ICAO APAC FPP Flight Procedure Design Online Seminar

EoR Concept and Applications

北京全顺辅科贸有限公司 | Beijing Transafe Technology and Trade Co.,

Contents

目录

01

PART ONE

Simultaneous Approach

同时进近

MODES OF OPERATION

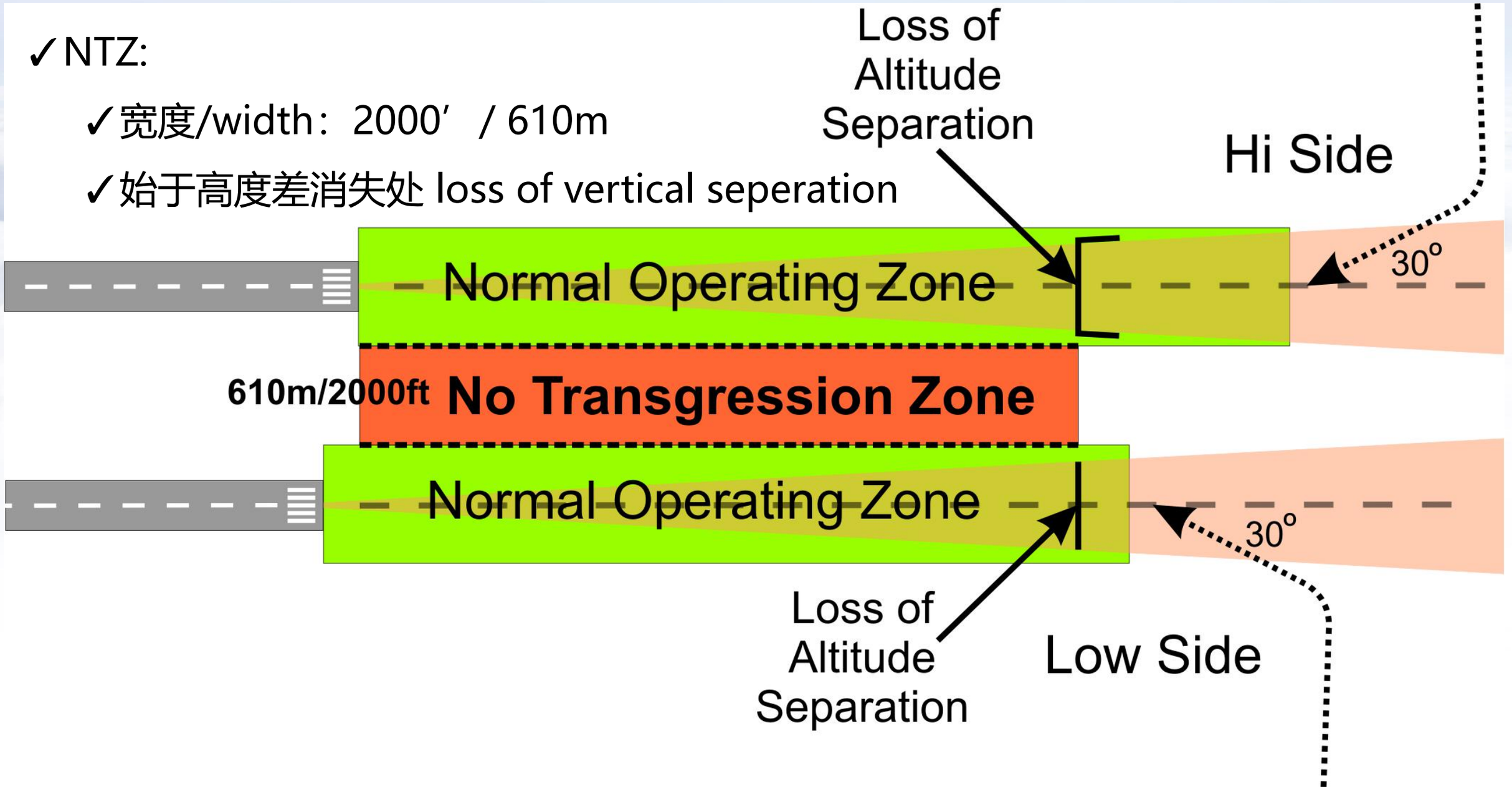
Runway centre line spacing	ATS surveillance system criteria
Less than 1 310 m (4 300 ft) but not less than 1 035 m (3 400 ft)	● a minimum accuracy for an ATS surveillance system as follows: ○ – for secondary surveillance radar (SSR), an azimuth accuracy of 0.06degrees (one sigma); or ○ – for multilateration system (MLAT) or automatic dependent surveillance - broadcast (ADS-B), an accuracy of 30 m (100 f)t; ● • an update period of 2.5 seconds or less; and ● • a high-resolution display providing position prediction and deviation alert isavailable.
Less than 1 525 m (5 000 ft) but not less than 1 310 m (4 300 ft)	● an ATS surveillance system with performance specifications other thanthose above, but equal to or better than: ○ – for SSR, a minimum azimuth accuracy of 0.3 degrees (one sigma); or ○ – for MLAT or ADS-B, a performance capability equivalent to, or betterthan, the SSR requirement can be demonstrated; ● an update period of 5 seconds or less; and• ● when it is determined that the safety of aircraft operations would not beadversely affected.
1 525 m (5 000 ft) or more	● a minimum SSR azimuth accuracy of 0.3 degrees (one sigma) or, for MLAT or ADS-B, a performance capability equivalent to, or better than, the ● SSR requirement can be demonstrated, and ● • an update period of 5 seconds or less.

NOZ&NTZ

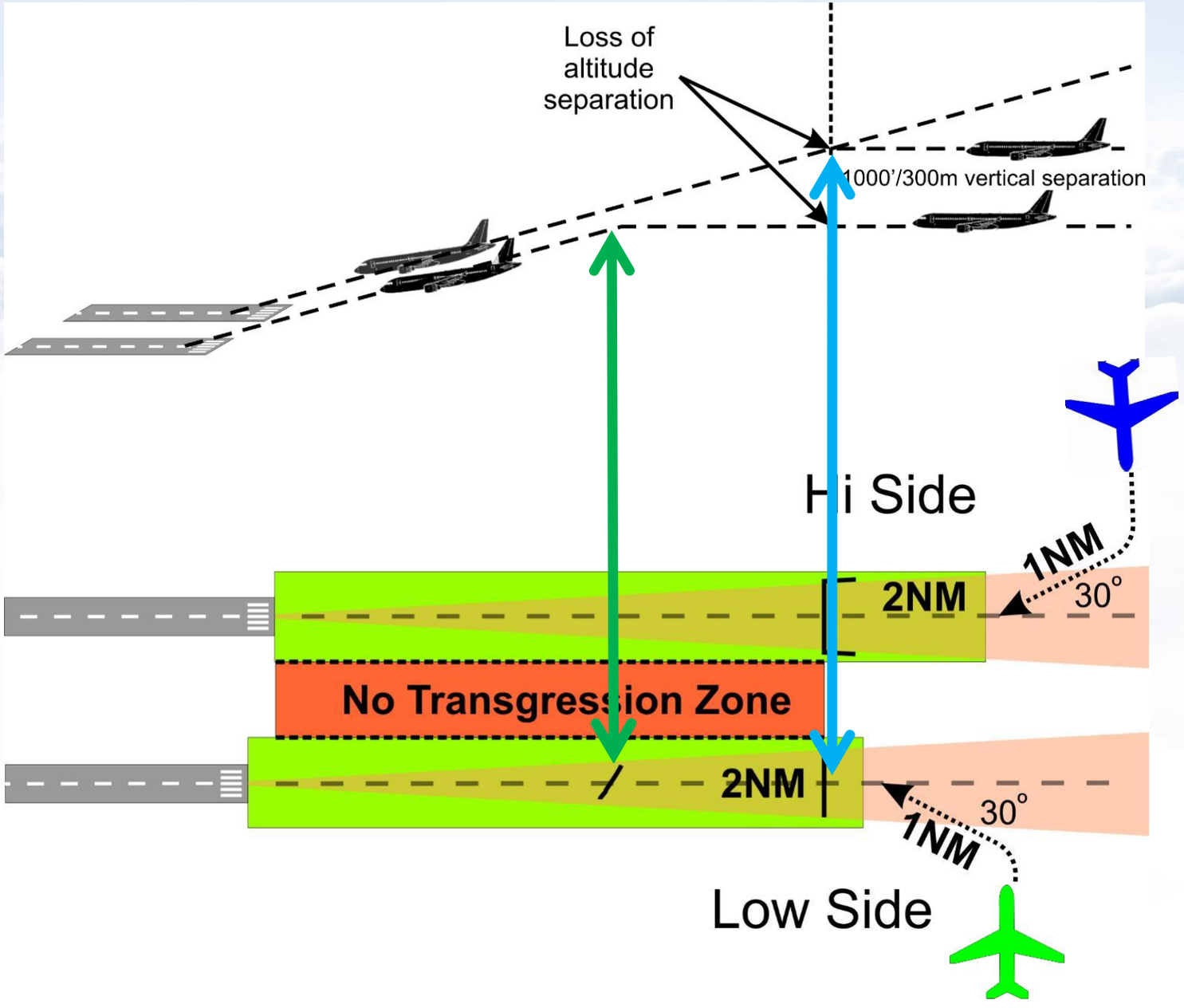
✓NTZ:

✓宽度/width：2000’ / 610m

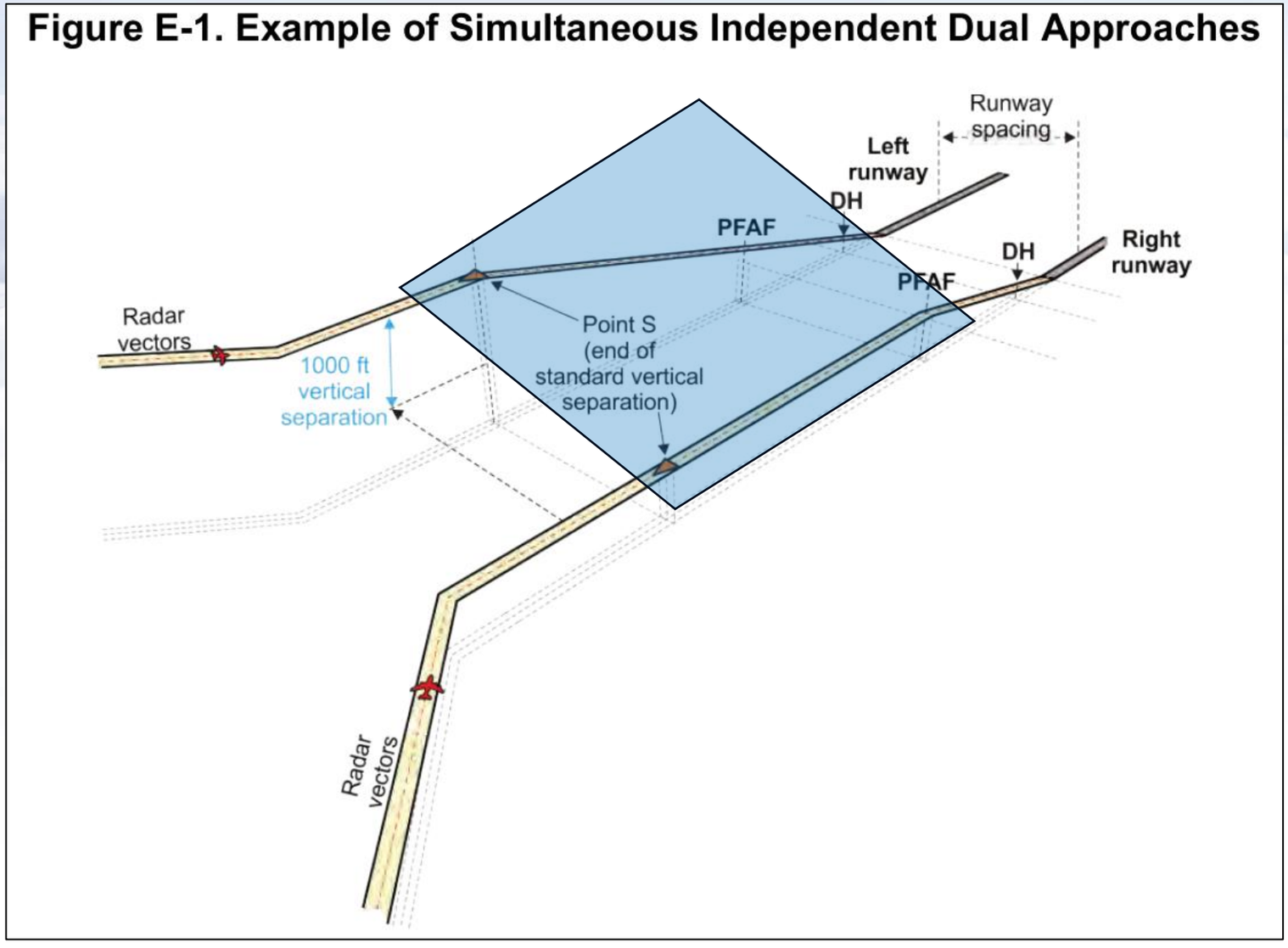
✓始于高度差消失处 loss of vertical seperation



PANS-ATM


Loss of
altitude
separation
1000'/300m vertical separation
Hi Side
1NM
30°
2NM
No Transgression Zone
2NM
30°
1NM
Low Side

ZPPP TCAS WARNING ISSUE



- **TCAS WARNING AREA**

Slightly after point S, the loss of the A minimum of 300 m (1 000 ft) vertical separation

