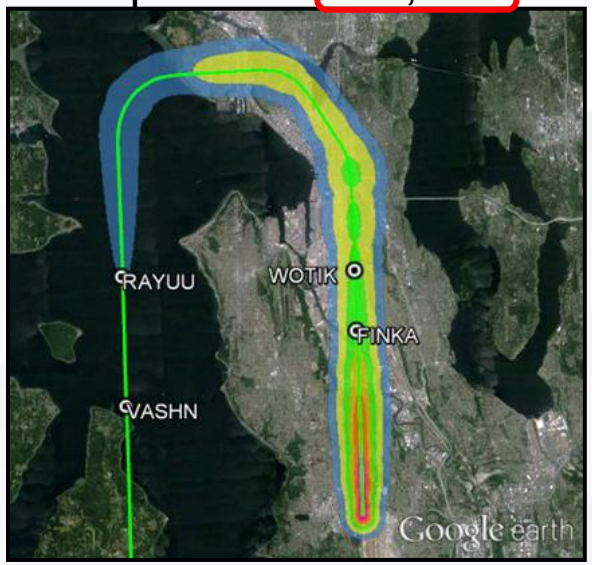
Redirected *and* less total noise

114,500 – 159,000 ** fewer people exposed to >55 dBA noise level

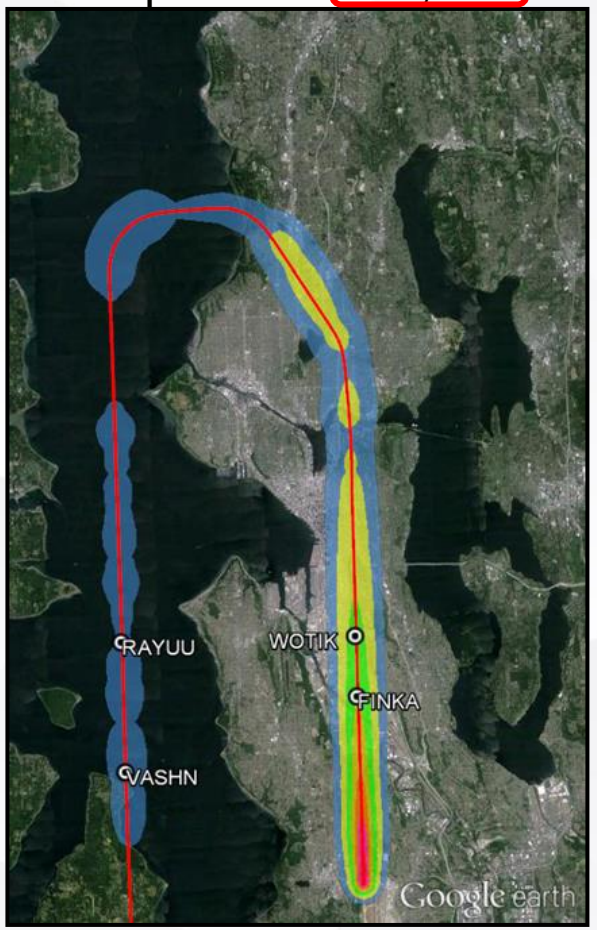
RNAV (RNP) Z RWY 16R
Population: 58,000



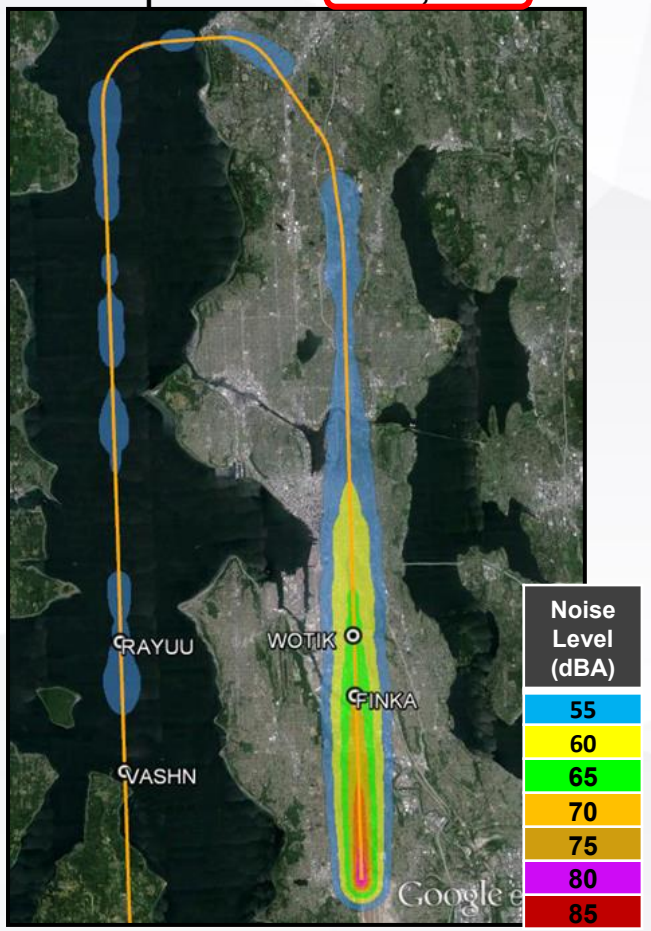
Earliest Vector Turn
Population: 172,500



Typical Vector Turn
Population: 217,000



Bad Weather Vector
Population: 193,500



Estimated population exposed to 55 dBA and greater

Source: US Census Bureau – 2010 TIGER Data

RNP AR concept review

PBN = RNAV + RNP

OPMA=Onboard Performance Monitoringn and Alerting

RNP = RNAV + OPMA

OPMA on Boeing Aircrafts

- OPMA is not a independent hardware device, but a function realized by MMR and other equipment.
- Display the OPMA information by MCDU

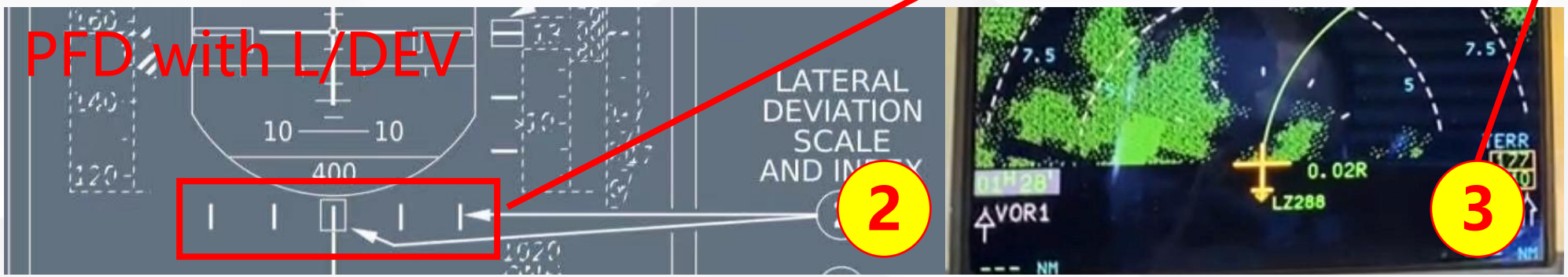
ANP

vs

RNP

OPMA on AirBus Aircrafts

TSE = EPU + FTE



Authorization Required

AR=Authorization Required

Trait

- Based on FMS
- Totally depend on GNSS
- RNP AR support RNP value < 0.3
- 2xRNP ½ AW of protection area
- Support RF leg （Radius Fixed Turn）

Why need authorization?

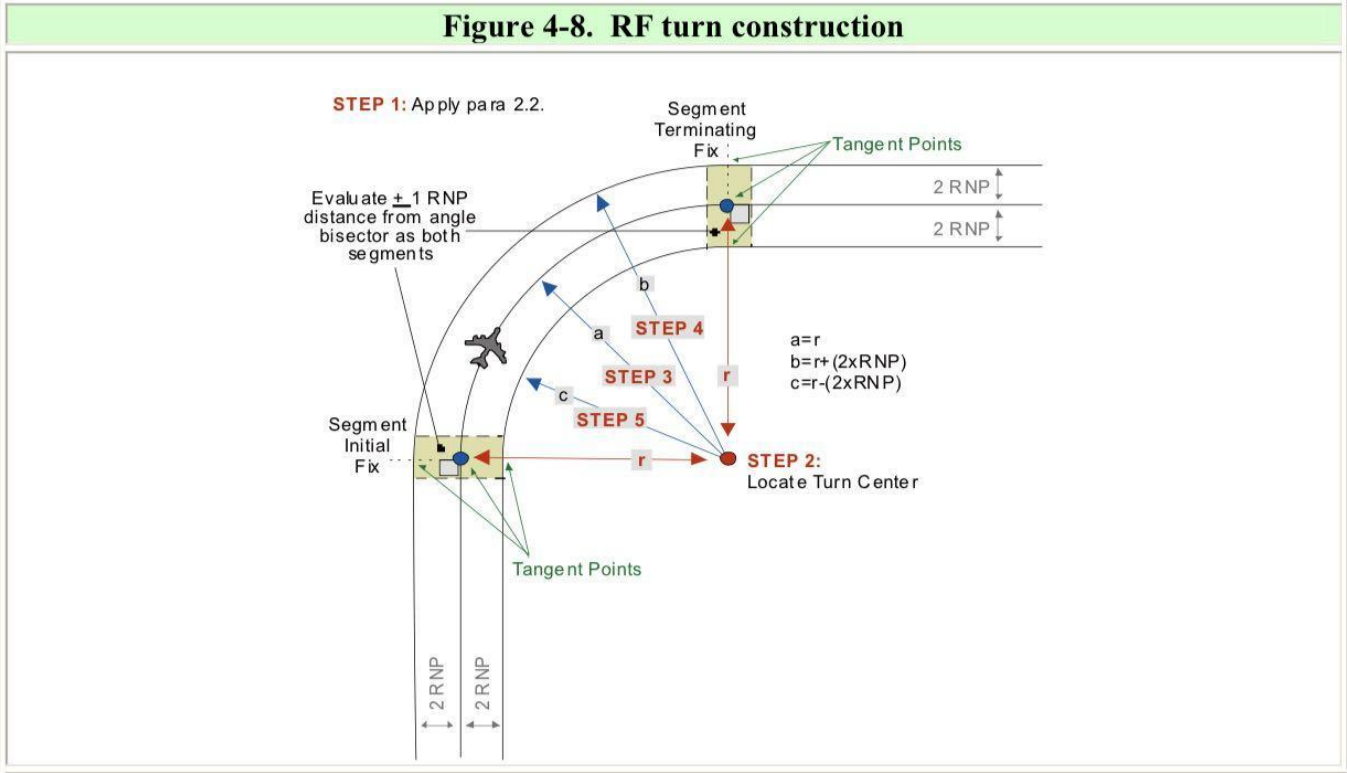
Because of

Narrower protection area and RF turn

- More training for pilot
- Higher requirements for airborne equipment

RF turn

Radius Fixed turn



- Provide a predictable and repeatable turning track.
- Preventing track instability caused by factors such as speed and early turn before point

Requirement for Airborne Equipment

飞机设备

开始 RNP AR 运行所要求的最少设备为:

- 2 部 FMGC Flight Management and Guidance Computer
- 2 部 MCDU Multi-function Control Display Unit
- 2 部 FD Flight Director
- 2 部 AP Auto Pilot
- 2 部 FAC Flight Augmentation Computer

- 2 部 ELAC Elevator and Aileron Computer
- 2 部 SFCC Slat and Flap Control Computer
- 2 部 RA Radar Altimeter
- 2 部有 L/DEV 和 V/DEV 显示的 PFD Primary Flight Display with L/DEV and V/DEV
- 2 部 ND Navigation Display
- 2 部 GPS(MMR) GPS (Multi-Mode Receptor)
- 3 部在 NAV 方式的 ADIRS Air Data Inertial Reference System
- 有地形显示的 TAWS Terrain Awareness and Warning System
- 带双通道的 FCU Flight Control Unit with Dual-channel

keep the track
&
fix the turn

Narrower protection area

ATMB

The birth of EoR

★ In 1996, Alaska Airlines flew the first RNP AR procedure in the terrain challenged environment surrounding Juneau airport.

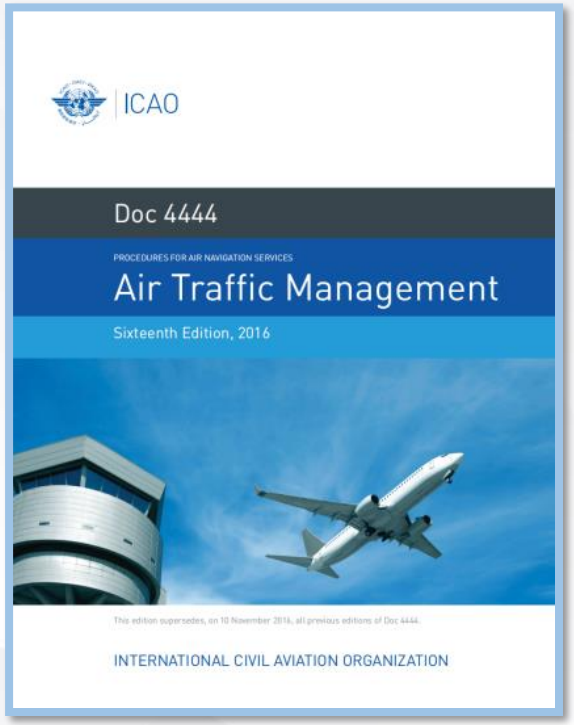
★ The three-dimensional nature and precise track containment of RNP AR procedures was soon recognized as having applications beyond terrain challenged environments.

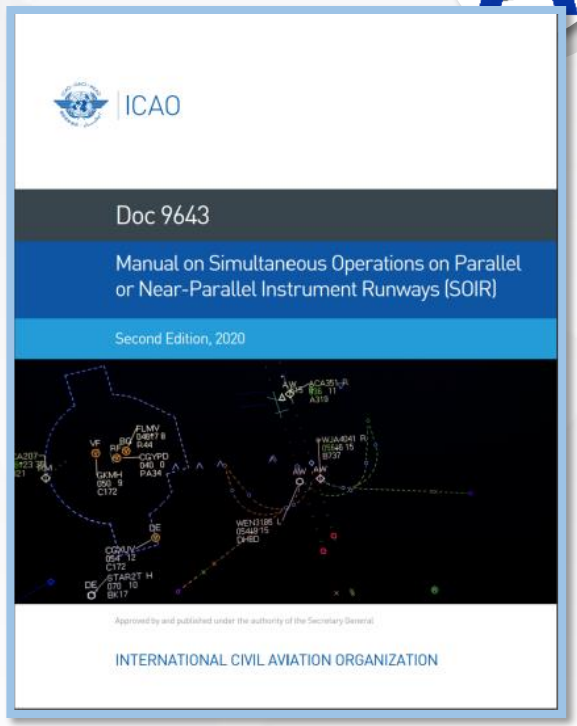
★ RNP AR procedures could be used in congested, high traffic airspace to separate aircraft from other aircraft or controlled airspace constraints.

★ In 2015, the Denver and Seattle airports in the United States respectively applied EoR technology to carry out independent and dependent parallel approach operations.

RNP AR provided a safer and predictable path to the airport

The birth of EoR

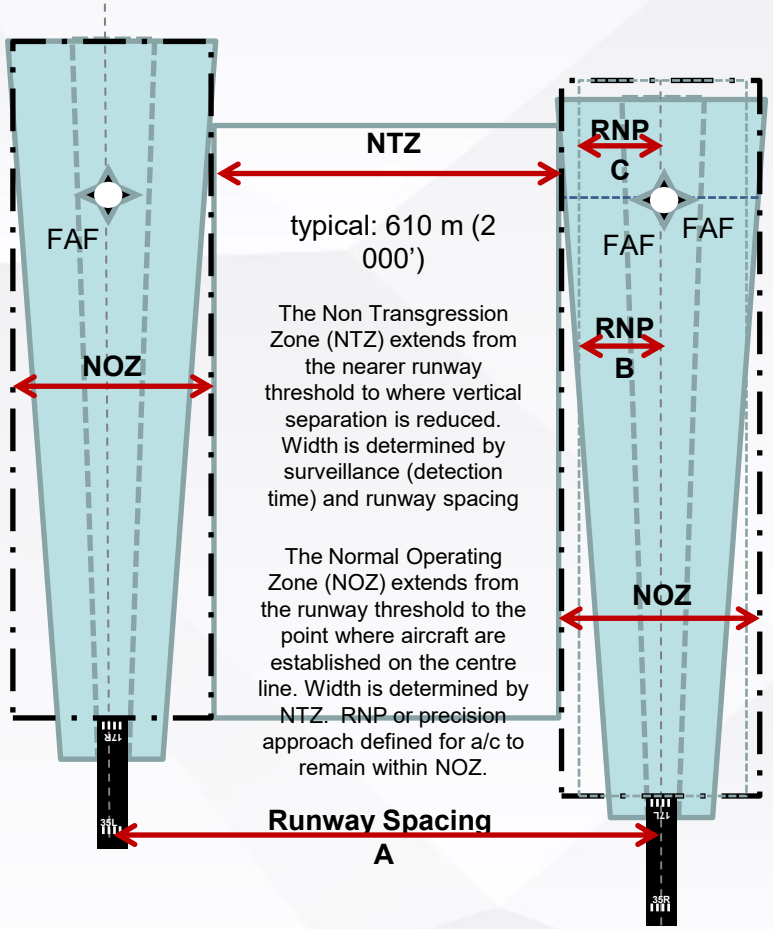




★ Since 2018, the specifications and standards for EoR have been included in ICAO Doc 4444 and Doc9643, encouraging countries to adopt this technology.

★ On November 8, 2018 coincidently with the inclusion of the Established on RNP AR APCH specifications and standards into ICAO PANS-ATM (Doc4444), Calgary International Airport (CYYC) in Canada, began full use of the new standard.

ICAO: Design Guidance for Simultaneous Use



- ILS
- GLS

- Approach designs are laterally separated
- Maintains NTZ and NOZ function

any combination of instrument approaches including:

1) a precision approach

2) an RNP AR procedure, if:

a. the RNP (B and C) does not exceed ¼ of the runway spacing (A), and

b. the RNP (B and C) is equal to or less than (A-NTZ)/2
[e.g. procedure is contained within NOZ]

2018: SOIR and PANS ATM (ICAO Doc 9643 & 4444).
Include "Established on RNP"
and the use of RNP procedures during SOIR .
EoR traffic separation can be applied
without vertical separation
(may use TF and RF transitions-to-final)

ICAO：Determination of EoR

6.7.3.5 DETERMINATION THAT AN AIRCRAFT IS ESTABLISHED ON RNP AR APCH

6.7.3.5.1 In addition to the requirements specified under 6.7.3.2, for the purposes of applying 6.7.3.2.5 b), an aircraft conducting an RNP AR A[illegible] the IAF/IF provided that:

a) the aircraft confirms th[illegible] location of such point t[illegible]

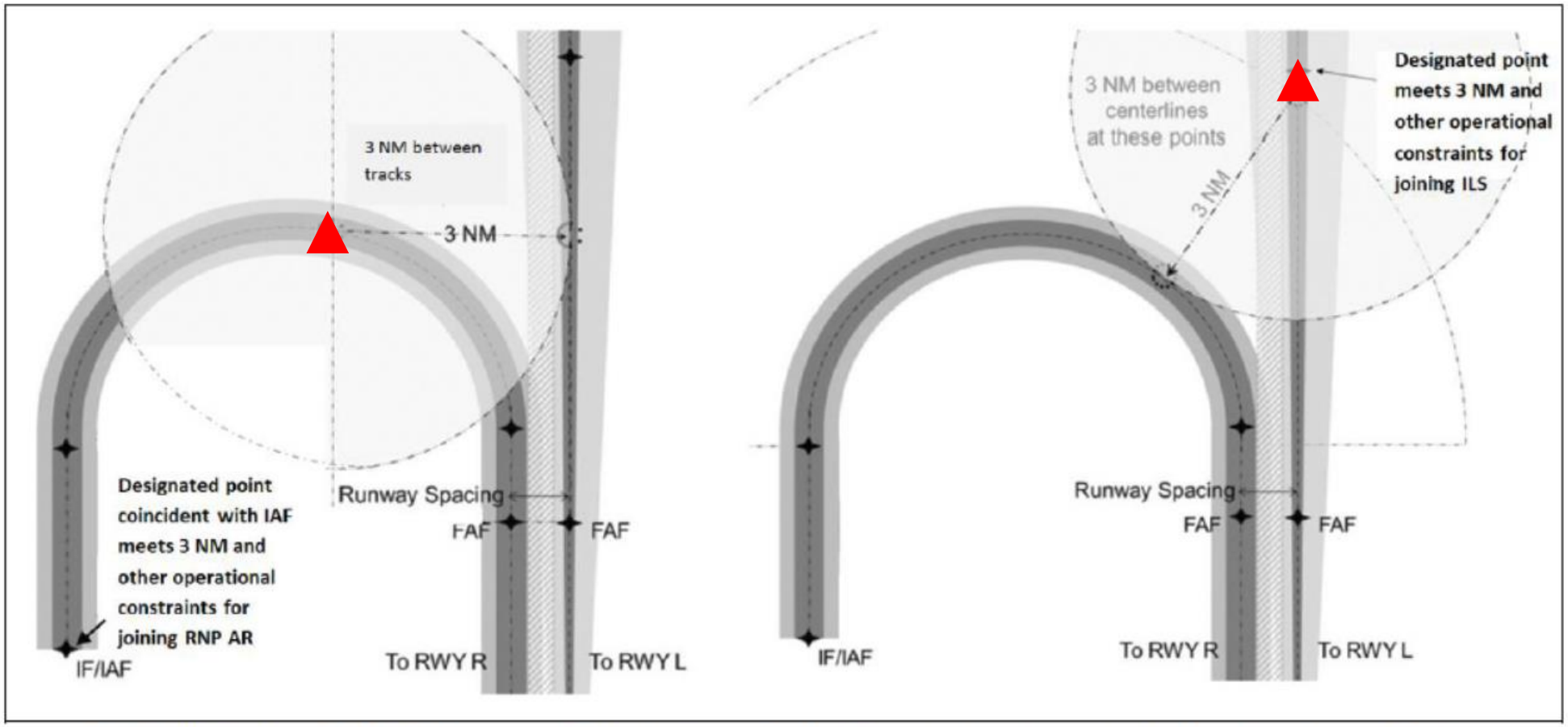
b) the designated point sh[illegible] minimum (e.g. 5.6 km ([illegible] may normally be coinci[illegible]

c) to facilitate the applicat[illegible] monitoring controllers.

6.7.3.5.2 Appropriate wak[illegible]

6.7.3.5.3 If, after reporting [illegible] the procedure, the pilot shall not [illegible] ATC instructions (e.g. break-out [illegible]

Note.— Break-out procedur[illegible] Instrument Runways (SOIR) *(Do[illegible]*



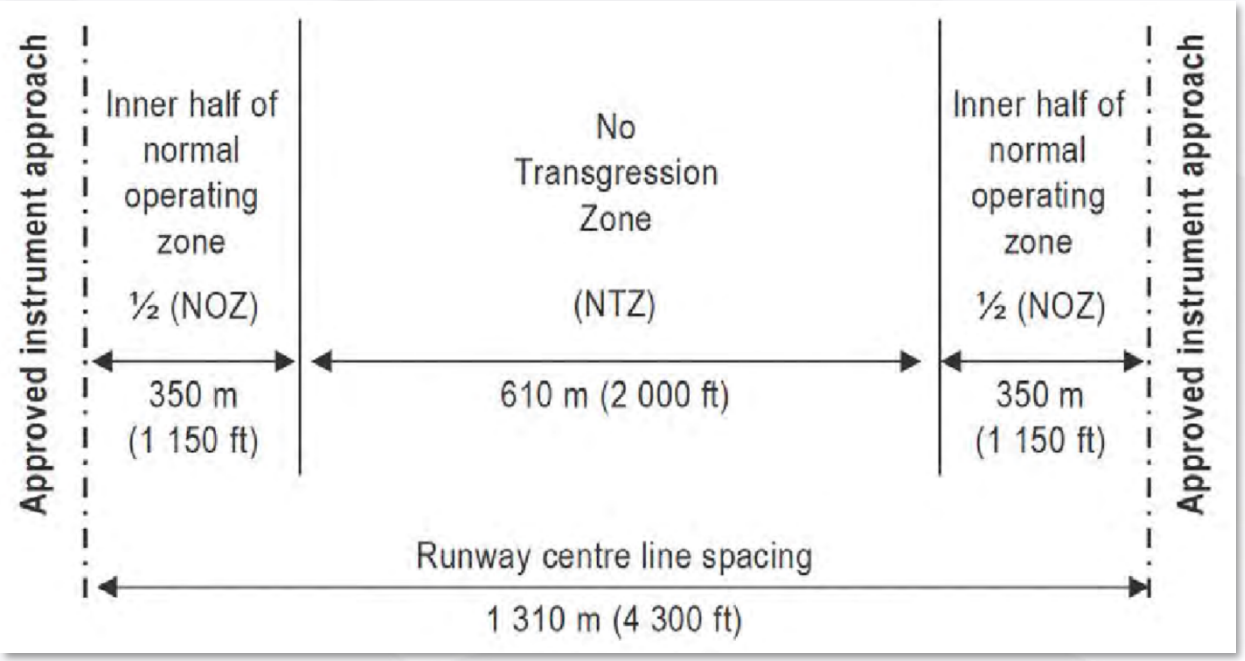
Established on RNP AR concept depicting the designated points at which aircraft are to be established on the approach

Other Key Elements——NTZ, NOZ

NTZ

A No Transgression Zone (NTZ) at least **610 m (2000 ft) wide** is established equidistantly between extended runway center lines and is depicted on the ATS surveillance system situation display. The NTZ extends from the point where vertical separation is reduced to the nearer runway threshold

Extending outward from the nearest runway threshold, until a point where **300m vertical and/or 3.0 NM horizontal separation is no longer provided**.



RNP Value

Table 2-1. RNP navigation accuracy requirements

Segment	*RNP AR*		
		Maximum	*Minimum*
Initial		1	0.1
Intermediate		1	0.1
Final		0.3	0.1
Missed approach		1.0	0.1*

* See section 4.6 for operational implications associated with missed approach segments' (MAS) most stringent RNP navigation accuracy requirements.