- **WARNING REASON**

HIGH EVEL（2100m+）
HIGH Ground Speed（+30kt）
LONG final（23nm/50km）

- **Pre-Solution**

Reset the TCAS THR after the intersection of final

- **RNP AR Solution**

short final, minima the pair approach duration

ZPPP TCAS WARNING ISSUE

➢ **Independented RNP AR operation:**

- APCH: RNP<=0.25NM

➢ **RNP AR OPS BENIFIT:**

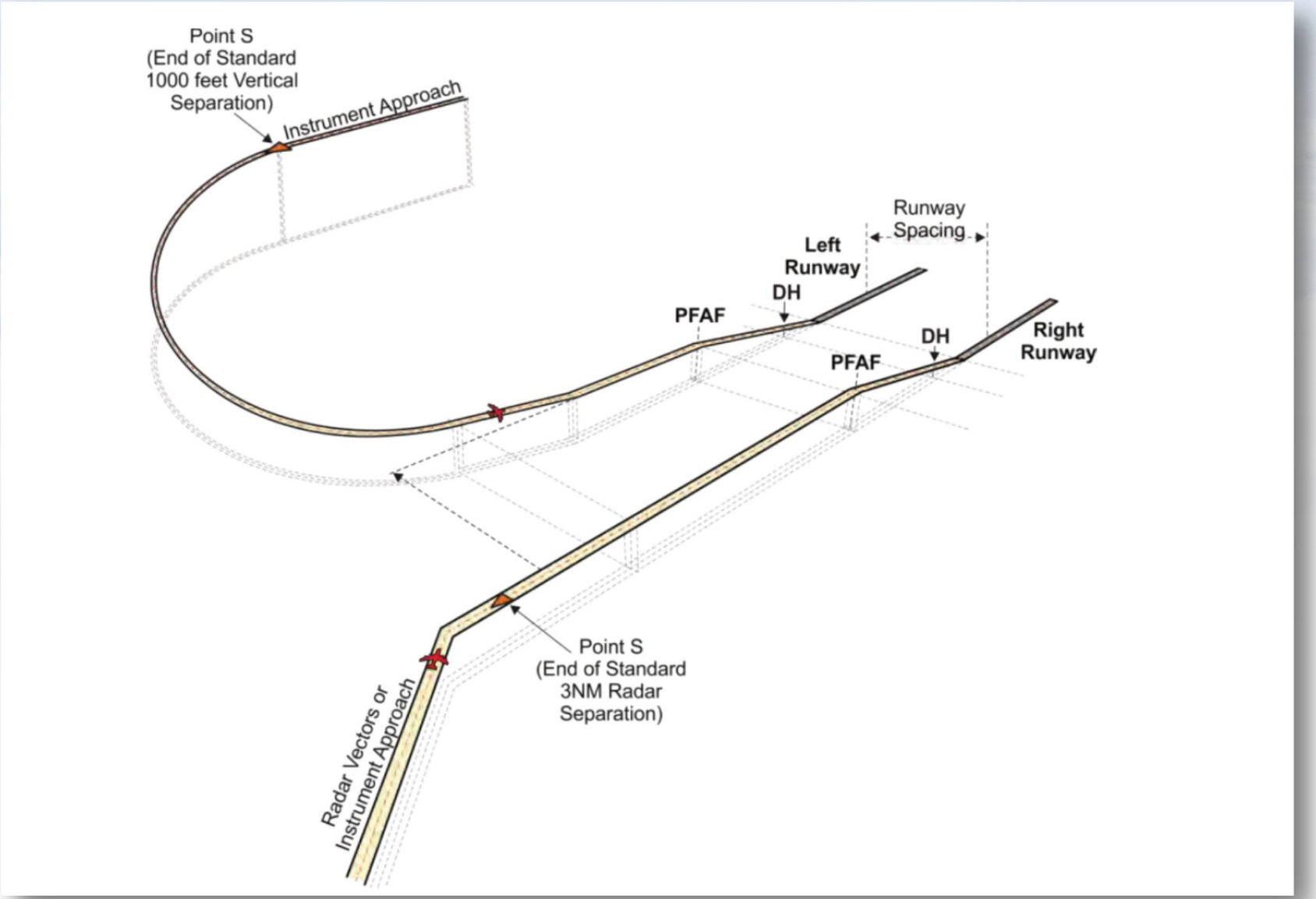
- Compliance with RNAV
- Short final, CDO, less fuel
- Less pair APCH duration, TCAS issus improved

➢ **Conventional&RNAV FP**

- HIGH SIDE: 3300m 10826.64ft
- LOW SIDE: 3000m 9842.4ft

➢ **RNP AR FP**

- LOWEST: 8800ft



02

PART TWO

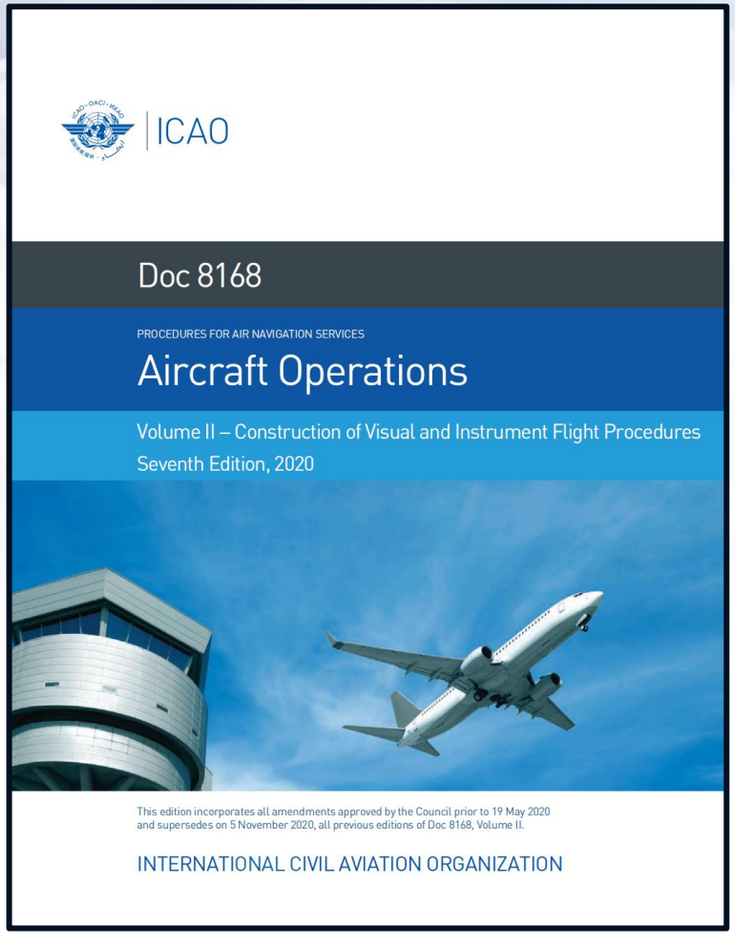
EoR

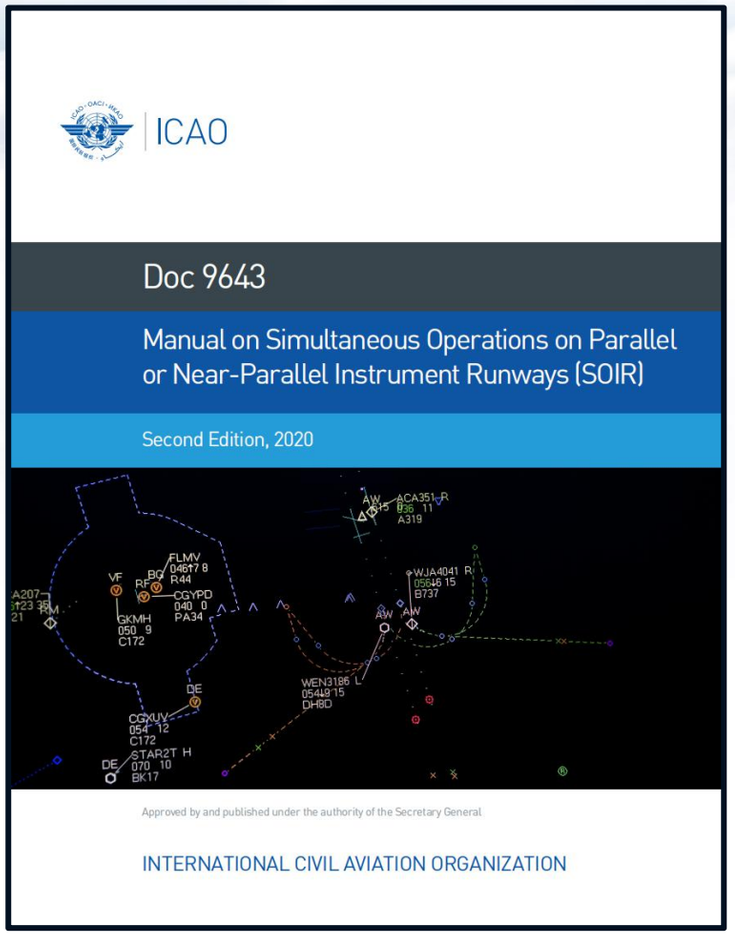
ICAO Doc

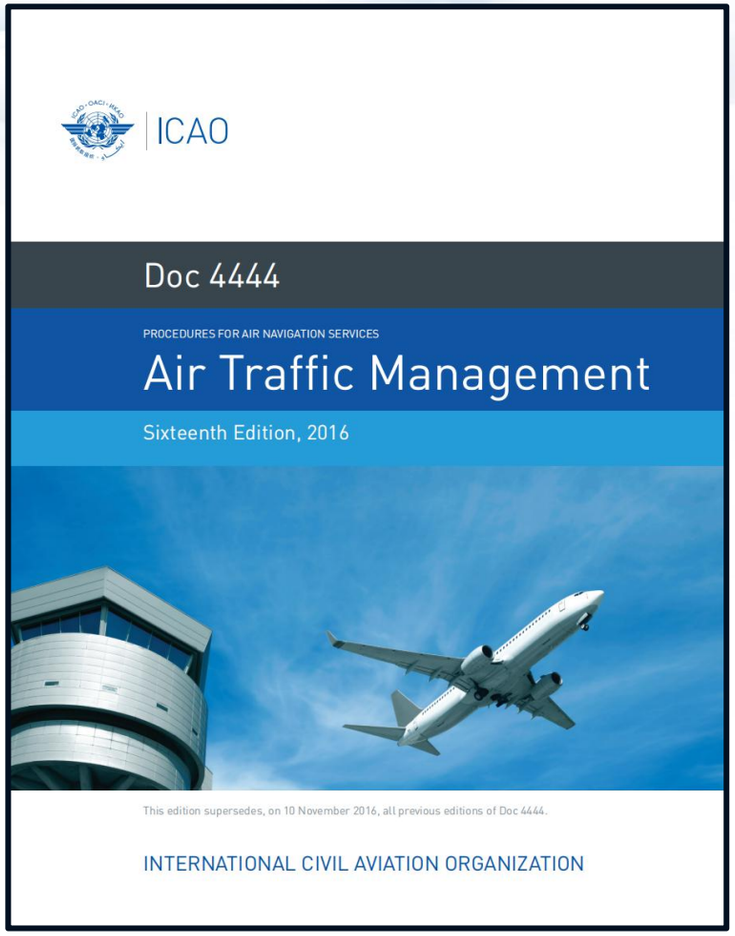
ICAO 4444 – Air Traffic Management **Sixteenth Edition, 2016**

ICAO 8168 – Aircraft Operations Volume II **Seventh Edition, 2020**

ICAO 9643 – SOIR **Second Edition, 2020**



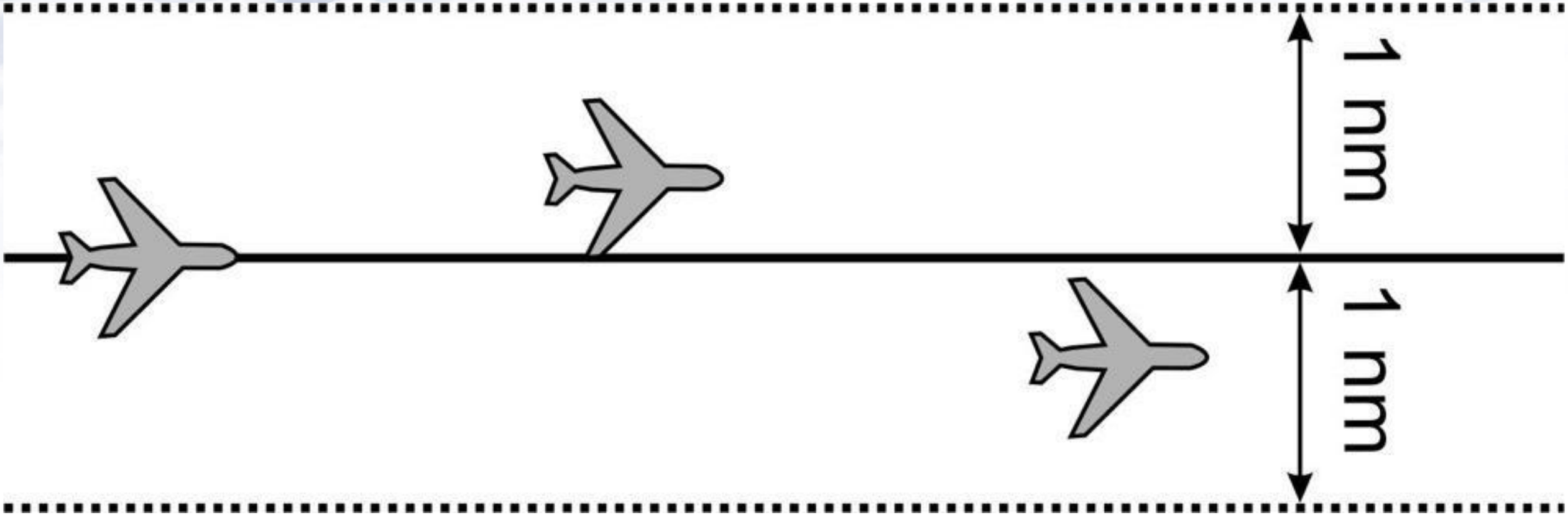




What is PBN?

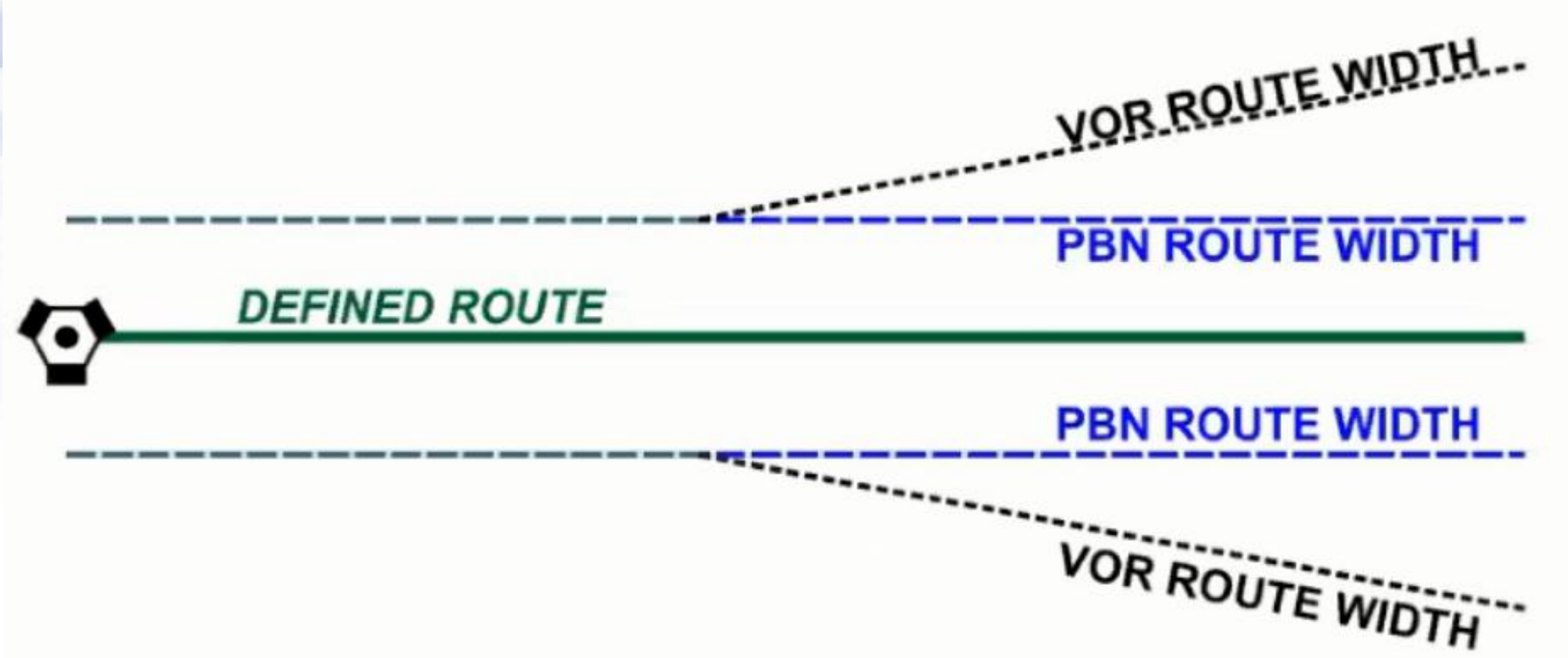
X is stand for the navigation perforance in the RNAV(X) and RNP(X)

eg,RNP1 means the aircraft would within 1nm laterical seperation tolerance.