- ✓ ICAO Doc9905, RNP AR Procedure Design Manual
- ✓ Parallel runway distance requirement

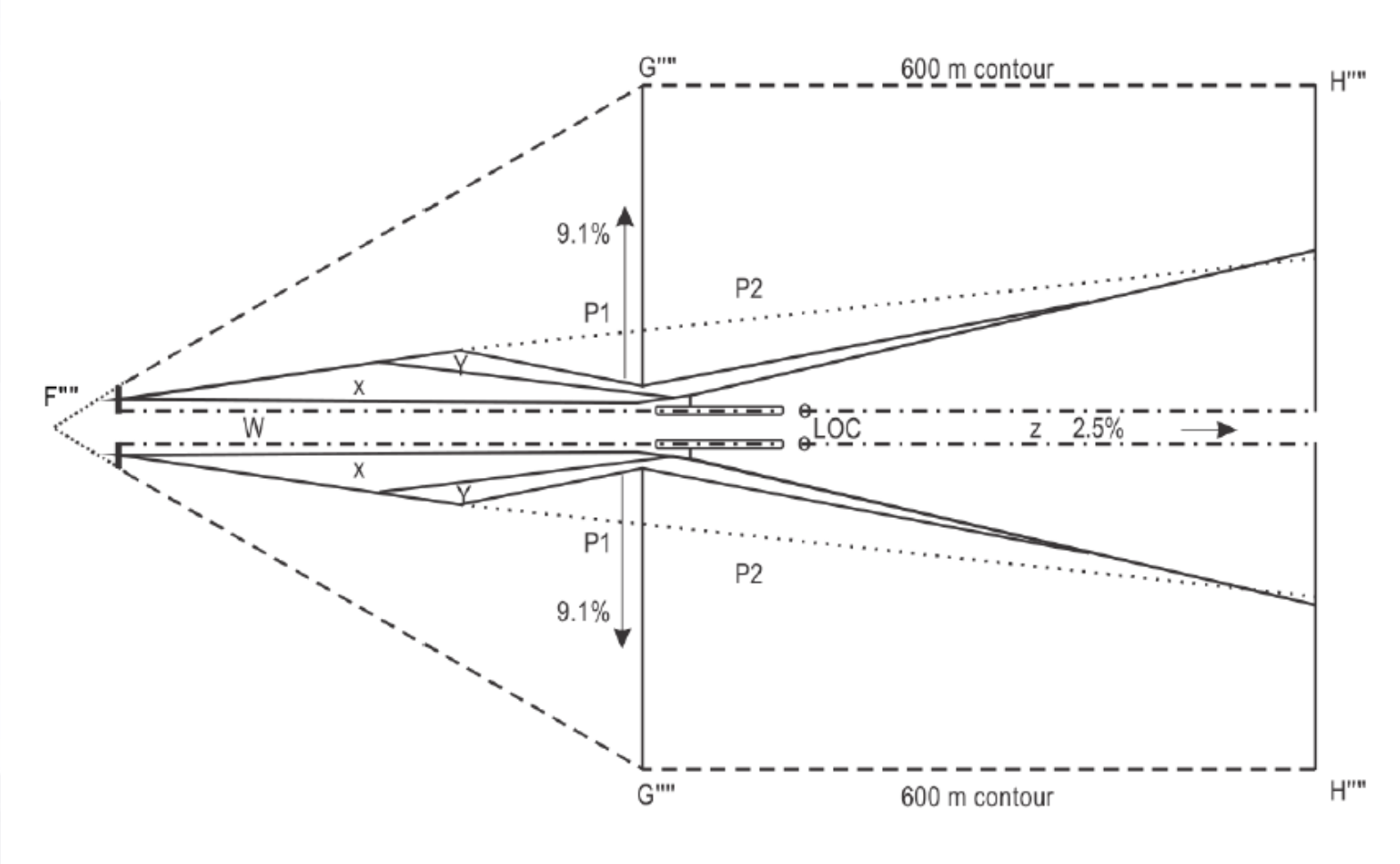
  RNP value ≤A/4

  RNP value ≤ （A-NTZ） /2

- ✓ Obstacle clearance requirement
- ✓ The higher the accuracy(smaller RNP value)is, the higher the requirement for GNSS signalstability

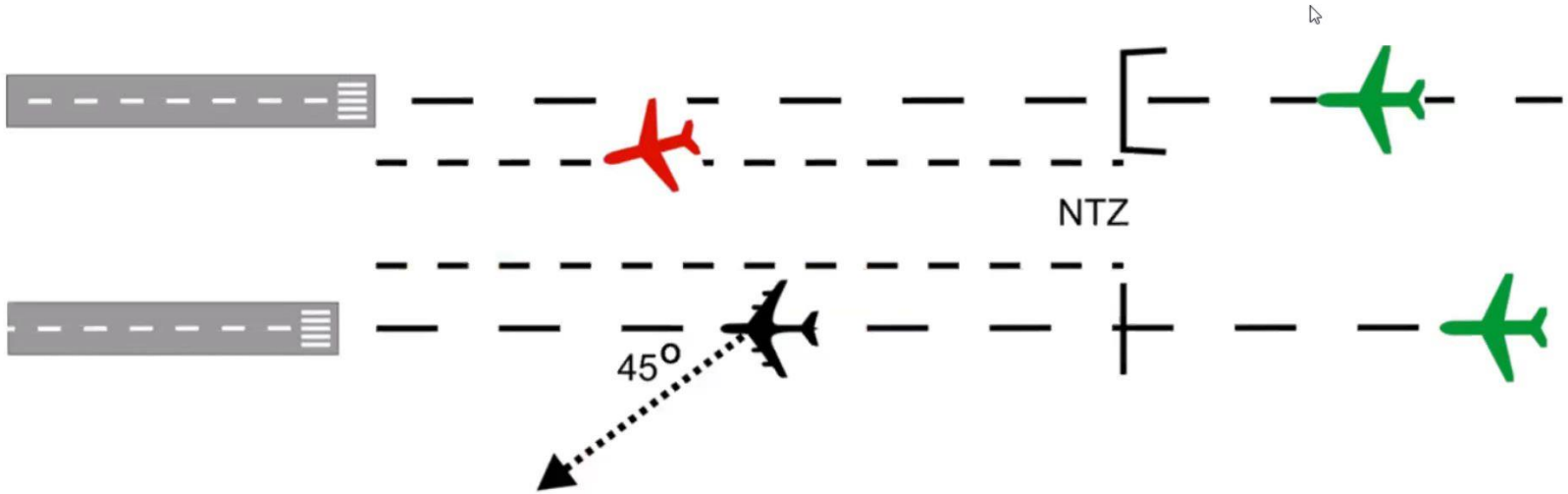
PAOAS Assessment

Parallel Approach Obstacle Assessment Surface



Break-out procedures

- When an aircraft is observed penetrating the NTZ, the aircraft on the adjacent approach track shall be instructed to immediately climb and turn to the assigned altitude/height and heading in order to avoid the deviating aircraft
- If, after reporting that it is established on the RNP AR APCH procedure, the aircraft is unable to execute the procedure, the pilot is required to notify the controller immediately with a proposed course of action and thereafter follow ATC instructions (e.g. break-out procedure).



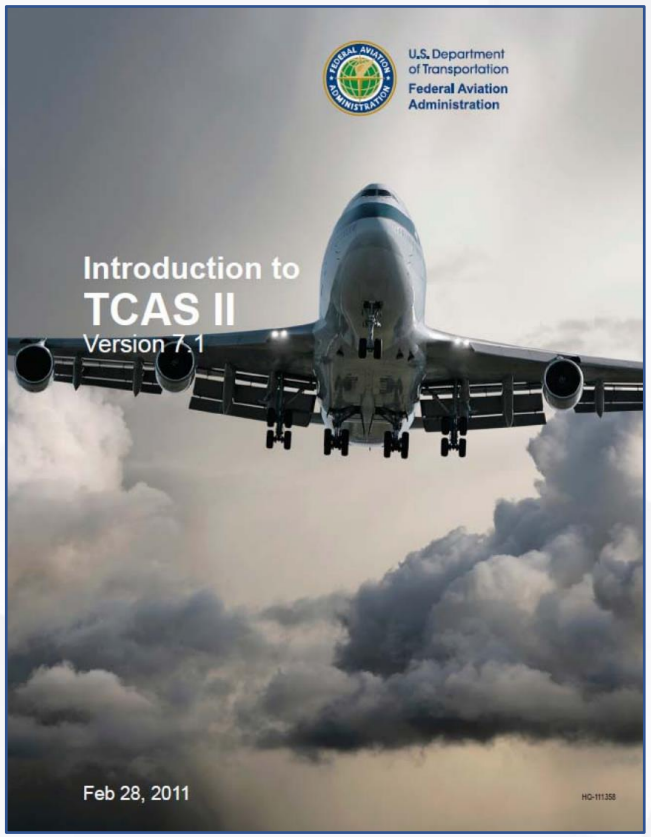
FOSA

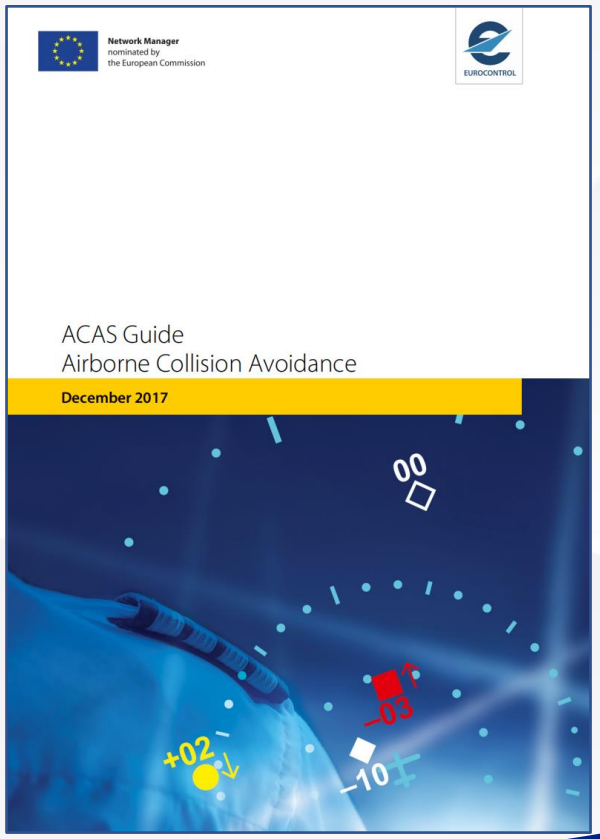
Flight Operation Safety Assessment

TCAS Analysis

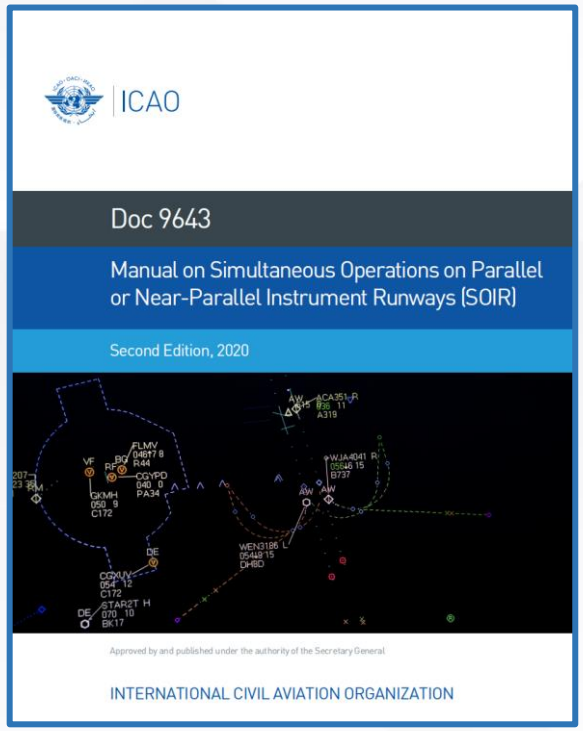
DOT FAA Introduction to TCAS II Version 7.1 — 2011 年

ACAS Guide/Airborne Collision Advoidance System - Euro Control — 2017年





TCAS Modelling



4. APPROACH DESIGN CONSIDERATION SPECIFIC TO SOIR

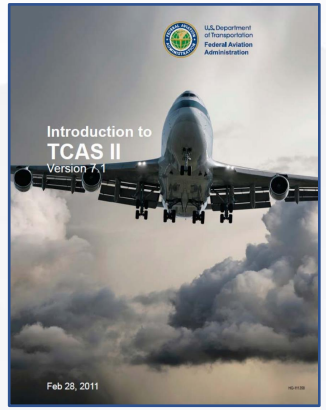
4.1 RNP AR APCH approaches need to be designed in accordance with ICAO *Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual* (Doc 9905) or other procedure design criteria approved by the appropriate State authority.

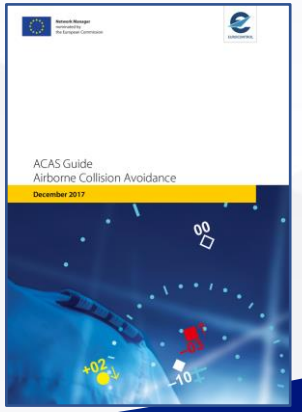
4.2 Approach design should ensure nuisance TCAS alerts are not generated. TCAS modelling may be used as part of the design process, and approach tracks altered accordingly.

4.3 An important safety requirement is to mitigate incorrect runway selection. One way of mitigating the hazard of incorrect runway selection is by design.

4.4 There may be several different design mitigations available, dependent on airspace and terrain restrictions, noise considerations, and traffic patterns. Figure A-6 shows a potential design mitigation where the incorrect runway selection will be evident to the controller in a timely manner. Where available, a selective airspace warning filter can also be used to alert the controller. Further mitigation could also be achieved by only publishing RNP AR APCH approach to the "near" runway.

- ✓ DOT FAA Introduction to TCAS II Version 7.1
- ✓ ACAS Guide/Airborne Collision Avoidance System - Euro Control





Calgary, Canada

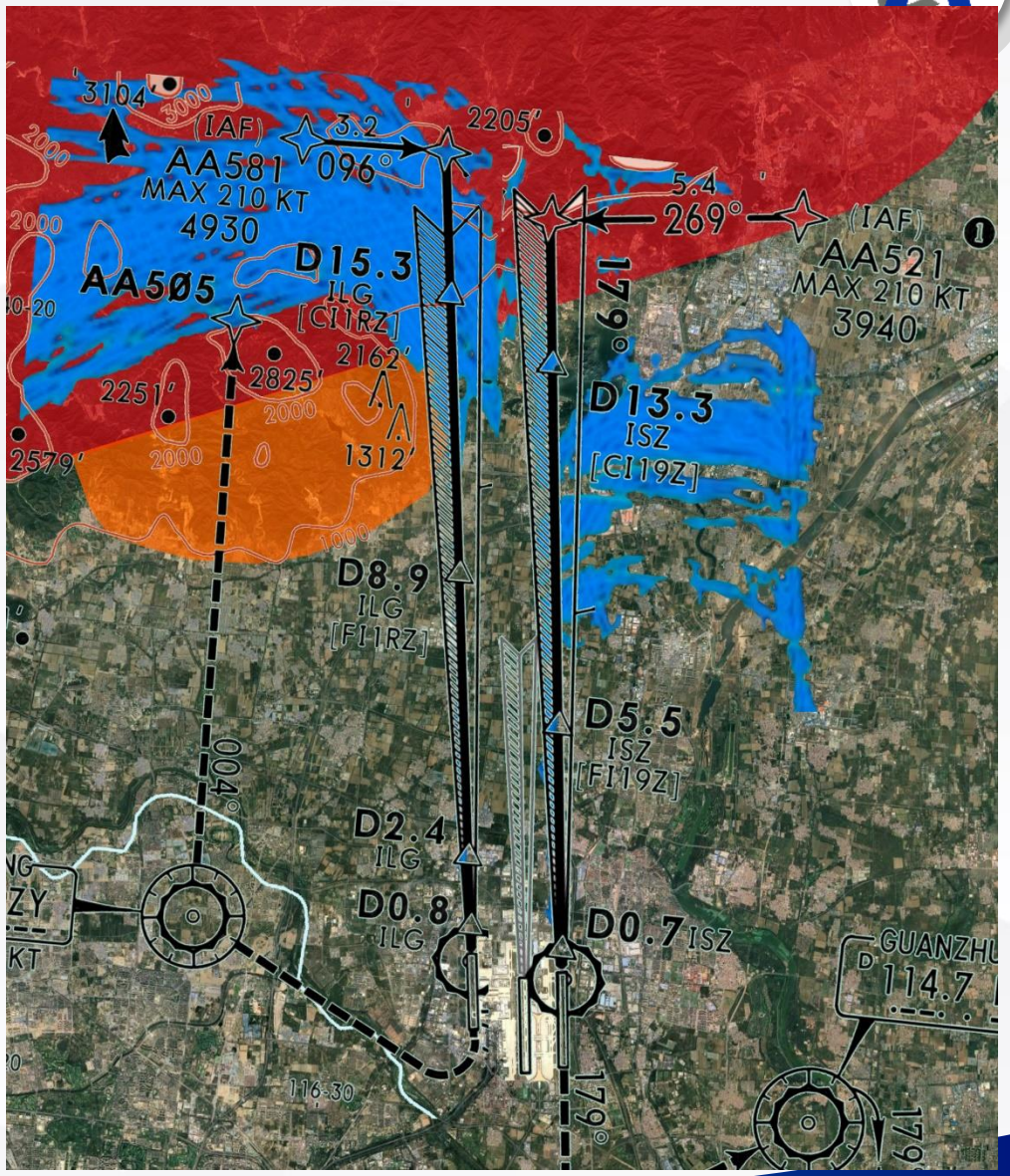
02

EoR Research and Trail in China

ZBAA，Limitations of south config parallel ILS operation

South Operation config of Beijing Capital Intl. Airport

- High terrain starts **10nm north** of airport.
- TMA airspace ends **20nm north** of airport.
- Unable to set up ‘approach gate’ for independent parallel ILS operations.
- Very small error tolerance for final vectoring.
- MVA penetration in case of radio failure.

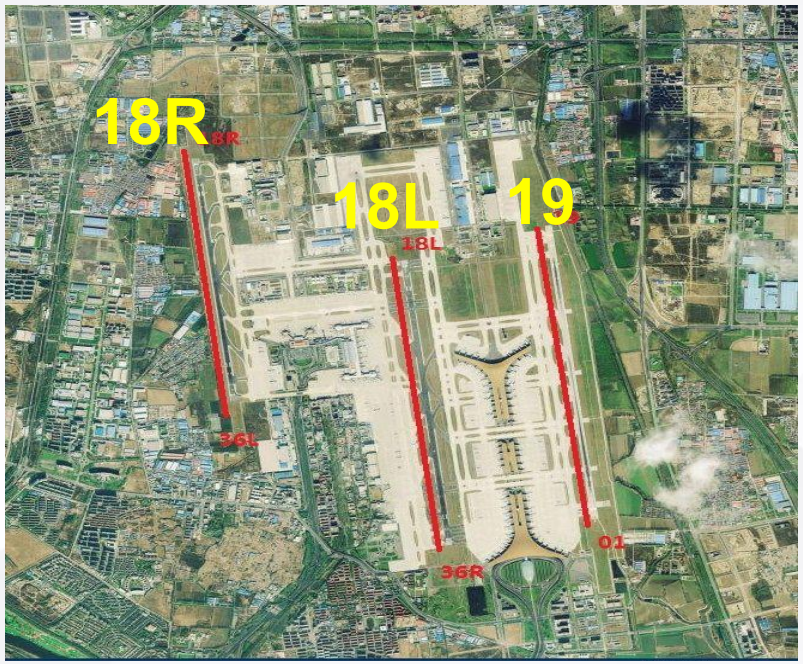


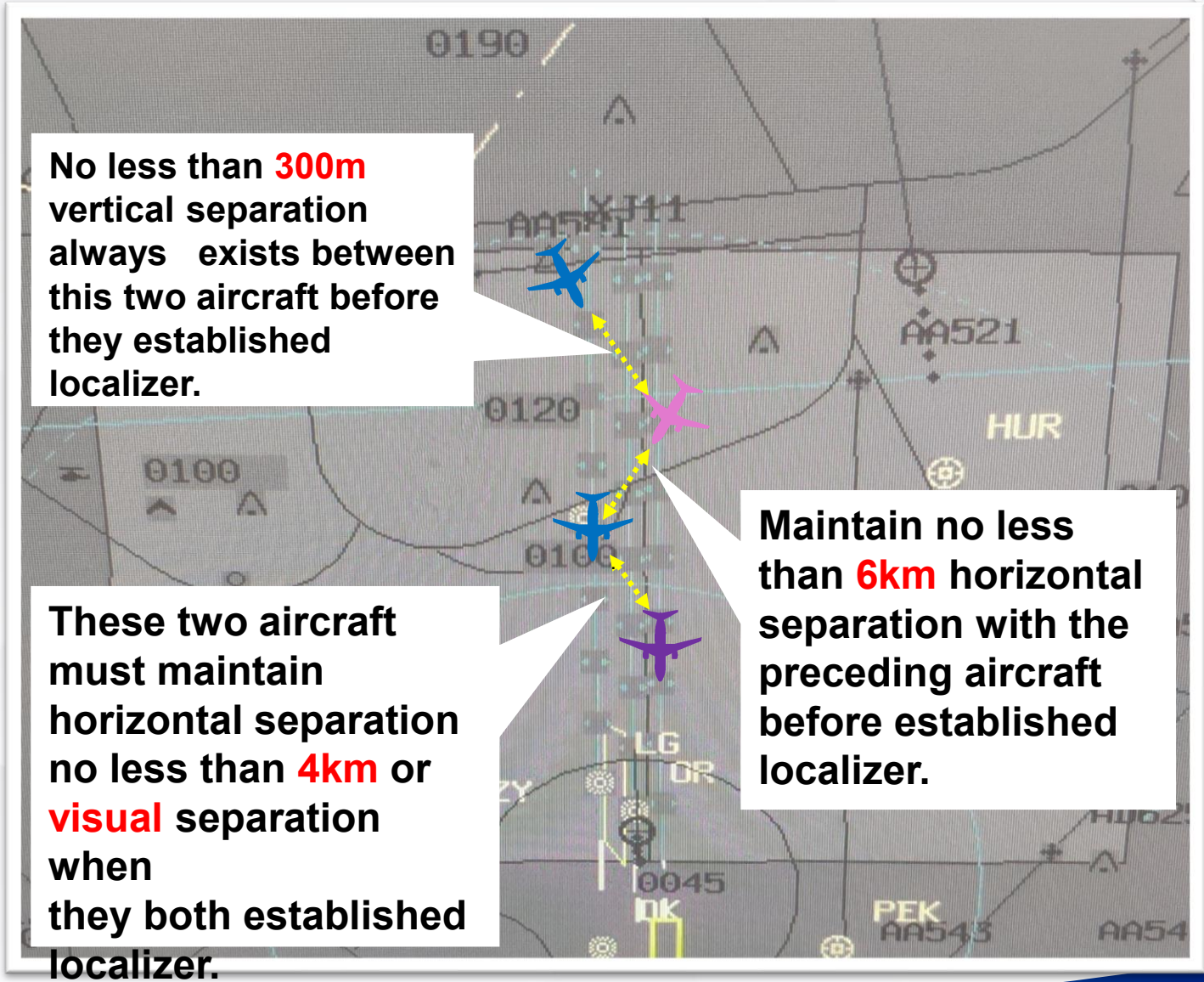
Purpose of EoR Operation of RWY 19

- Improve landing efficiency of Runways for south config operations
- Reduce the influence on operational safety caused by high terrain
- Reduce overall rafar vectors and controller workload

Final Approach (South config)

Dependent Parallel Instrument Approaches on RWY18R/19





No less than 300m vertical separation always exists between this two aircraft before they established localizer.

Maintain no less than 6km horizontal separation with the preceding aircraft before established localizer.

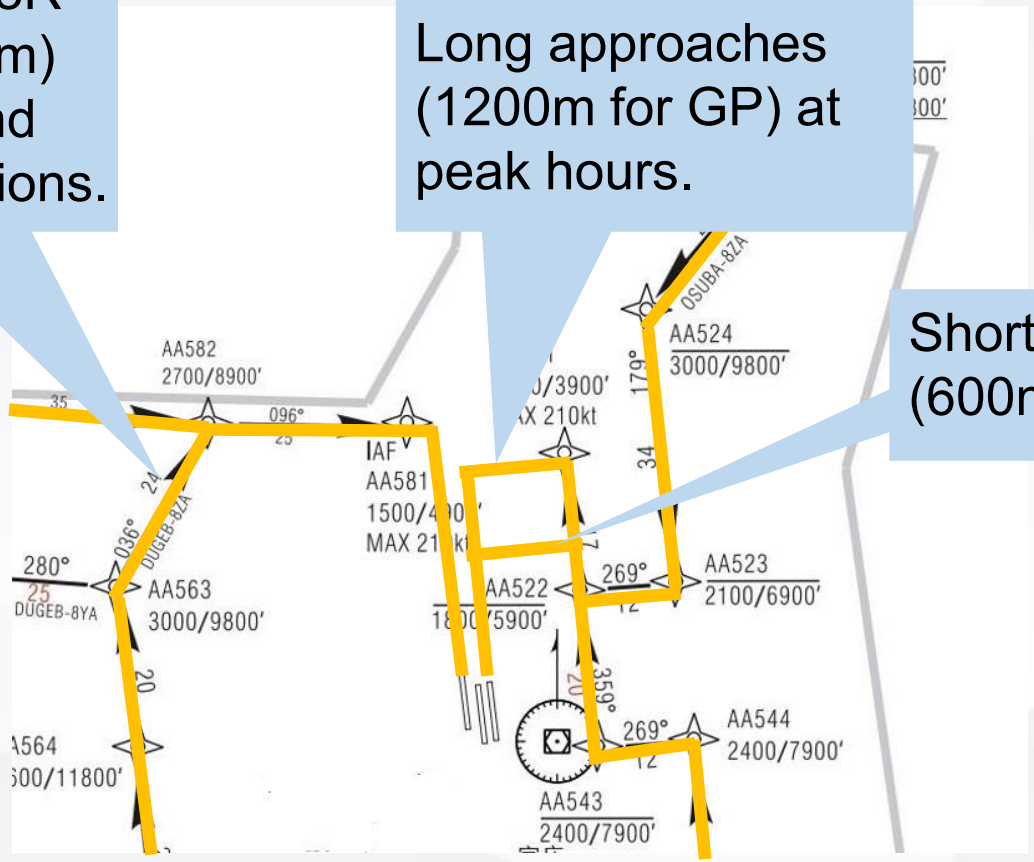
These two aircraft must maintain horizontal separation no less than 4km or visual separation when they both established localizer.

Arrival & Initial Approach (South config)

‘High Side’ for 18R approach (1500m) due to terrain and airspace restrictions.

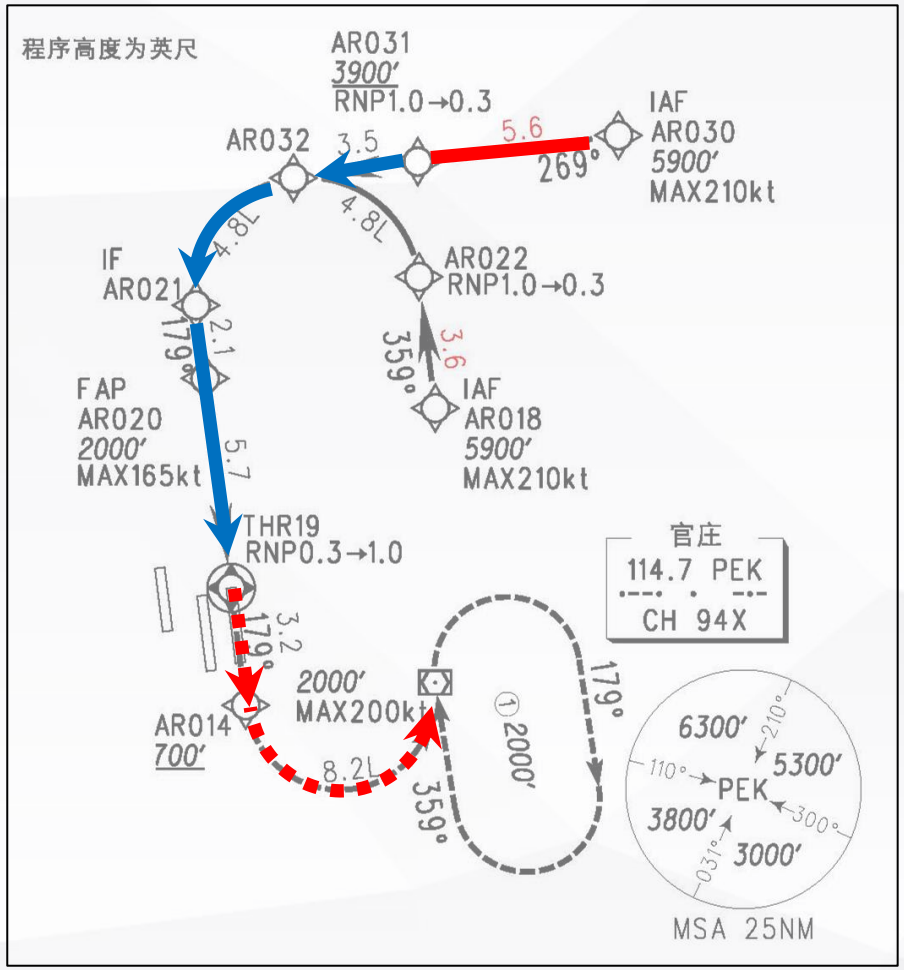
Long approaches (1200m for GP) at peak hours.