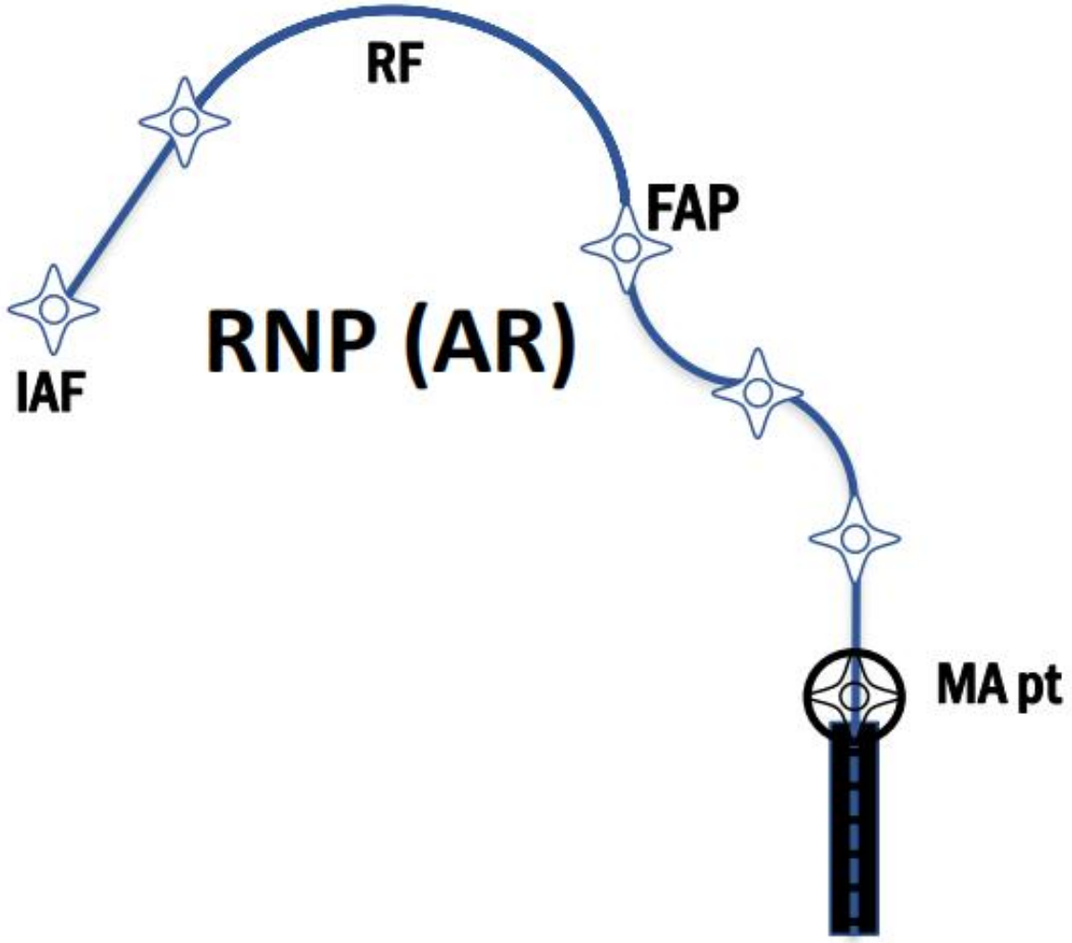
PANS-ATM defination

location logic is the very differance between PBN and conventional navigation，PBN measure through the error with the Nominal track.



RNP AR APCH

- RNP AR APCH
  - Curve approach in final phase
  - Final RNP，Std 0.3，Min 0.1
  - MA RNP Std1.0，Min Final RNP
  - RF allowed in MA
- RNP APCH
  - Straight APCH only
  - Final RNP 0.3
  - MA RNP Std1.0



PANS-ATM defination

2.2.1.4 To conduct independent parallel approaches, the instrument approach procedures that align the aircraft with the extended runway centre lines need to be designed to support the operation.

a) The procedures are identified for simultaneous use in Table 2-2;

b) the tracks of adjacent missed approach procedures diverge by at least 30 degrees; and

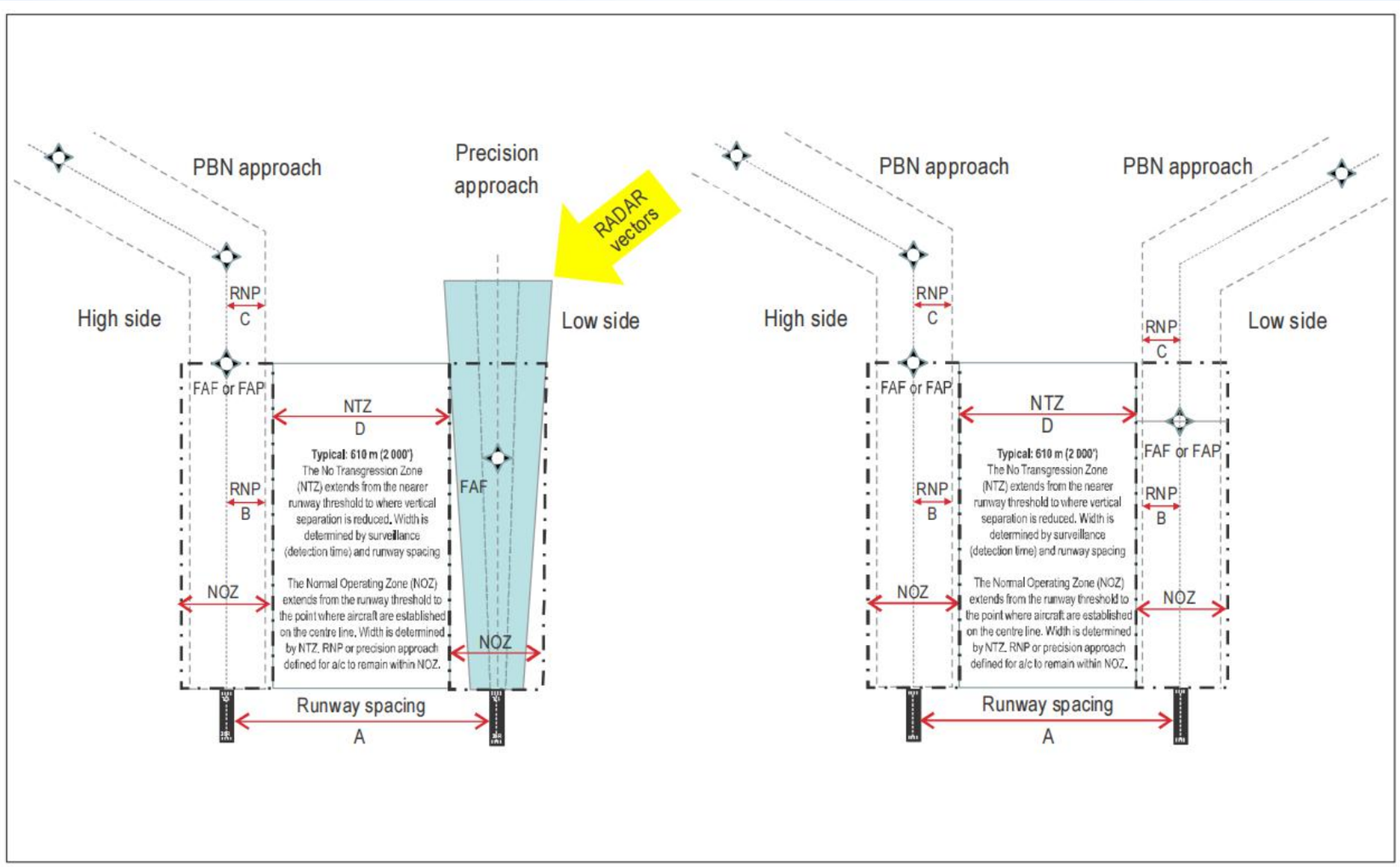
c) an obstacle survey and evaluation is completed

Instrument Approach	Can this approach type be used for Simultaneous Approaches?
ILS	Yes
GLS	Yes
MLS	Yes
SBAS CAT I Applicable in Final Approach Segment	Yes
RNP AR APCH	Yes
RNP AR APCH (non-conforming to 2.2.1.5)	Provided an approach and mitigation-specific, documented safety assessment has shown that an acceptable level of safety can be met, and operations are approved by the appropriate ATS authority.
RNP APCH (LNAV/VNAV)(LPV)	
RNP APCH (LNAV)	No
LOC	No
NDB	No
VOR	No

PANS-ATM defination

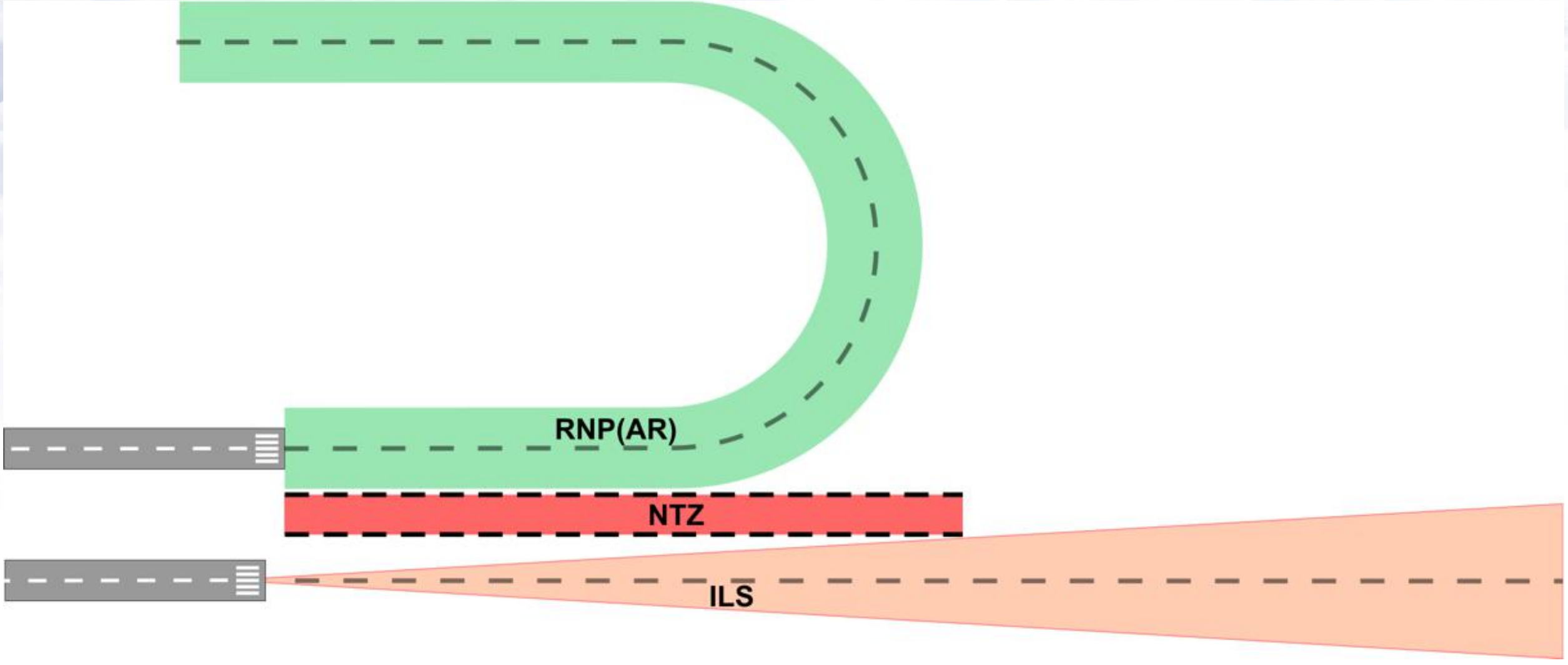
Independent parallel approaches.

Simultaneous approaches to parallel or near-parallel instrument runways where ATS surveillance system separation minima between aircraft on adjacent extended runway centre lines are **not prescribed**.