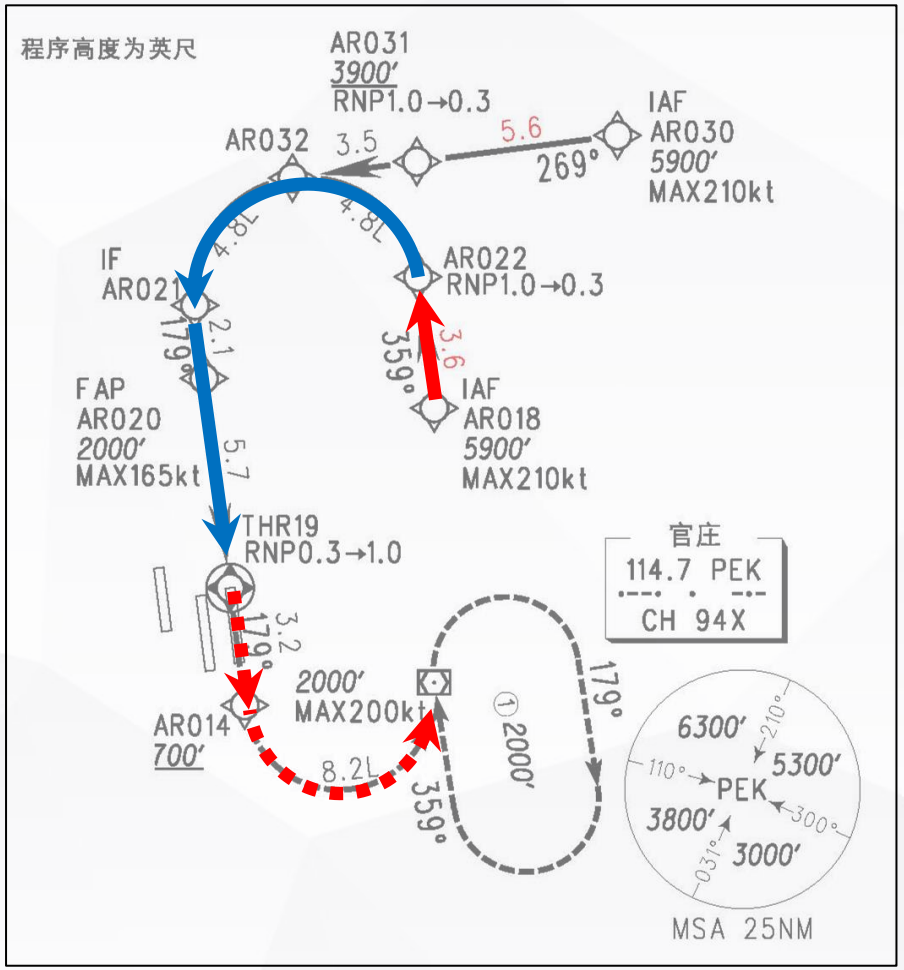
Short approaches (600m for GP)



ZBAA EoR Road Map

Flight Procedure Design

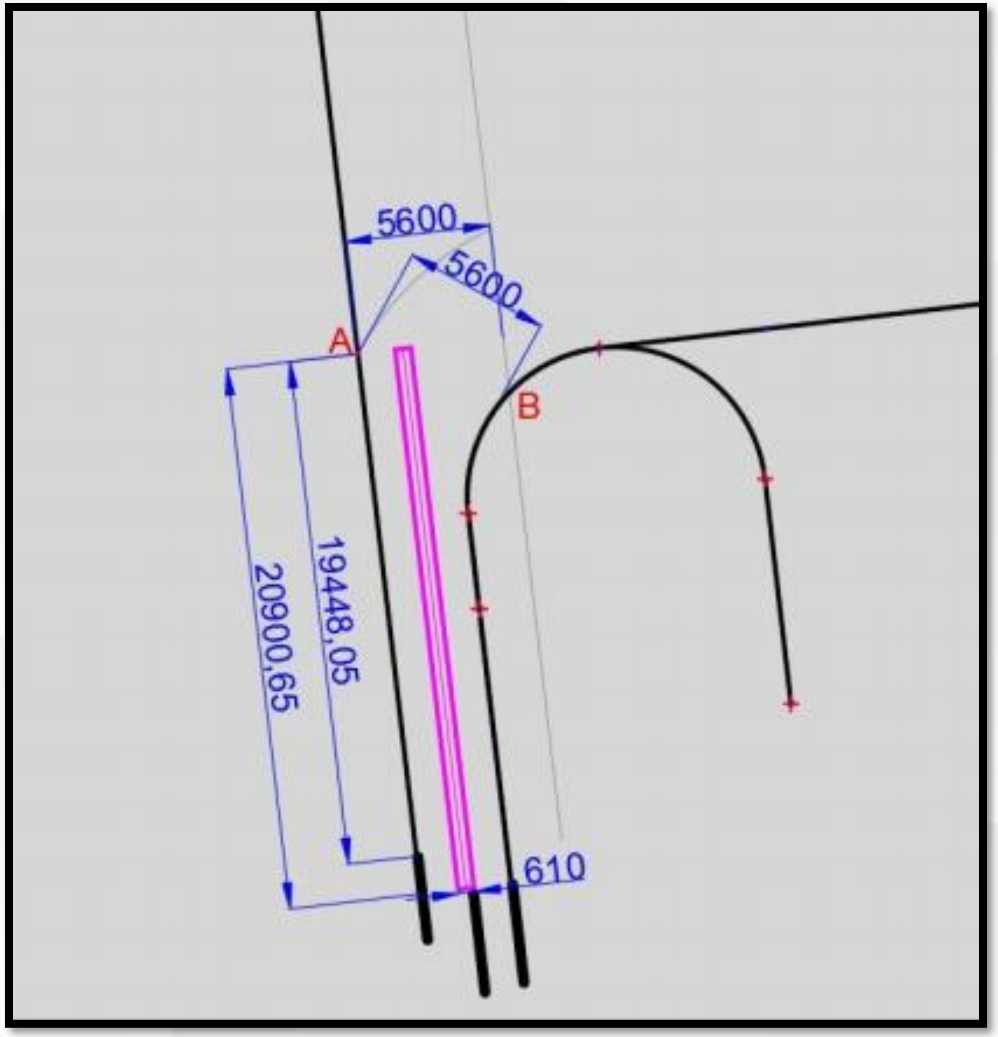




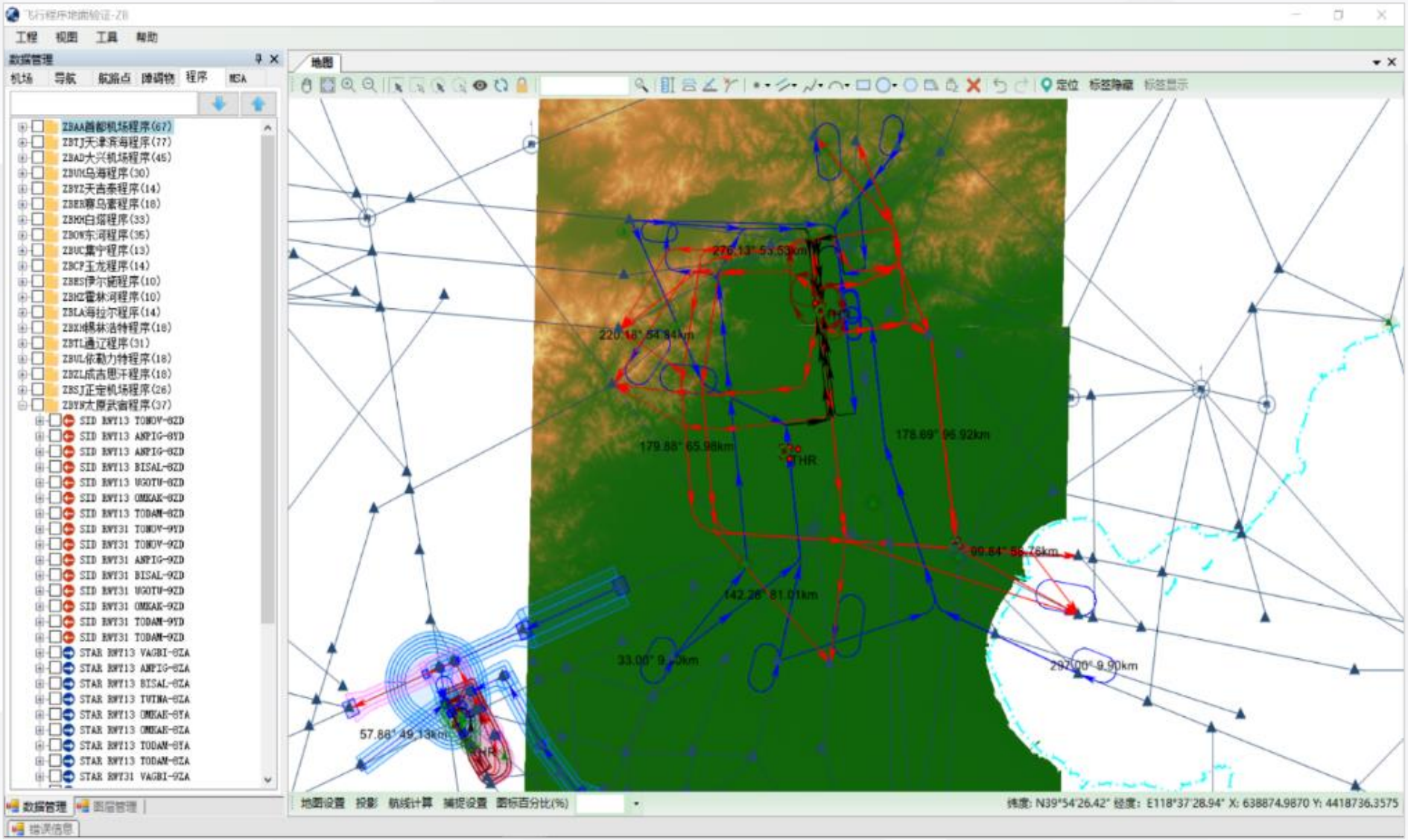
Designation of NTZ

- Point A and B are positions where 300m(1000ft)/5.6km(3.0NM) seperations are no longer provided.

- NTZ starts abeam THR of RWY18R, in between RWY19 and 18R, width 610m, ends abeam point A.



Ground Validation



Flight Simulator Validation

Scenarios
Run 1 (Base line) **RWY19 RNP AR APCH** Join RNP AR APCH at IAF（AR018） Temperature: 15℃ Wind: Calm Course: AR018-AR022-AR021-AR020-THR19 Altitude: 1800m（AR018）-1200m（AR022）-600m（AR021）-600m（AR020） IAS: 210kt（AR018）-185kt（AR022）-165kt（AR020）
Run 2 **RWY19 RNP AR APCH under tailwind (Check downwind)** Join RNP AR APCH at IAF（AR018） Temperature: 40℃ Wind: 180° 45kt for 600-1800m，35kt for ground to 600m Course: AR018-AR022-AR021-AR020-THR19 Altitude: 1800m（AR018）-1200m（AR022）-600m（AR021）-600m（AR020） IAS: 210kt（AR018）-185kt（AR022）-165kt（AR020）
Run 3 **RWY19 RNP AR APCH under crosswind** Join RNP AR APCH at IAF（AR018） Temperature:15℃ Wind: 090°，45kt for 600-1800m，35kt for ground to 600m Course: AR018-AR022-AR021-AR020-THR19 Altitude: 1800m（AR018）-1200m（AR022）-600m（AR021）-600m（AR020） IAS: 210kt（AR018）-185kt（AR022）-165kt（AR020）
Run 4 **RWY19 RNP AR APCH under crosswind** Join RNP AR APCH at IAF（AR018） Temperature:15℃ Wind: 045°，60kt for 600-1800m，15kt for ground to 600m Course: AR018-AR022-AR021-AR020-THR19 Altitude: 1800m（AR018）-1200m（AR022）-600m（AR021）-600m（AR020） IAS: 210kt（AR018）-185kt（AR022）-165kt（AR020）
Run 5 **Join RWY19 RNP AR APCH higher than nominal altitude at IAF (Normal condition)** Join RNP AR APCH at IAF（AR018）on higher altitude Temperature: 15℃ Wind:Calm Course: AR018-AR022-AR021-AR020-THR19 Altitude: **2100m**（AR018）-1200m（AR022）-600m（AR021）-600m（AR020）

第三章　飞行机组操作

一、风险评估和缓解措施

编号	危险描述	严重性	概率	风险指数	推荐的缓解措施	剩余风险
1	气压高度表设定错误	危险	很小	3B	机组程序和训练要求，在 TL 设定当前高度表，并且向 ATC 再次证实 QNH 值，机组执行交叉检查当前高度表。EGPWS/TAWS 提供更多的防止此风险的安全保护功能。	2B
2	不正确的程序设定或加载	危险	很小	3B	机组程序和培训要求设置和确认所加载的程序	2B
3	飞行控制模式选择不正确	轻微	偶发	4D	机组程序和培训提供飞行控制模式选择的引导。EGOWS/TAWS,TCAS 和 ATC 提供地形和飞行活动间隔。	2D
4	RNP 设置不正确	重大	很小	5C	导航数据库中编码了 RNP 值并被自动加载(当加载了程序时），机组程序和培训要求机组在按程序飞行时，检查和确认 RNP 值	2C
5	较差的气象条件	轻微	频繁	5D	航图显示每个程序必须执行的天气最低标准。机组程序和培训提供与复飞有关的程序和引导。	5E
6	不适当的修改飞行计划	轻微	很小	3D	机组程序和培训要求加载和确认程序，并且禁止修改飞行计划	2D
7	不适当地截获 RF 航段	轻微	偶发	4D	机组程序和培训要求向机组提供在特定航路点截获 RNP 进近的方法，并且提供可以截获 RNP 程序的指导	3D
8	在没有所需设备的情况下执行程序	重大	很小	3C	机组程序和培训要求给机组提供关于执行 RNP AR 运行最低所需设备的指导，不能满足 RNP AR	2C

第六章　ATC 操作

一、风险评估及缓解措施

序号	危险描述	严重性	可能性	风险指数	建议缓解措施	剩余风险
1	程序被应用于不合适的飞机	危险的	少有的	3B	A319/A330 飞机有能力实施 RNP AR 飞行。签派员被提供给最低所需设备清单放行飞 RNP AR 程序的飞机。飞行机组有责任通知 ATC 安排给飞行机组或飞机的程序不合格或不能被接受。ATC 飞行计划包括 RNP AR 能力。	2B
2	ATC 引导进近以至于所需导航性能无法保持	重大的	偶然的	4C	机组程序和训练要求机组在特定地标切到 RNP 进近，并且提供引导在什么地点 RNP 可以被切入。ATC 将会被培训在什么时候及怎样引导 RNP 飞机，如果不接受许可指令，机组总是有责任给管制员建议。	3C
3	错误的气压高度表信息	较小的	少有的	3D	机组程序和训练需要在最后进近点前设定和交叉检查当前的高度表，EGPWS/TAWS 对该风险提供一个额外的保护，机组也会多次复诵高度表信息。这也是 ATC 训练的一部分。	2D
4	通信丢失	重大的	少有的	3C	从机组的观点出发，应用标准通信失效程序，同样标准丢失通信程序也是 ATC 培训的一部分。	3D
5	GPS 干扰，导致无法执行程序或偏离程序	较小的	少有的	3D	ATC 应当有无法执行程序或偏离程序的预案，该预案也是 ATC 培训的一部分。	2D

TCAS Simulation

BEIJING EoR

Parallel Approaches Operational Simulation

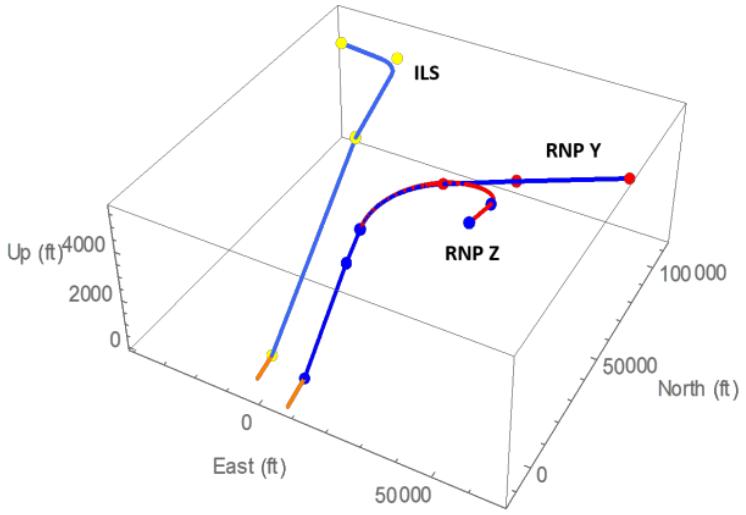
5 June 2023

Jeff Musiak and Sheila Conway

4 TCAS Analysis

The following plots of the procedures show the differences in the geometries of the two different RNP approaches. In these plots, the runways are shown as orange lines, RNP-AR approaches are shown as dark blue or red lines and the ILS approach is light blue. The dots on the plots indicate waypoints.

The perpendicular distance from 19L threshold to 18L runway is 0.83 nm and, given that the RNP level for the approach is 0.3 nm, nuisance TA's are not expected to be an issue.

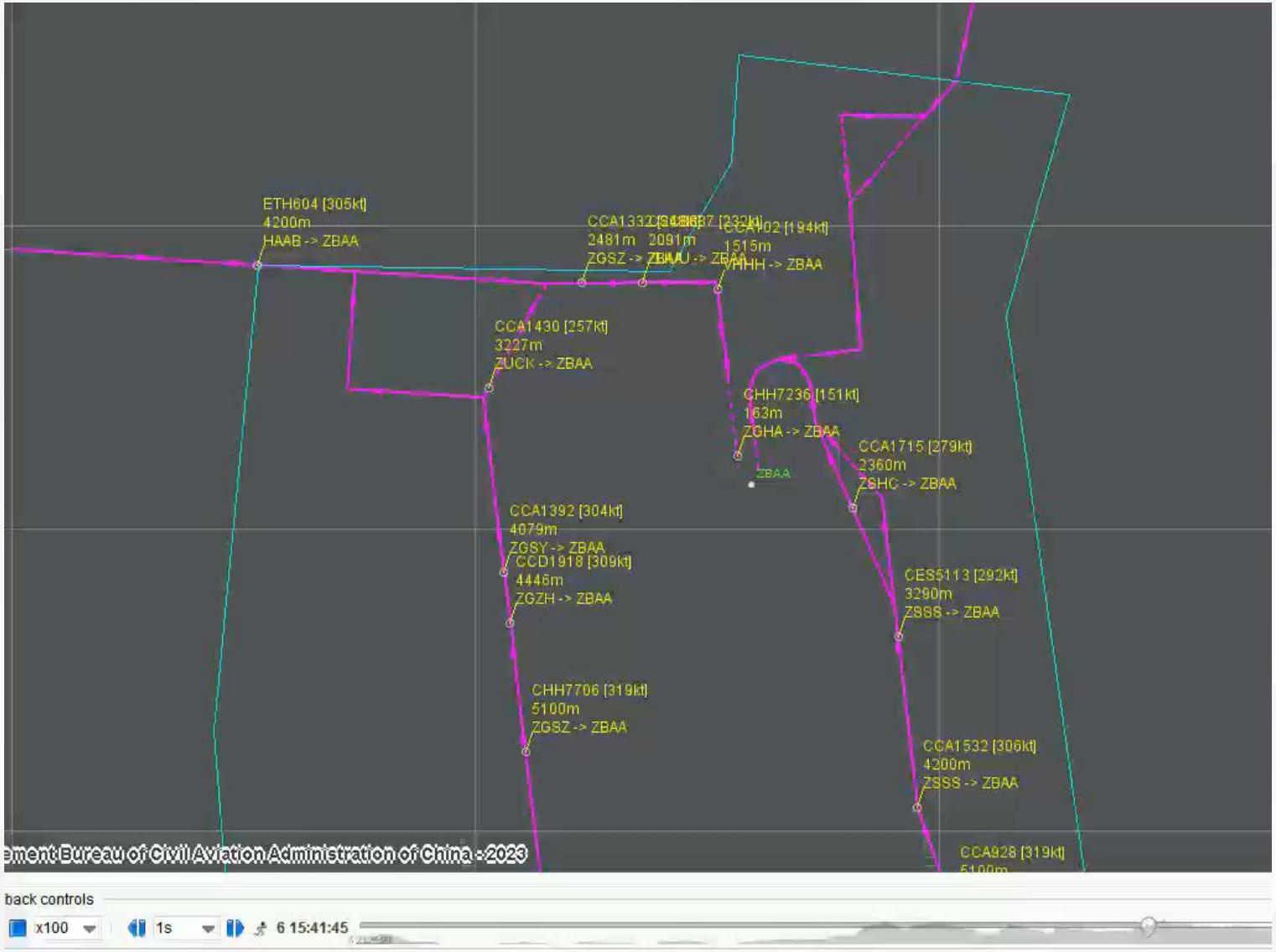


For each ILS – RNP paring 10,000 Monte Carlo realizations were run and no TA's nor RA's were generated.

But, as an additional check, because excess speed could contribute to additional TA's, the analysis was also performed increasing the speeds before the FAF by 20 kts and 40 kts (simulating a following tail wind).

	Standard Speeds		Speed + 20 kts		Seed + 40 kts	
	RNP y RWY 19 AR	RNP z RWY 19 AR	RNP y RWY 19 AR + 20 kts	RNP z RWY 19 AR + 20 kts	RNP y RWY 19 AR + 40 kts	RNP z RWY 19 AR + 40 kts
Monte Carlo Realizations	10,000	10,000	10,000	10,000	10,000	10,000
Traffic Advisories (TA)	0	0	0	0	0	0
Resolution Advisories (RA)	0	0	0	0	0	0

Fast-time Simulation



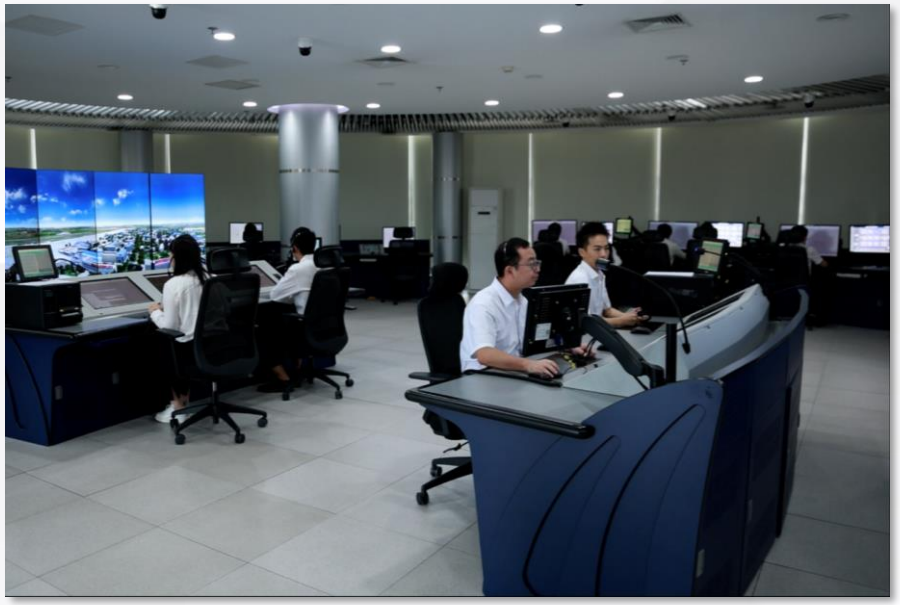
- ✓ **Per Flight**
  Reduces flying time by 3.7mins
  Saving approx. 17.5km,
  Reduce 109kg of fuel

- ✓ **Per Day**
  Reduction of flying time of 13.65 hours
  Saving approx. 3795 track miles
  Reduce 23.7 tons of fuel

- ✓ **Per Year**
  Reduction of flying time of 1495 hours
  Saving approx. 415553km
  Reduce 2595 tons of fuel

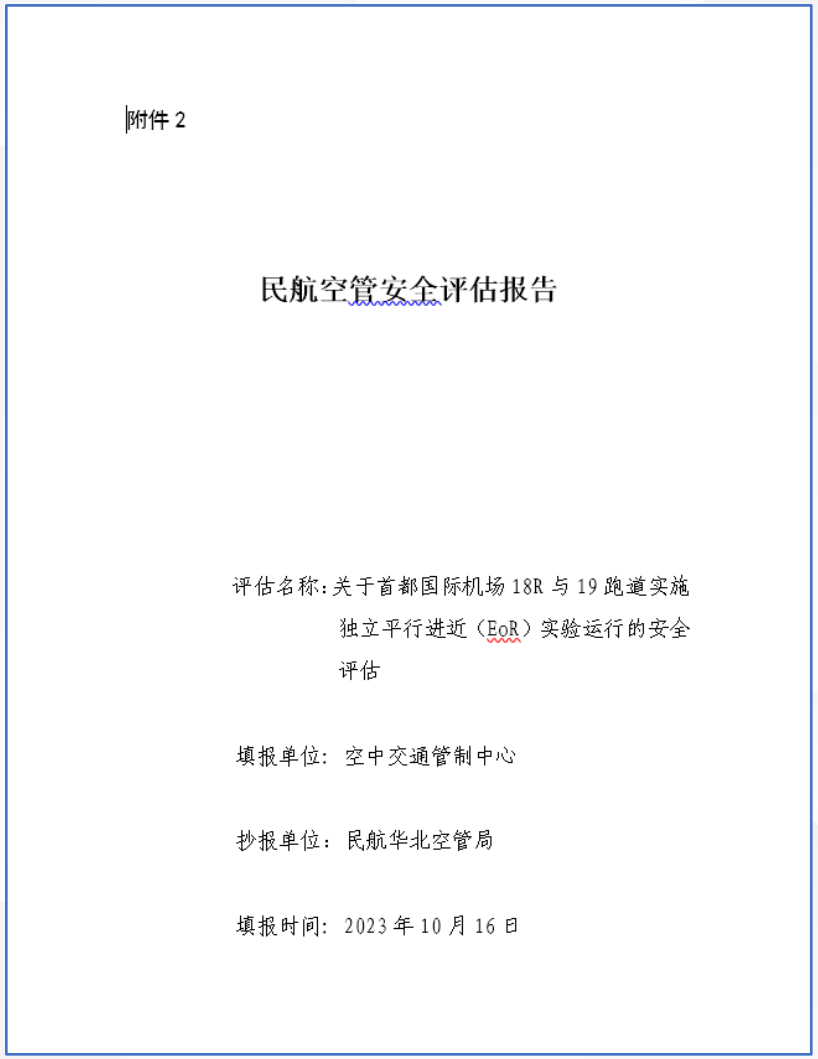
- ✓ **ATC workload**
  has been reduced by more than 11%

Flight-Control Joint Validation



2023年10月19日北京首都机场EoR应用飞行/管制模拟机验证工作顺利完成

ATC Safety Assessment



附件 2

民航空管安全评估报告

评估名称：关于首都国际机场 18R 与 19 跑道实施独立平行进近（EoR）实验运行的安全评估

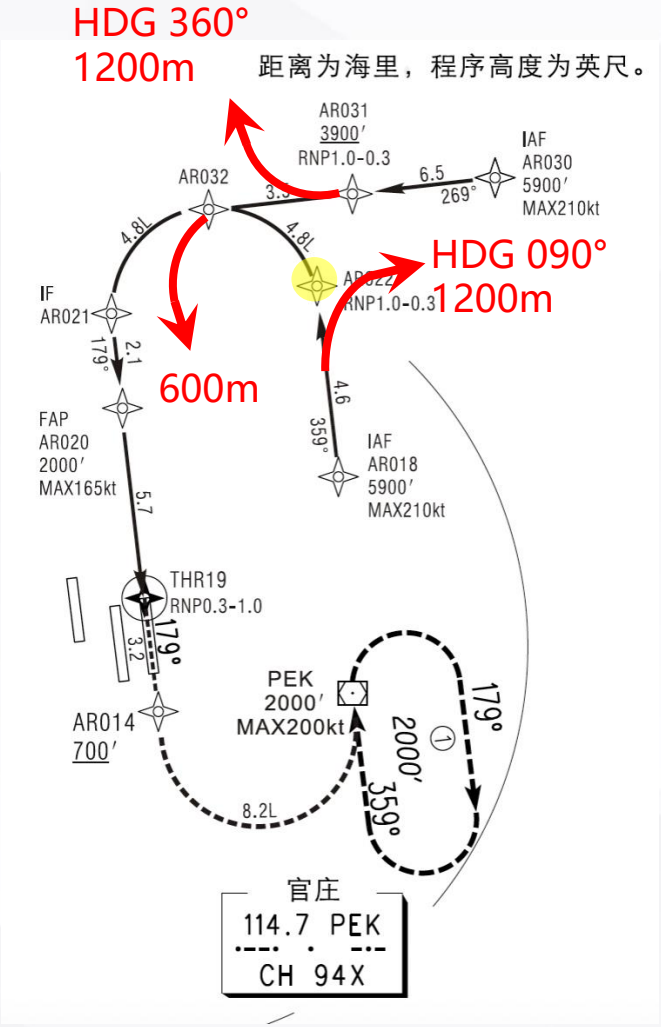
填报单位：空中交通管制中心

抄报单位：民航华北空管局

填报时间：2023 年 10 月 16 日

序 号	危险源描述	可能导致的后果	风险等级	风险可容忍度
1	实施RNP AR进近的航空器报告丧失RNP AR能力	发生小于间隔的不安全事件	2B	可容忍的
2	EoR运行时，不具备RNP AR进近能力的航空器的数量超出18R跑道承受能力	发生小于间隔的不安全事件	3D	可容忍的
3	EoR运行时，使用19跑道进近的航空器发生通讯失效情况	发生小于间隔的不安全事件	3C	可容忍的

① RNP AR capability lost



Mitigation: Break-out Procedures

South bound aircrafts (Join from AR018)

- Report RNP AR capability lost before AR022
- Report RNP AR capability lost after AR022

North bound aircrafts (Join from AR030)

- Report RNP AR capability lost before AR032
- Report RNP AR capability lost before AR032

② Exceeding RWY Capacity

Hazard :

The number of aircrafts without RNP AR approach capability exceeds the landing capacity of RWY18R.