RNP (EoR) Established On RNP

Established on an RNP AR meas stablized on the final approach course or track



03

PART THREE

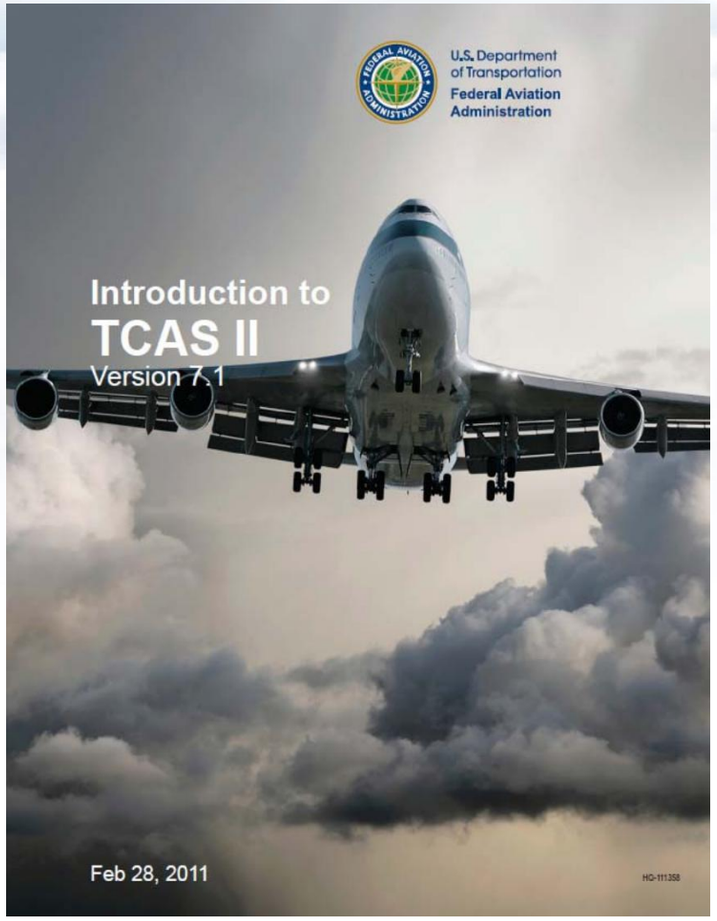
TCAS

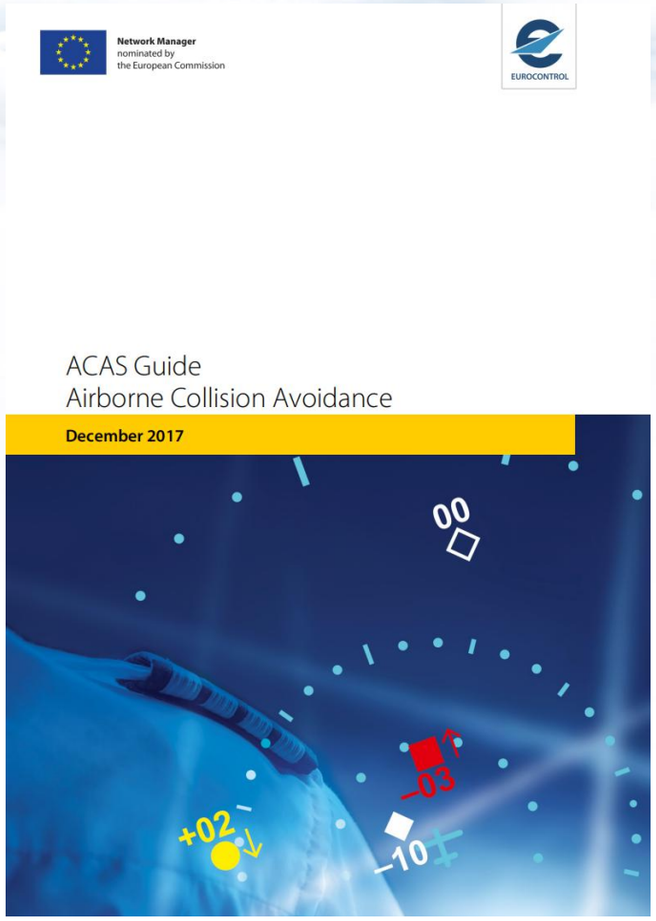
Doc

ICAO 9643 SOIR — 2020

DOT FAA Introduction to TCAS II Version 7.1 — 2011

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





SOIR Requirement

4. APPROACH DESIGN CONSIDERATION SPECIFIC TO SOIR

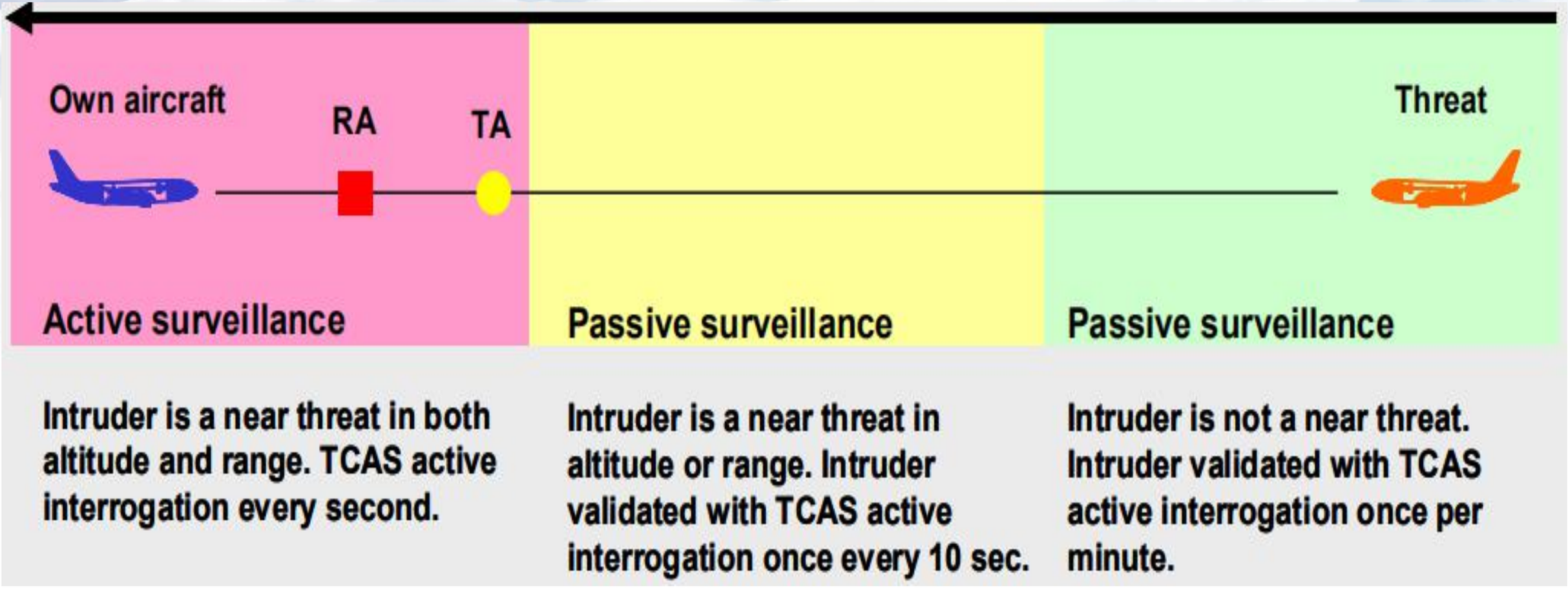
4.1 RNP AR APCH approaches need to be designed in accordance with ICAO Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual (Doc 9905) or other procedure design criteria approved by the appropriate State authority.

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.

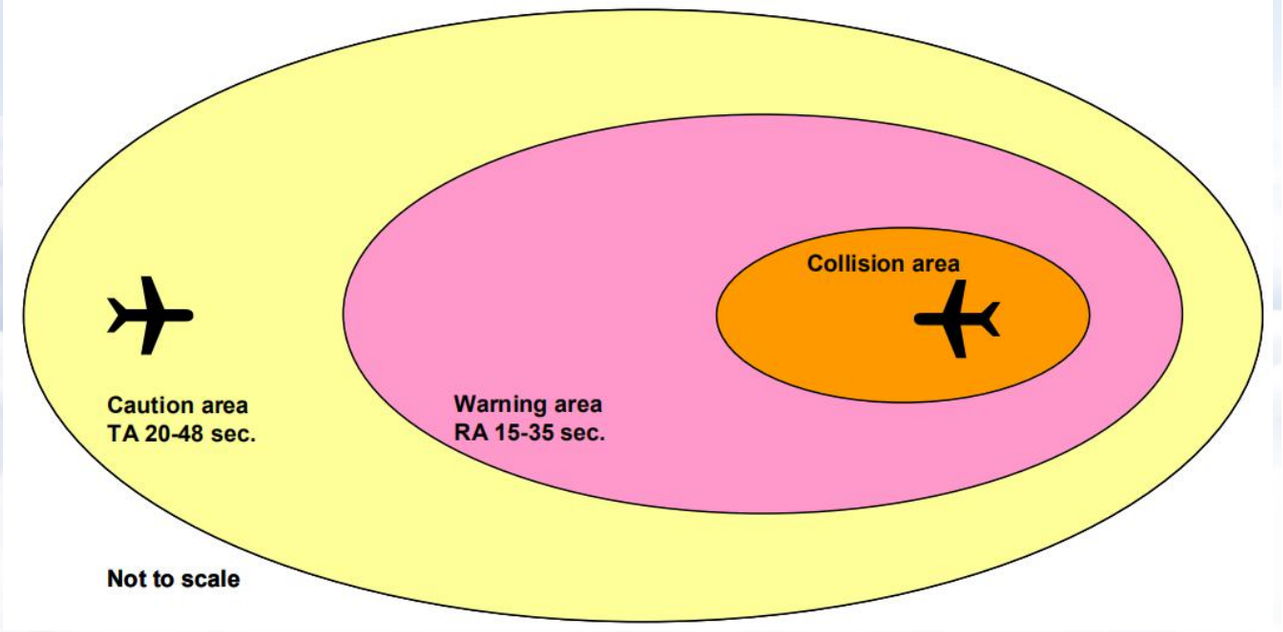
4.3 An important safety requirement is to mitigate incorrect runway selection. One way of mitigating the hazard of incorrect runway selection is by design.

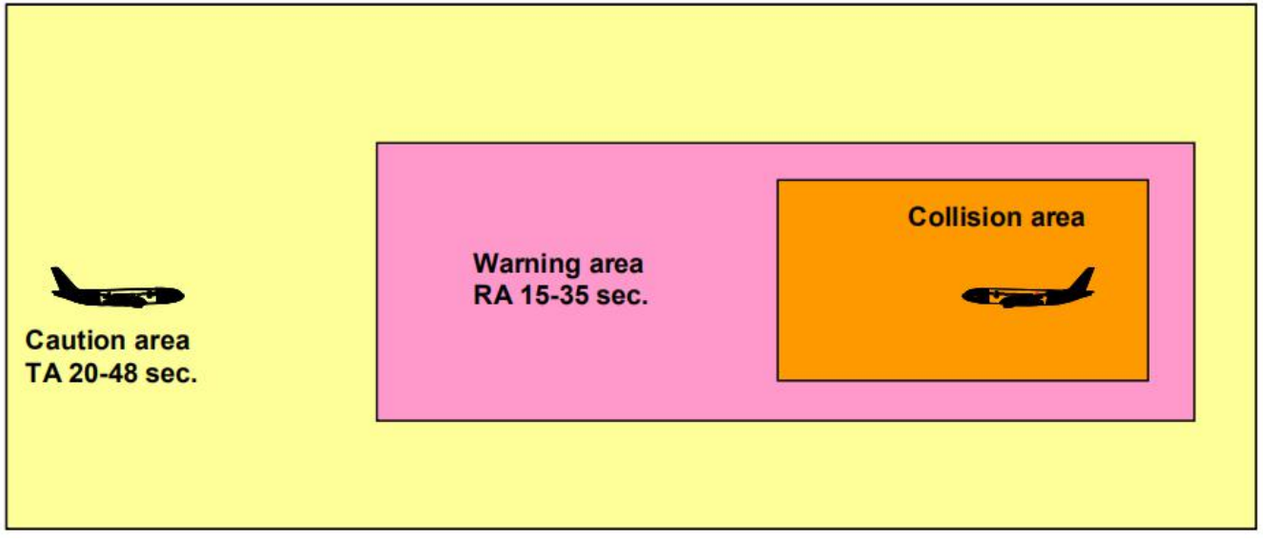
TCAS

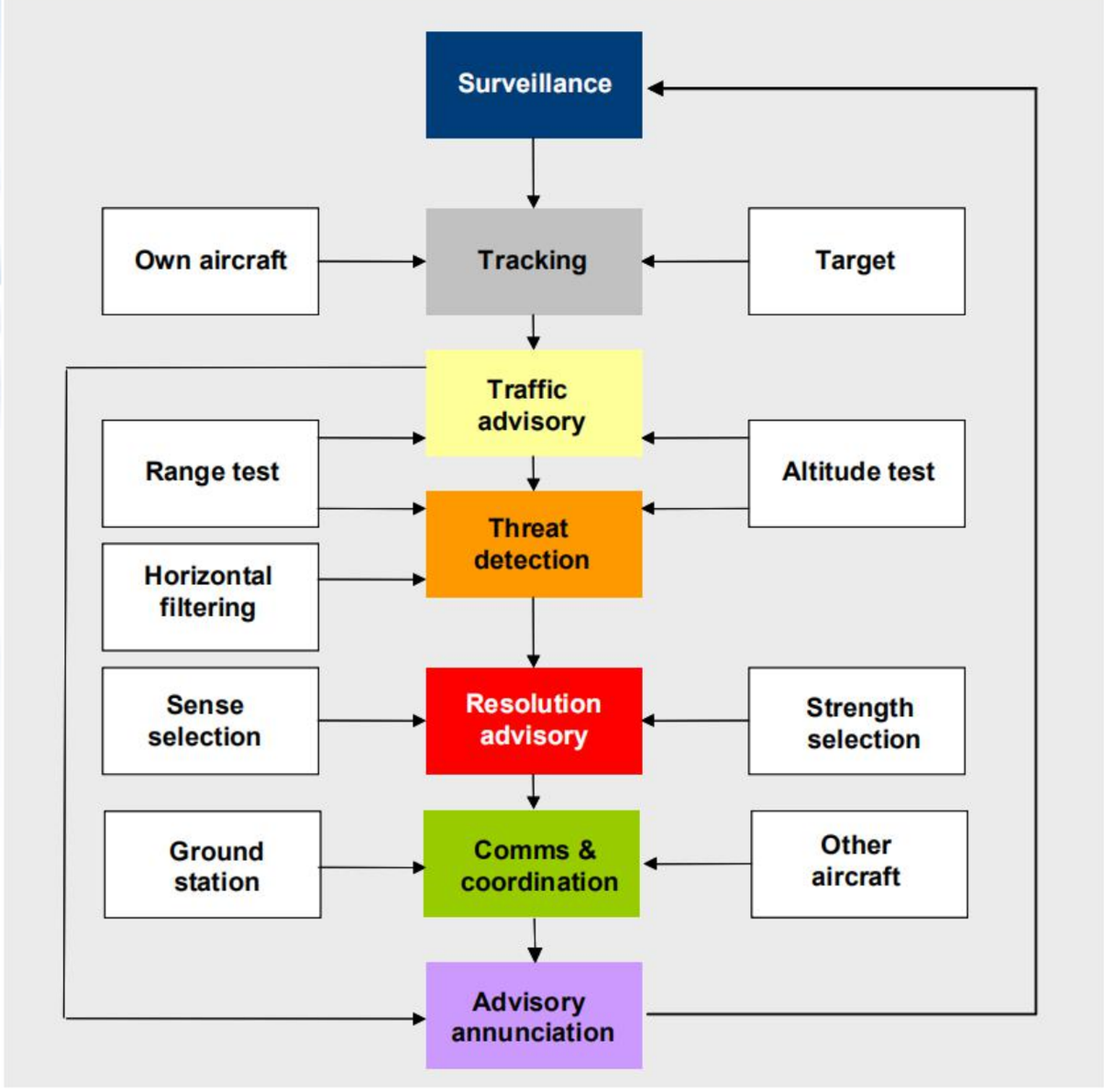
- TA(Traffic Advisories)交通警戒显示：
- RA(Resolution Advisories)决策信息显示：



TCAS


Collision area
Caution area
TA 20-48 sec.
Warning area
RA 15-35 sec.
Not to scale