Mitigation :

- Choose non-busy time period for EoR operation.
- Vector the aircrafts without RNP AR capability to hold.
- When the number of holding aircrafts exceed 4, terminate EoR operation

③ Radio Failure

Hazard :

During EoR operation, aircraft conducting RNP AR APCH on RWY19 experience a radio communication failure.

Mitigation :

- Develop radio failure disposal procedure.
- Emphasize the radio failure disposal procedure in the process of EoR promotion.
- Publish radio failure disposal procedure for RNP AR APCH of RWY19

Flight Validation

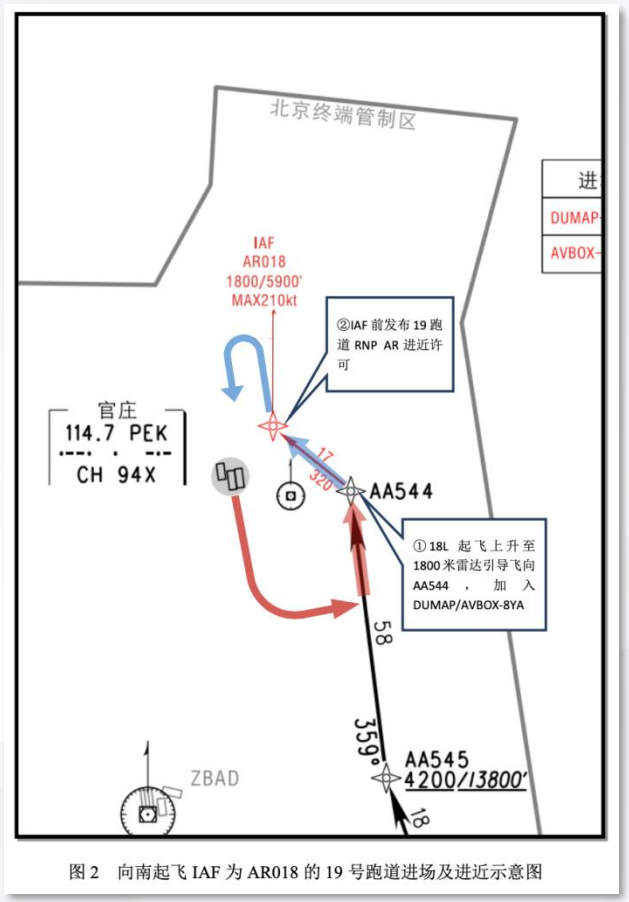


图 2　向南起飞 IAF 为 AR018 的 19 号跑道进场及进近示意图

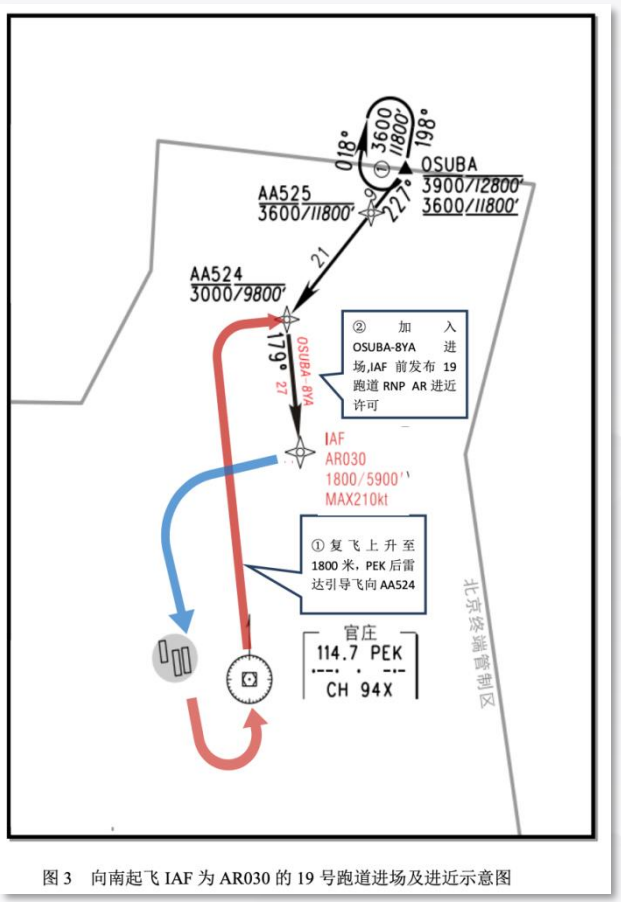


图 3　向南起飞 IAF 为 AR030 的 19 号跑道进场及进近示意图

Experimental Operation

Experimental operation

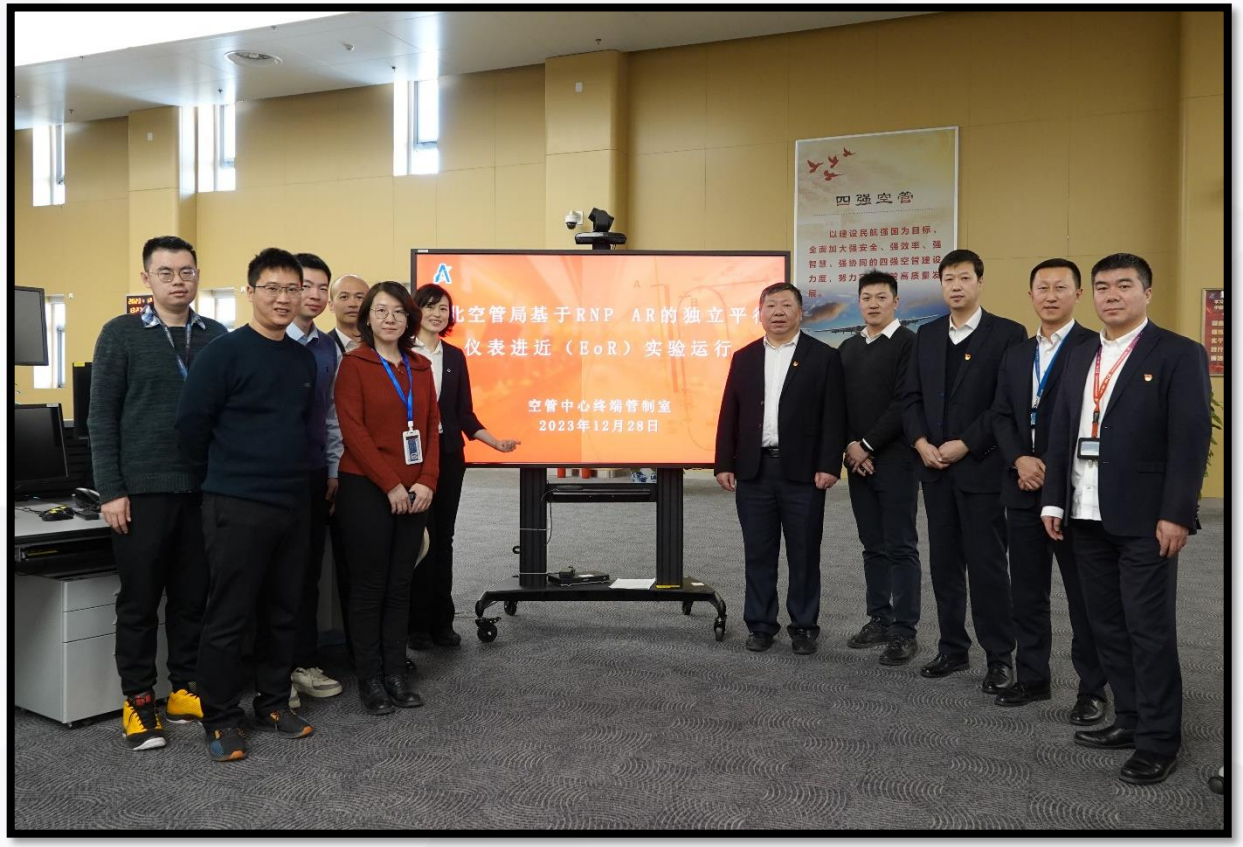
Starts from 28th Dec 2023

Requirements

- Beijing capital airport in south operation (south config)
- No harsh weather in the vicinity, VIS greater than 2000m
- VHF transmission override capability
- No existing GPS interference

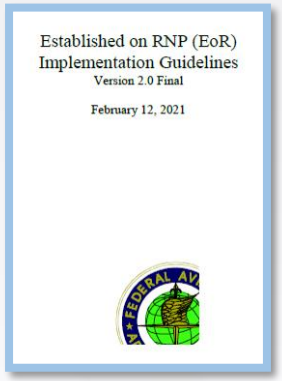
Personnel

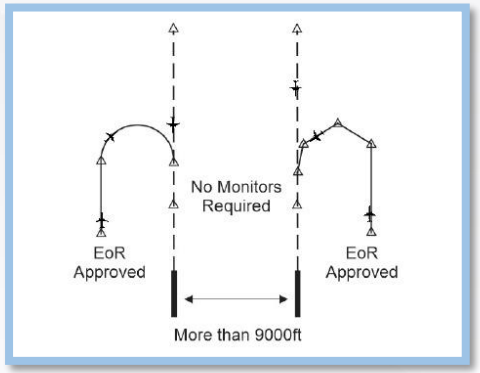
- AP01/02 sector rating obtained
- EoR operation training completed (theoretical and simulator)



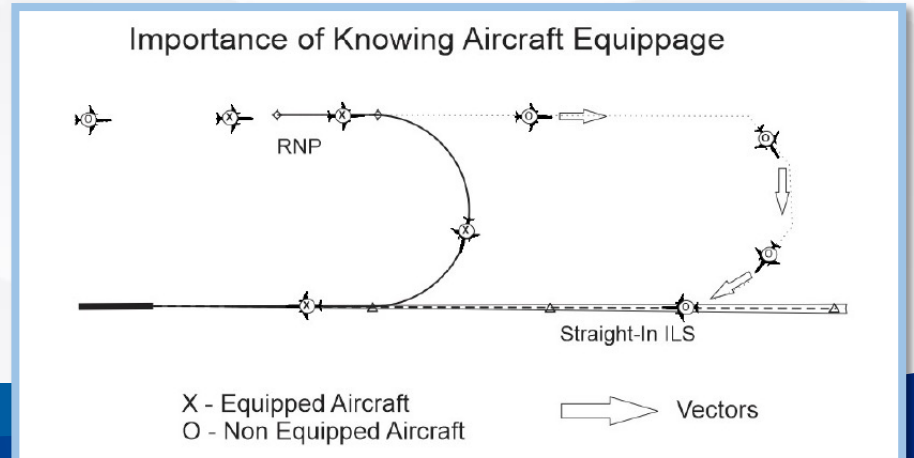
Operating Procedure of EoR

- ✓ RNP-AR for Rwy 19, ILS for Rwy 18R, dual Rwy independent parallel approaches, no final monitor position required.