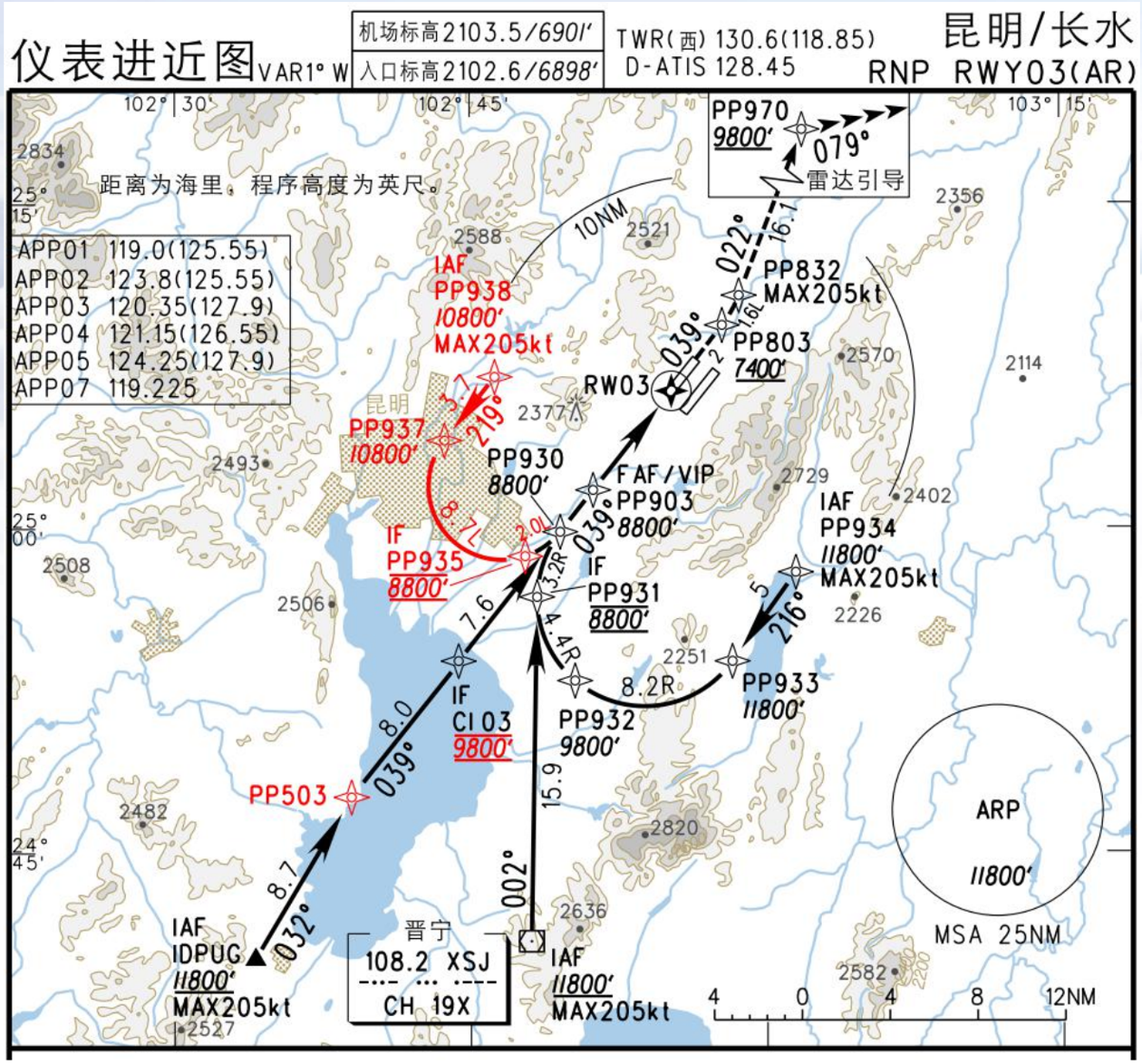

Collision area
Warning area
RA 15-35 sec.
Caution area
TA 20-48 sec.

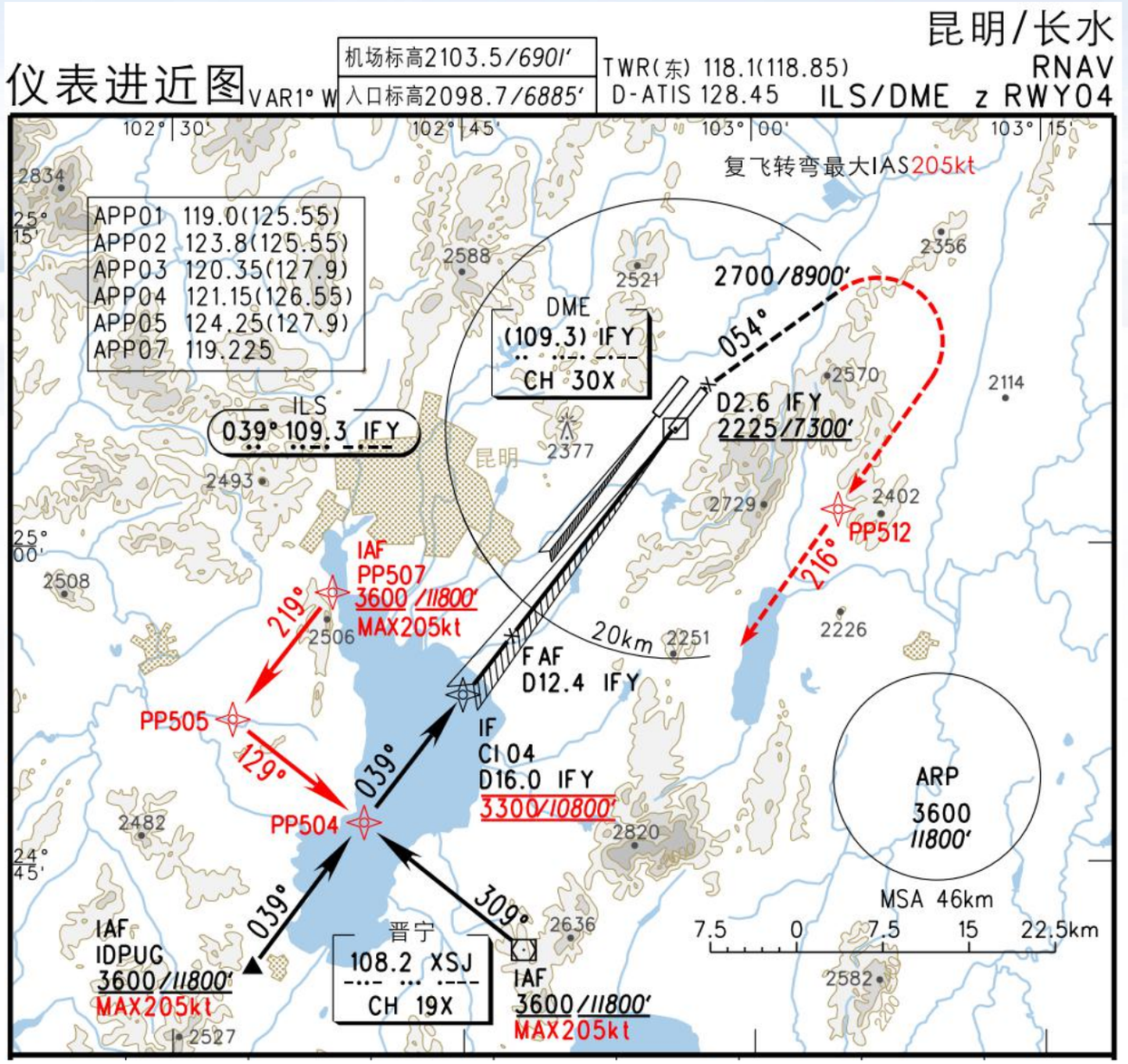

Surveillance
Own aircraft
Tracking
Target
Traffic advisory
Range test
Altitude test
Threat detection
Horizontal filtering
Sense selection
Resolution advisory
Strength selection
Ground station
Comms & coordination
Other aircraft
Advisory annunciation

TCAS

Own Altitude	SL	*tau* values (sec)		*TVTHR* (sec)	*DMOD* values (NM)		*ZTHR* (feet) Alt. Threshold		*ALIM* (feet)
		TA	RA	RA	TA	RA	TA	RA	RA
0 – 1000 ft AGL	2	20	no RA	no RA	0.30	no RA	850	no RA	no RA
1000 – 2350 ft AGL	3	25	15	15	0.33	0.20	850	600	300
2350 ft AGL – FL50	4	30	20	18	0.48	0.35	850	600	300
FL50 – FL100	5	40	25	20	0.75	0.55	850	600	350
FL100 – FL200	6	45	30	22	1.00	0.80	850	600	400
FL200 – FL420	7	48	35	25	1.30	1.10	850	700	600
Above FL420	7	48	35	25	1.30	1.10	1200	800	700

TCAS


仪表进近图 VAR1° W
机场标高2103.5/6901'
入口标高2102.6/6898'
TWR(西) 130.6(118.85)
D-ATIS 128.45
昆明/长水
RNP RWY03(AR)
距离为海里，程序高度为英尺。
APP01 119.0(125.55)
APP02 123.8(125.55)
APP03 120.35(127.9)
APP04 121.15(126.55)
APP05 124.25(127.9)
APP07 119.225
PP970 9800' 079° 雷达引导
PP832 MAX205kt
PP803 7400'
RW03
IAF PP938 10800' MAX205kt
PP937 10800'
PP930 8800'
FAF/VIP PP903 8800'
IF PP935 8800'
IF PP931 8800'
IAF PP934 11800' MAX205kt
PP933 11800'
PP932 9800'
IF CI03 9800'
PP503
IAF IDPUG 11800' MAX205kt
晋宁 108.2 XSJ CH 19X
IAF 11800' MAX205kt
ARP 11800'
MSA 25NM
昆明


仪表进近图 VAR1° W
机场标高2103.5/6901'
入口标高2098.7/6885'
TWR(东) 118.1(118.85)
D-ATIS 128.45
昆明/长水
RNAV ILS/DME z RWY04
复飞转弯最大IAS205kt
APP01 119.0(125.55)
APP02 123.8(125.55)
APP03 120.35(127.9)
APP04 121.15(126.55)
APP05 124.25(127.9)
APP07 119.225
DME (109.3) IFY CH 30X
ILS 039° 109.3 IFY
2700/8900'
054°
D2.6 IFY 2225/7300'
PP512
216°
IAF PP507 3600 /11800' MAX205kt
219°
PP505
129°
FAF D12.4 IFY
IF CI04 D16.0 IFY 3300/10800'
PP504
039°
309°
IAF IDPUG 3600/11800' MAX205kt
晋宁 108.2 XSJ CH 19X
IAF 3600/11800' MAX205kt
ARP 3600 11800'
MSA 46km
20km
昆明

TCAS分析

TCAS

RWY03 ILS and RWY04 RNP AR APCH

- OPS DIR：North and South
- Track devation：moninal and 0.2nm boundary track
- GS：ground speed，190kt to 300kt，interval 10kt
- TAU：RF alt 9800’ to 8800’ ，SL5，RA TAU 25s，TA TAU 40s