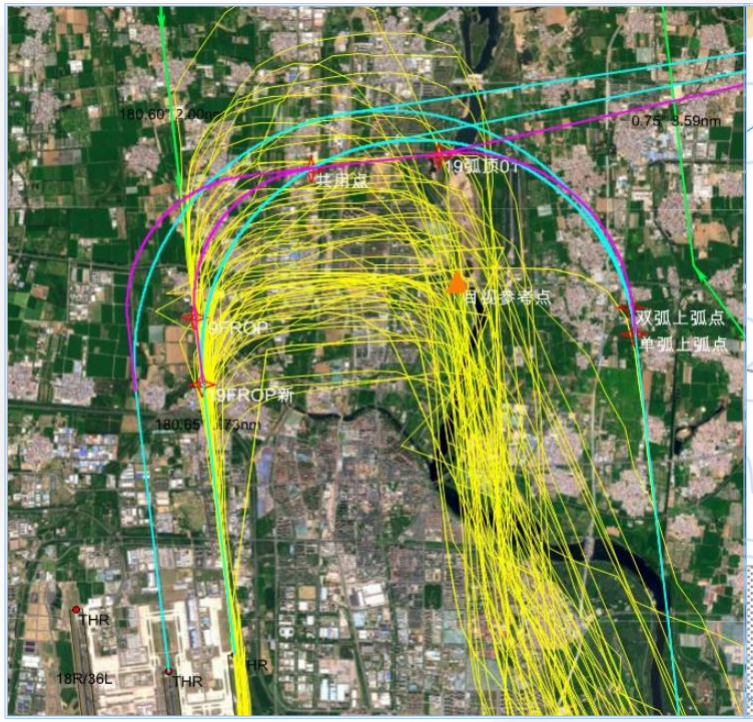


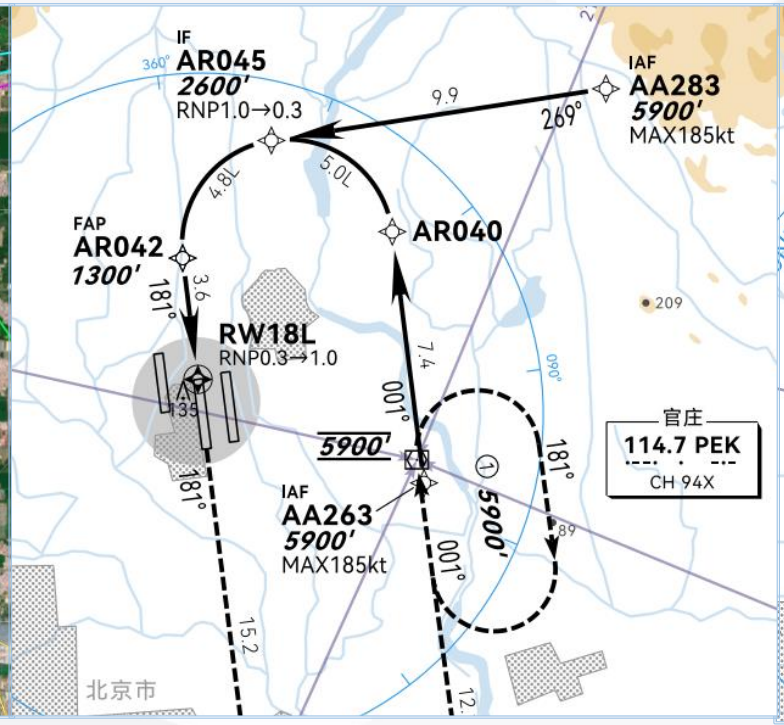


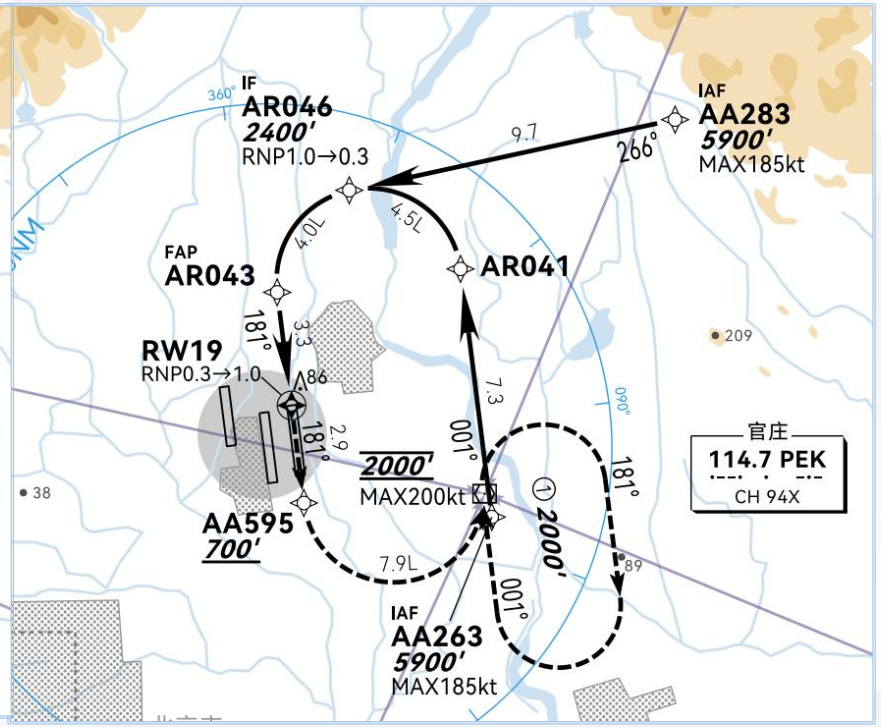
- ✓ During early implementation, Rwy 19 is for RNP-AR capable aircraft only. Otherwise use 18R.



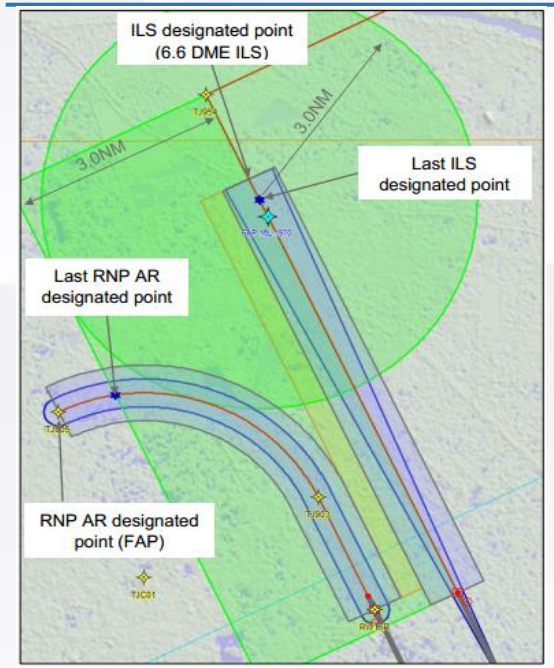
Further Optimization of RNP AR Procedure

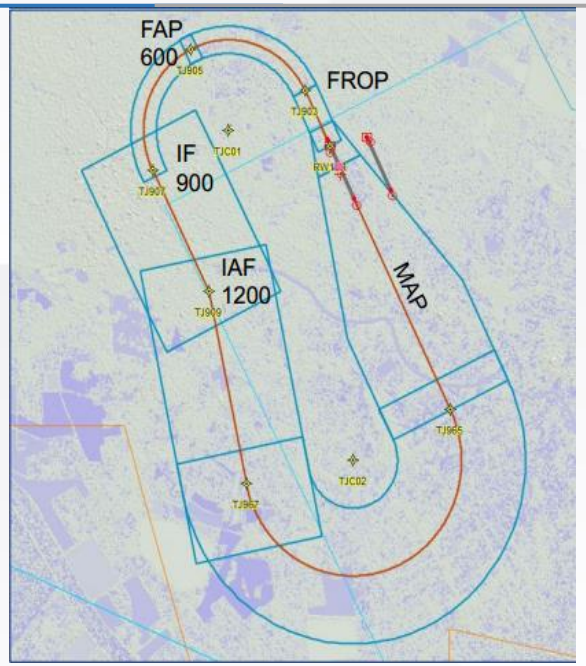


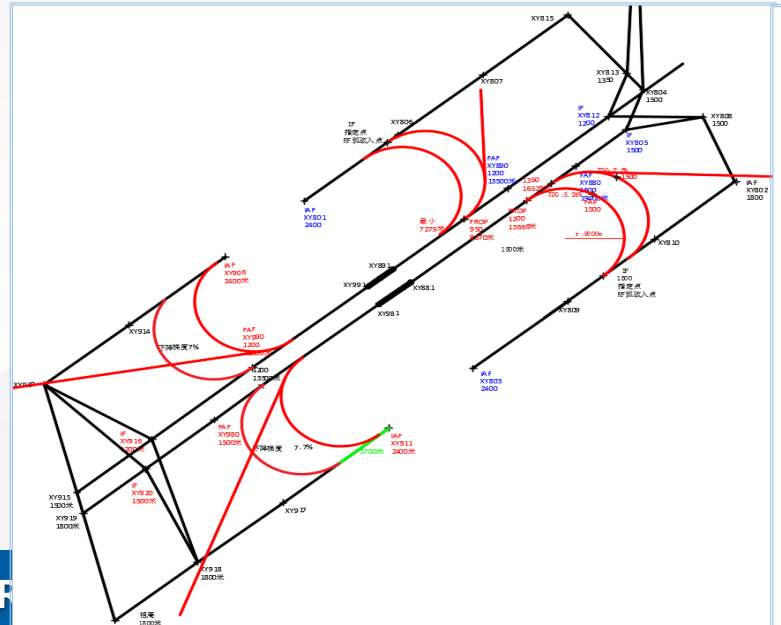


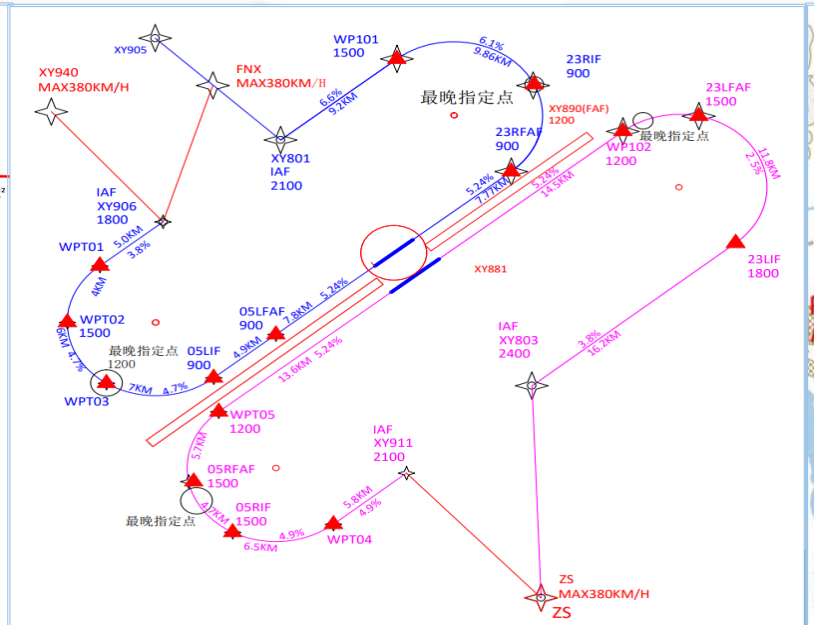


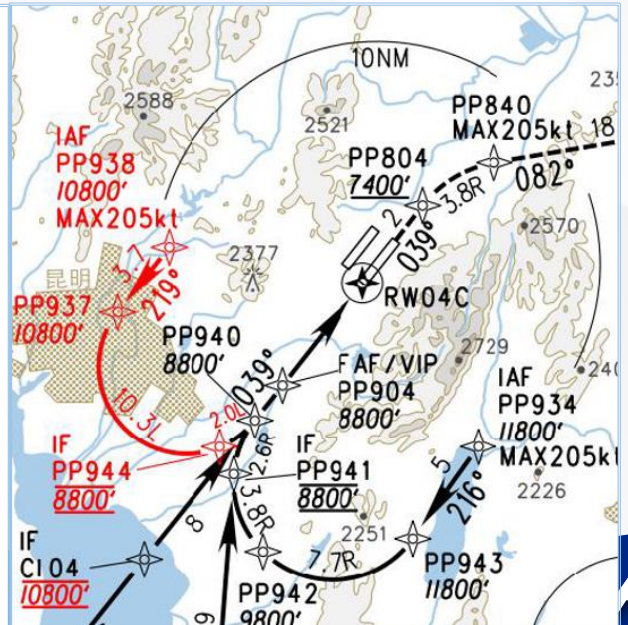
Implementation at other airports in China











03 Experience Gained

Fast-time Simulation is Helpful

✓ To visualize and validate the airspace design concept

✓ To establish situational awareness and enhance understandings of EoR scenario for ATC controllers

✓ Provide Quantitative Support

Joint Validation is Crucial

Joint Efforts are the Key to Success

✓Flight -Control simulator and fast time simulation
✓飞行管制模拟机和仿真

Trial Implementation on Dec.28th

✓Flight operation safety assessment
✓飞行运行安全评估

✓Publication and trainning
✓资料公布及飞行、管制员培训

✓Real flight validation and trial operation
✓真机试飞和实验运行

✓Concept and flight procedure design
✓概念和飞行程序设计

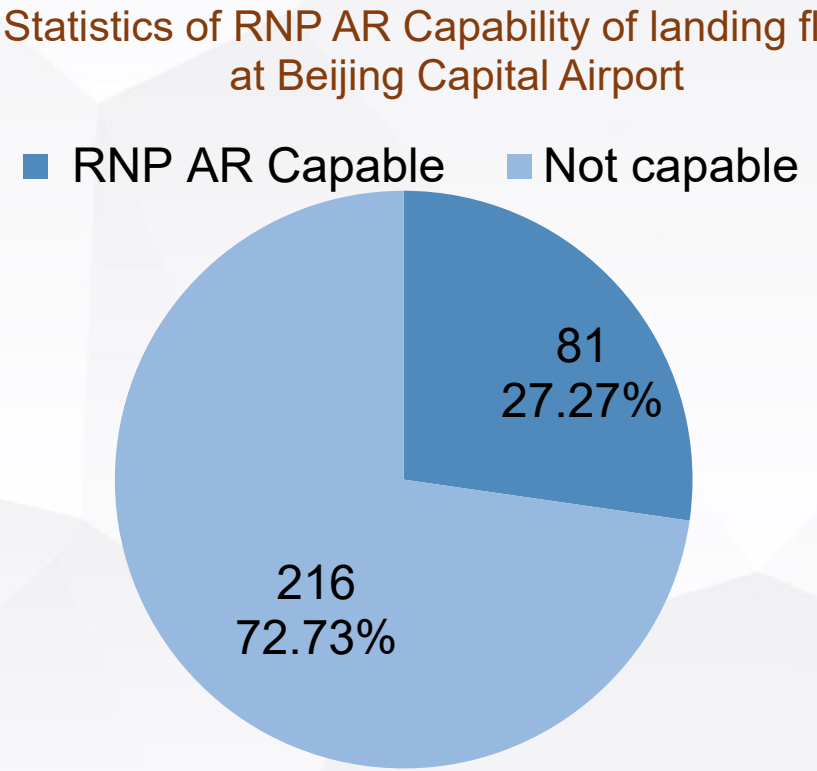
04

Future Plan

Future Plan

Expand EoR to other Airports

Increase the proportion of ACFT with RNP AR capability



Thank you

Lizhi@atmb.net.cn