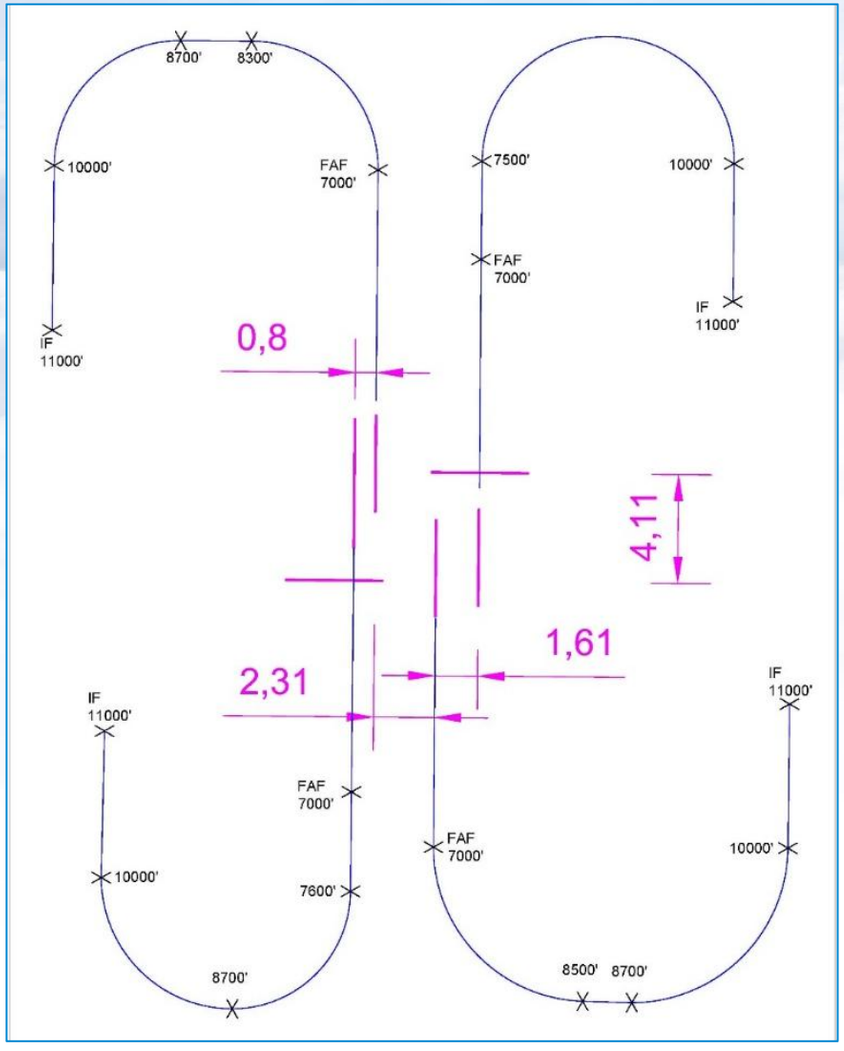
04

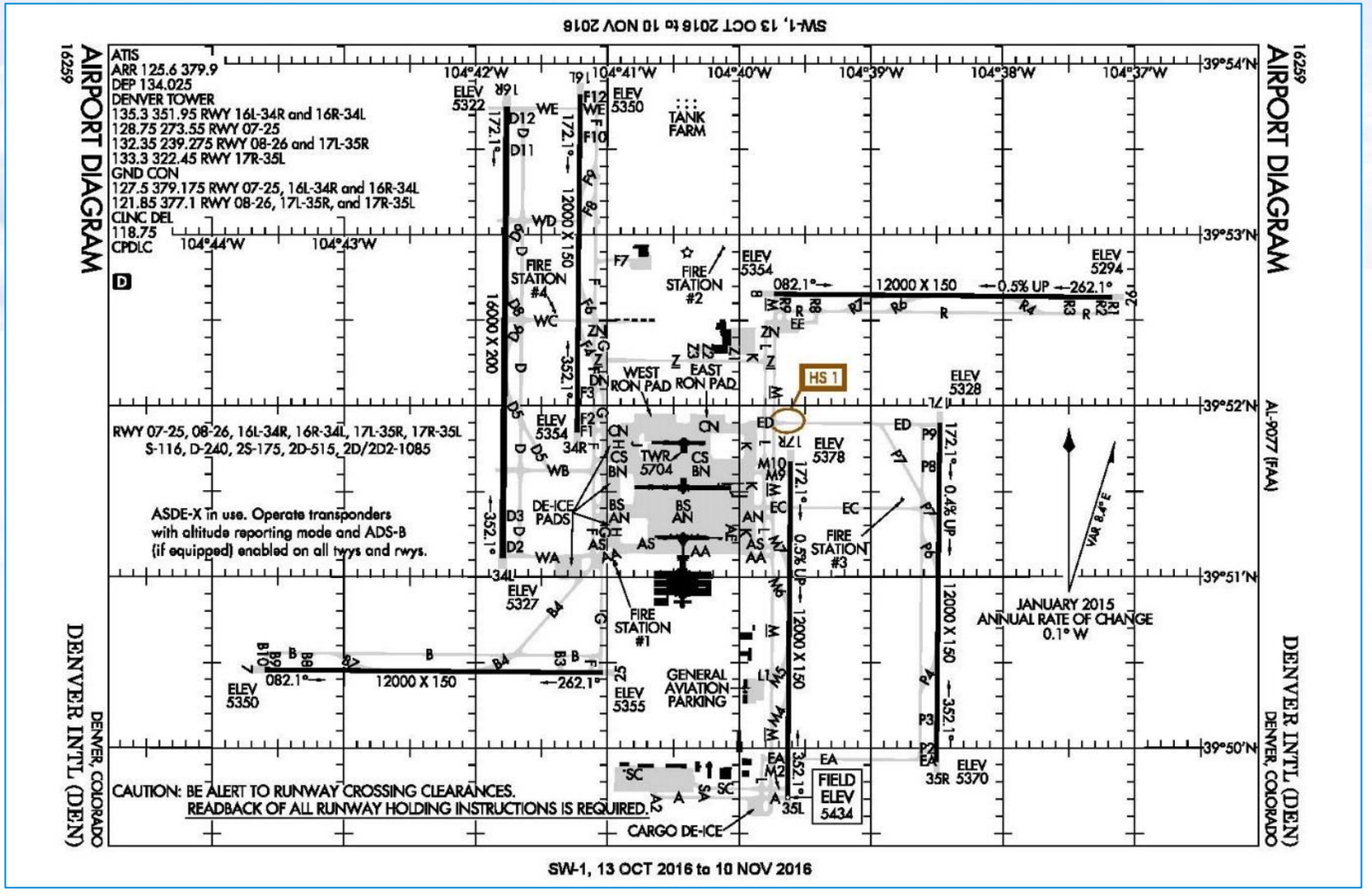
PART FOUR

EoR Applications

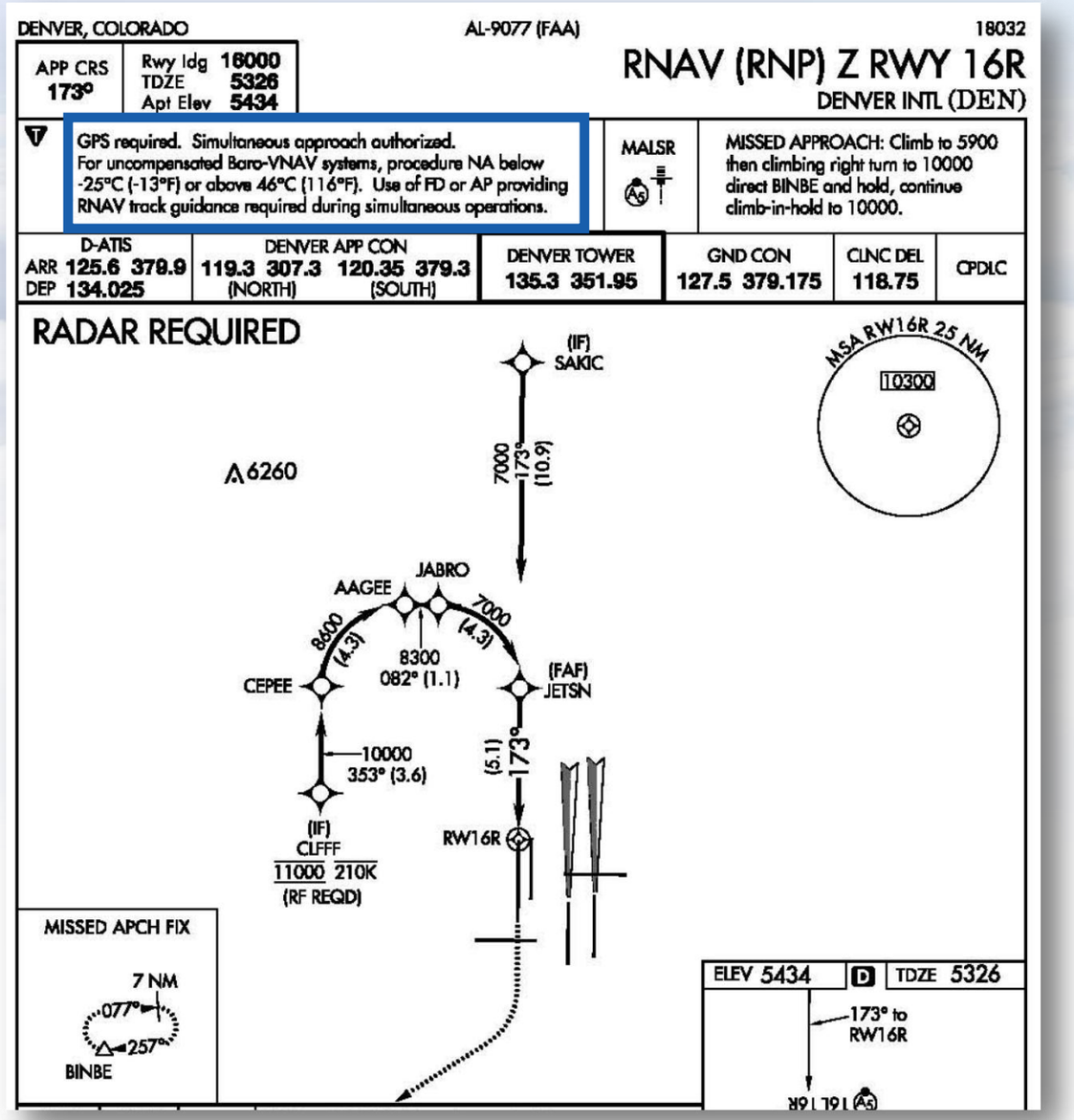

2011
KDEN,USA
2015
KSEA,USA
2018
CYYC,CANADA
2019
ZGSZ,CHINA
RNP AR+ILS vs
RNAV+ILS
2021
ZPPP,CHINA

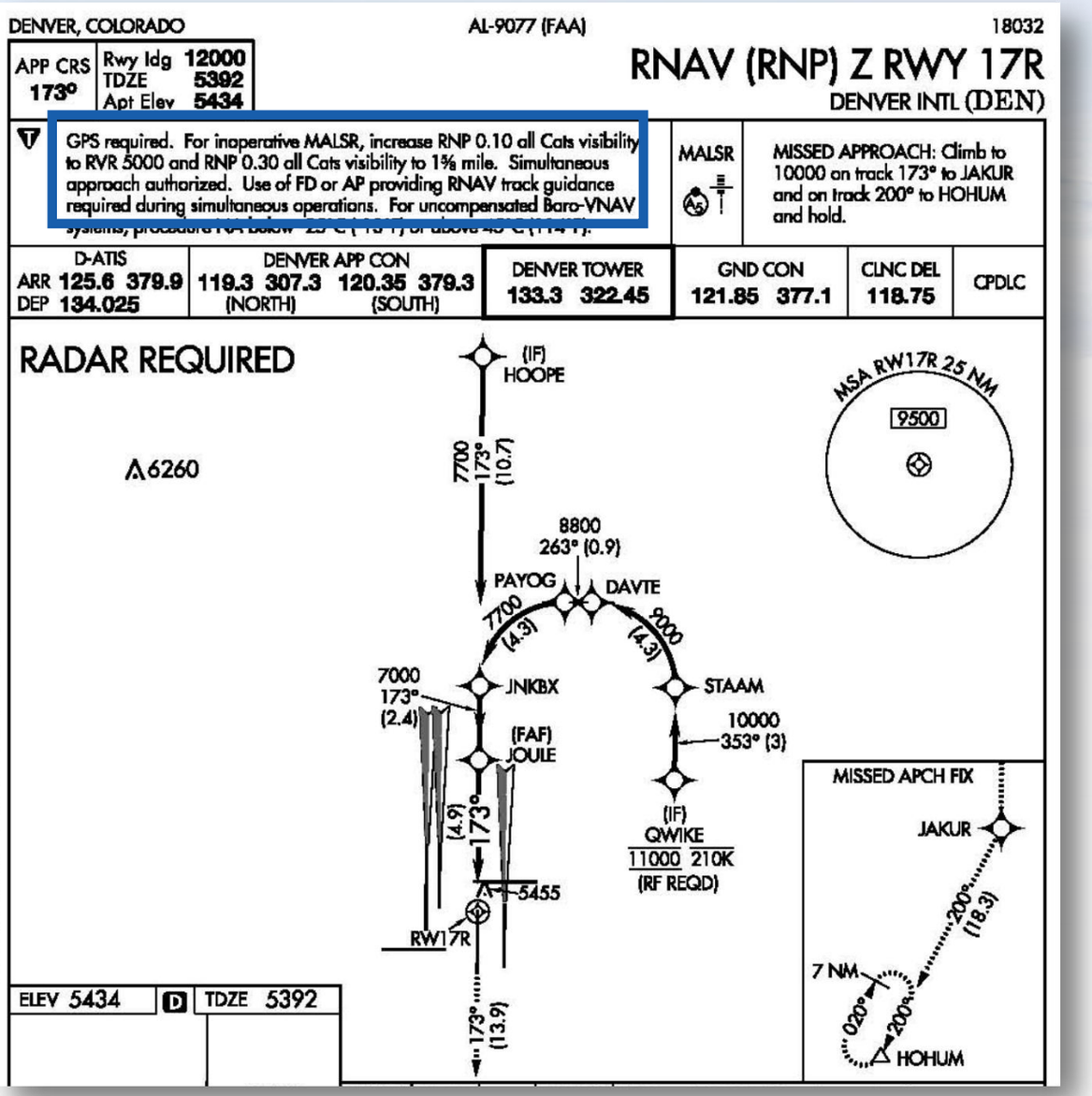
Denver International Airport 美国丹佛国际机场



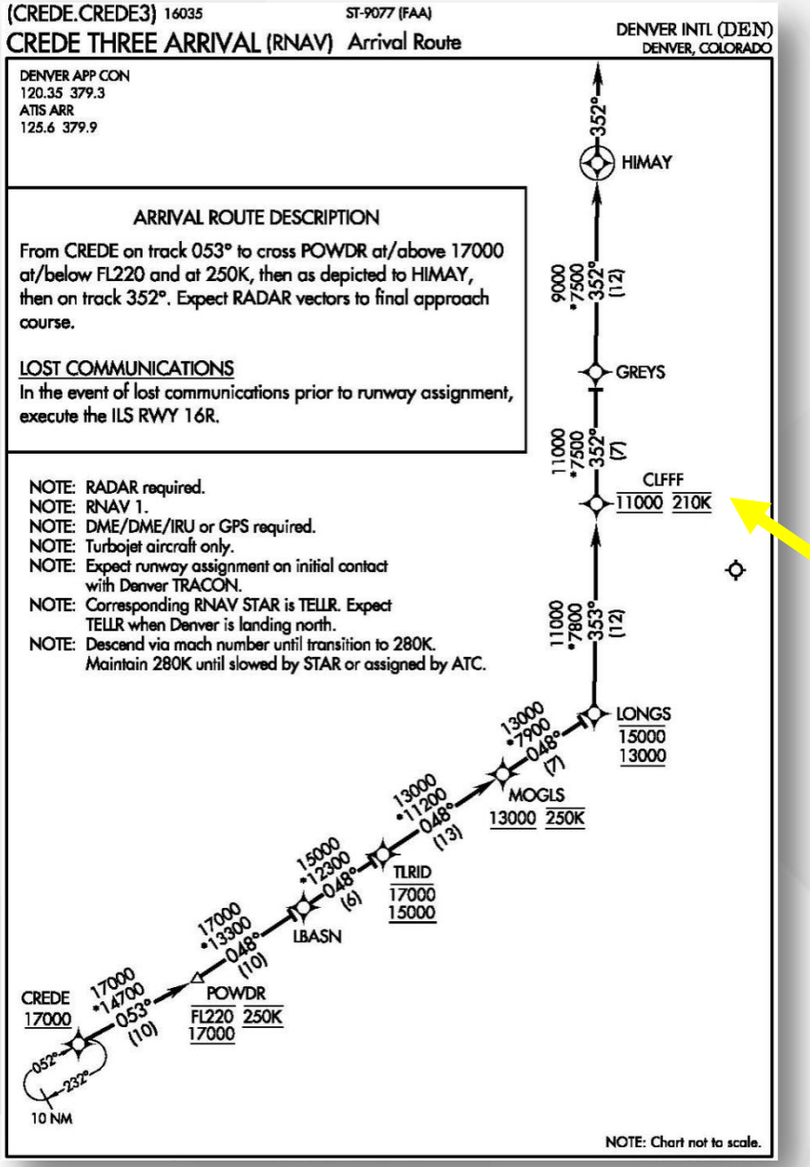


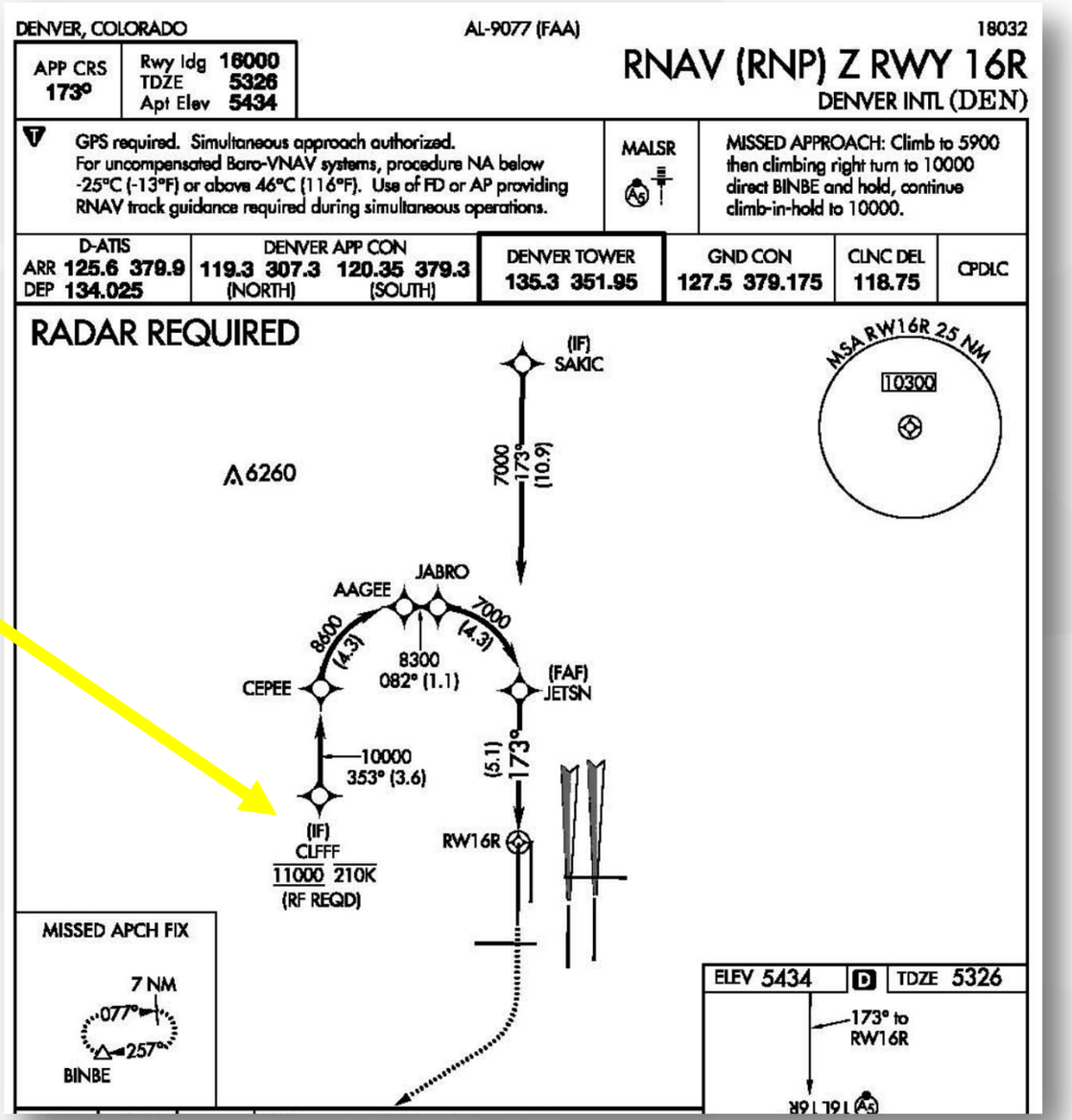
Denver International Airport美国丹佛国际机场





Denver International Airport美国丹佛国际机场





Denver International Airport美国丹佛国际机场

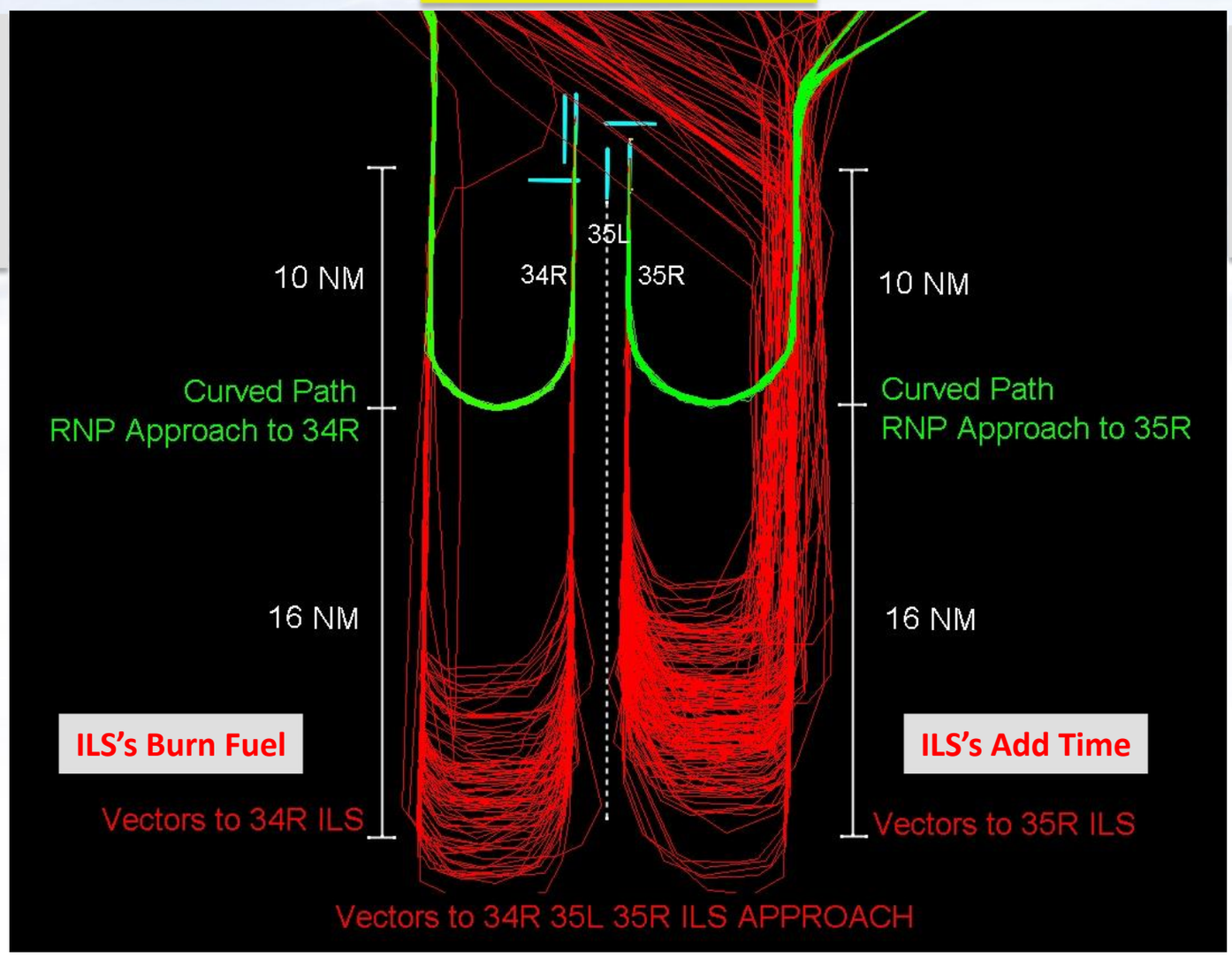
RNP vs ILS

Airlines Savings:

9 minutes

800lbs fuel

Per Flight



All Airlines Participating

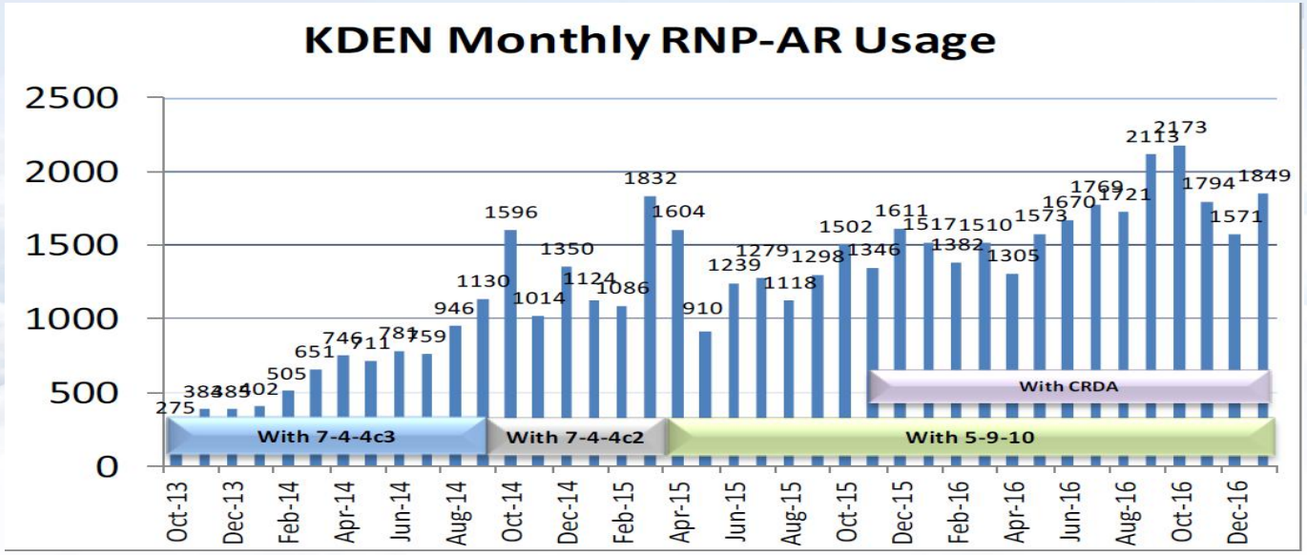
SWA, UAL, FFT, AAL
DAL, ASA, ACA, JBU

Denver International Airport美国丹佛国际机场

Airline RNP-AR Benefits

- Fuel
  - 100lbs less compared to Visuals
  - 800lbs less compared to simultaneous ILS's
- Time
  - 2 mins less compared to Visuals
  - 9 mins less compared to simultaneous ILS's
- Flight Time Predictability: The flight's mileage/time airborne is not affected when operations change from VMC to IMC because the same flight path is flown.
- Safety (Airline)
  - Pilot workload reduction
  - Increased pilot situational awareness.
  - Stabilized instrument approaches vs visual approaches.

Denver International Airport美国丹佛国际机场

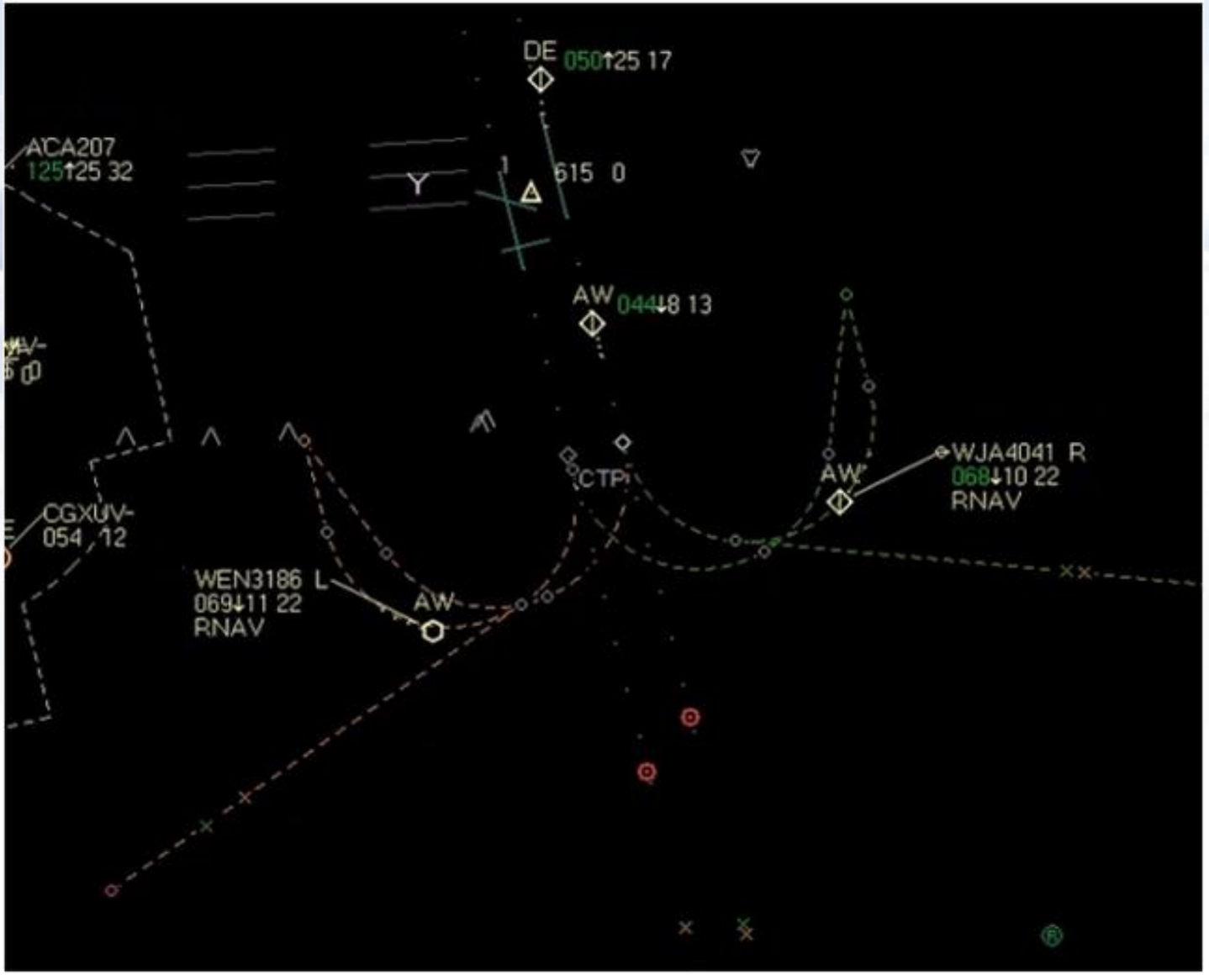


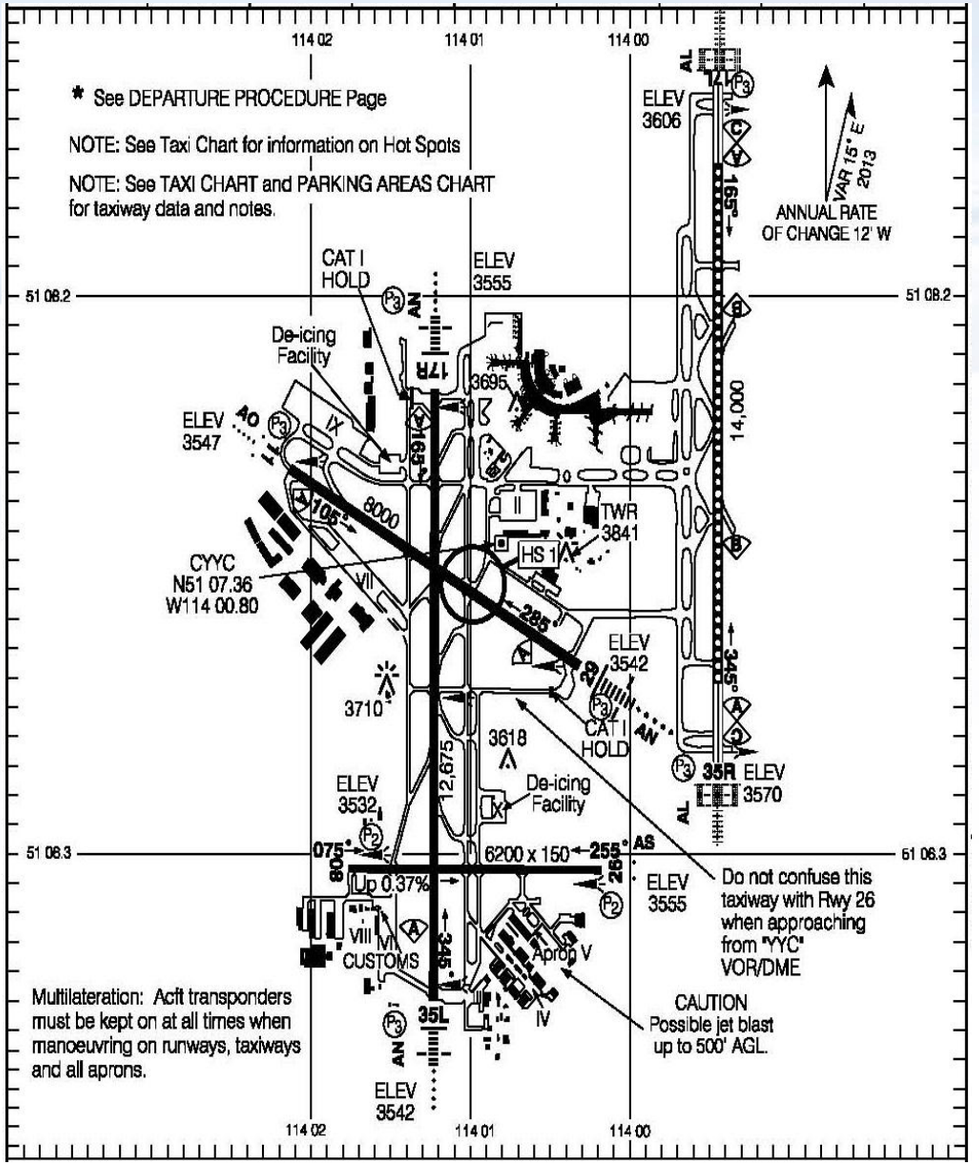
- Designed and implemented PBN based arrivals and departures to (SIDS/STARS)
  - improve efficiency and reduce delays
  - reduce fuel burn, noise, emissions
- Implemented Established on RNP AR (EoR AR) Independent to Widely Spaced Runways
- FAA Handbook 7110.65 W

*"**United** estimates uninterrupted idle descent from cruise to final approach will result in savings of 200-600lb (90-360 kgs)of fuel per flight, depending on the size of the aircraft." – DIA press release*

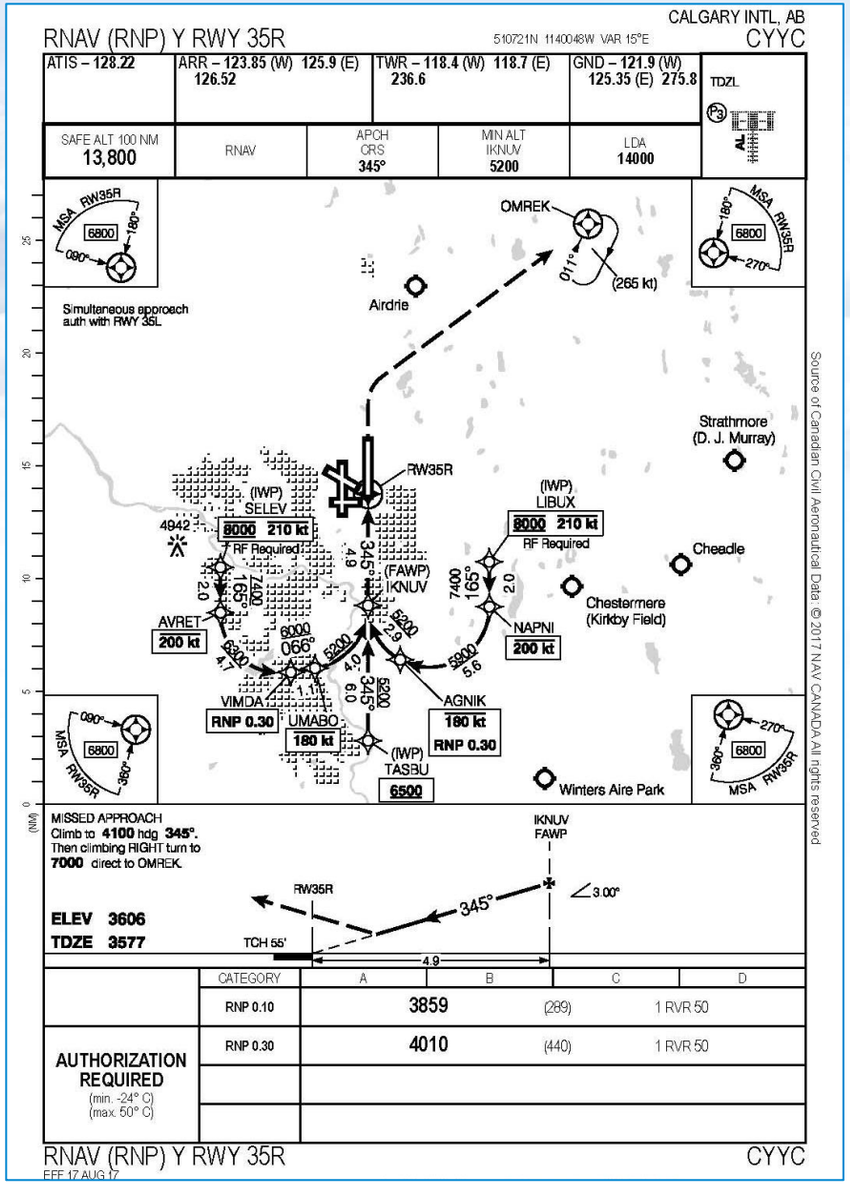
Southwest : "RNP approaches can reduce flying by …up to 20 nm during an instrument approach ….save …more than 90 gallons (270 kgs) of fuel per flight on instrument approaches." – SWA press release

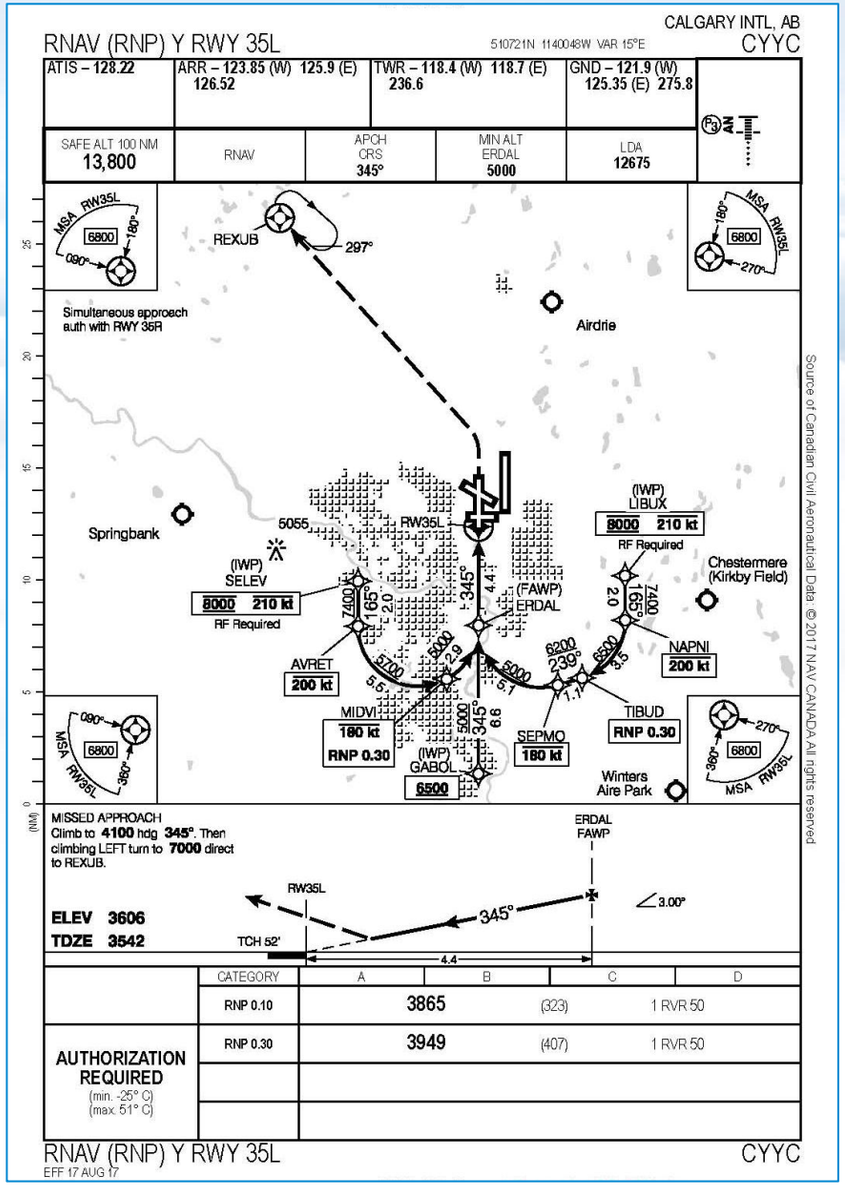
Calgary International Airport 加拿大卡尔加里国际机场



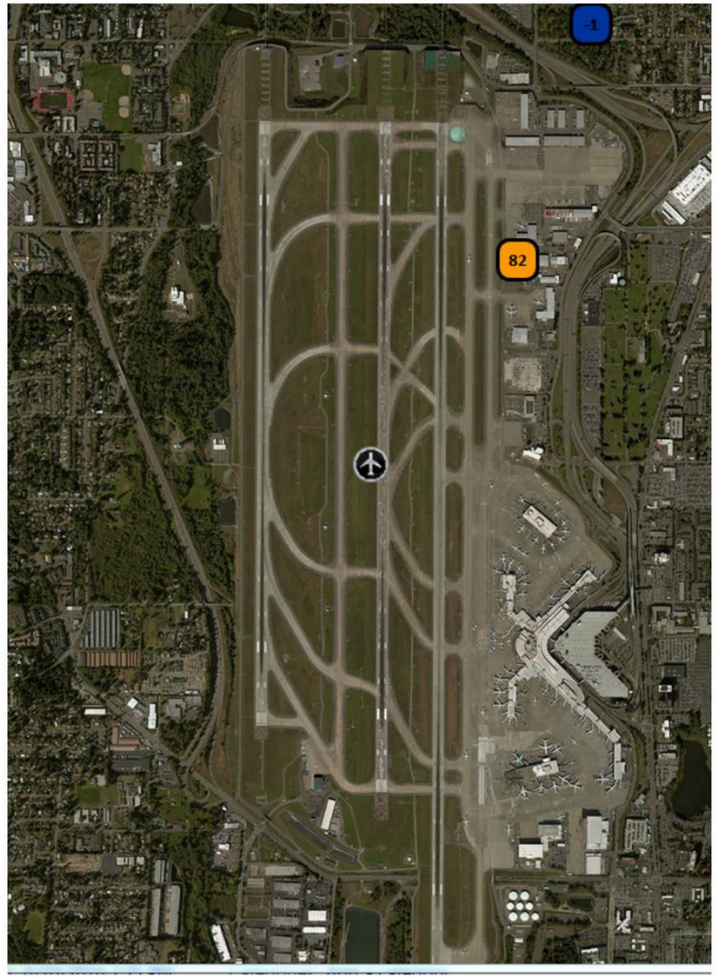


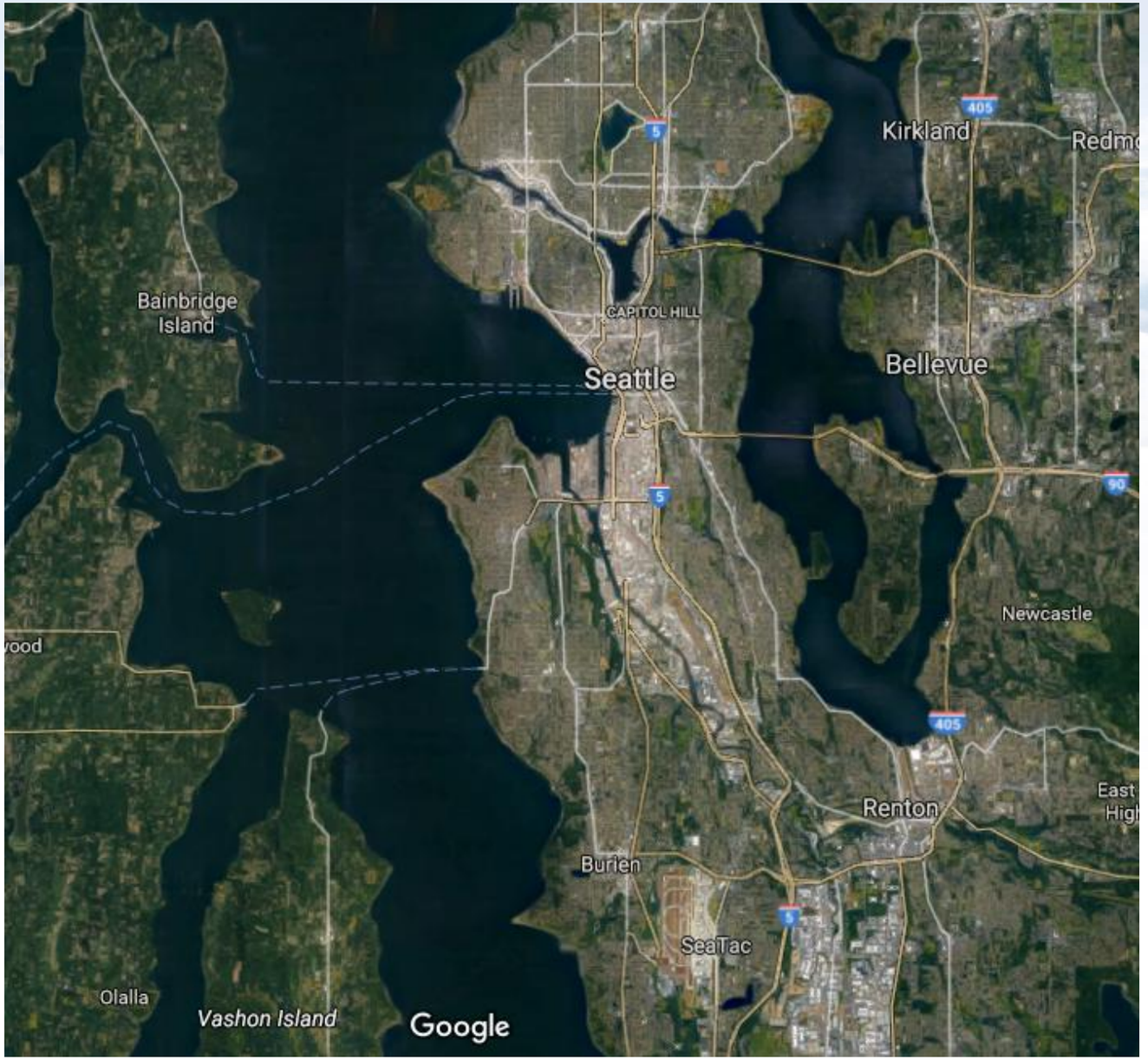
Calgary International Airport 加拿大卡尔加里国际机场



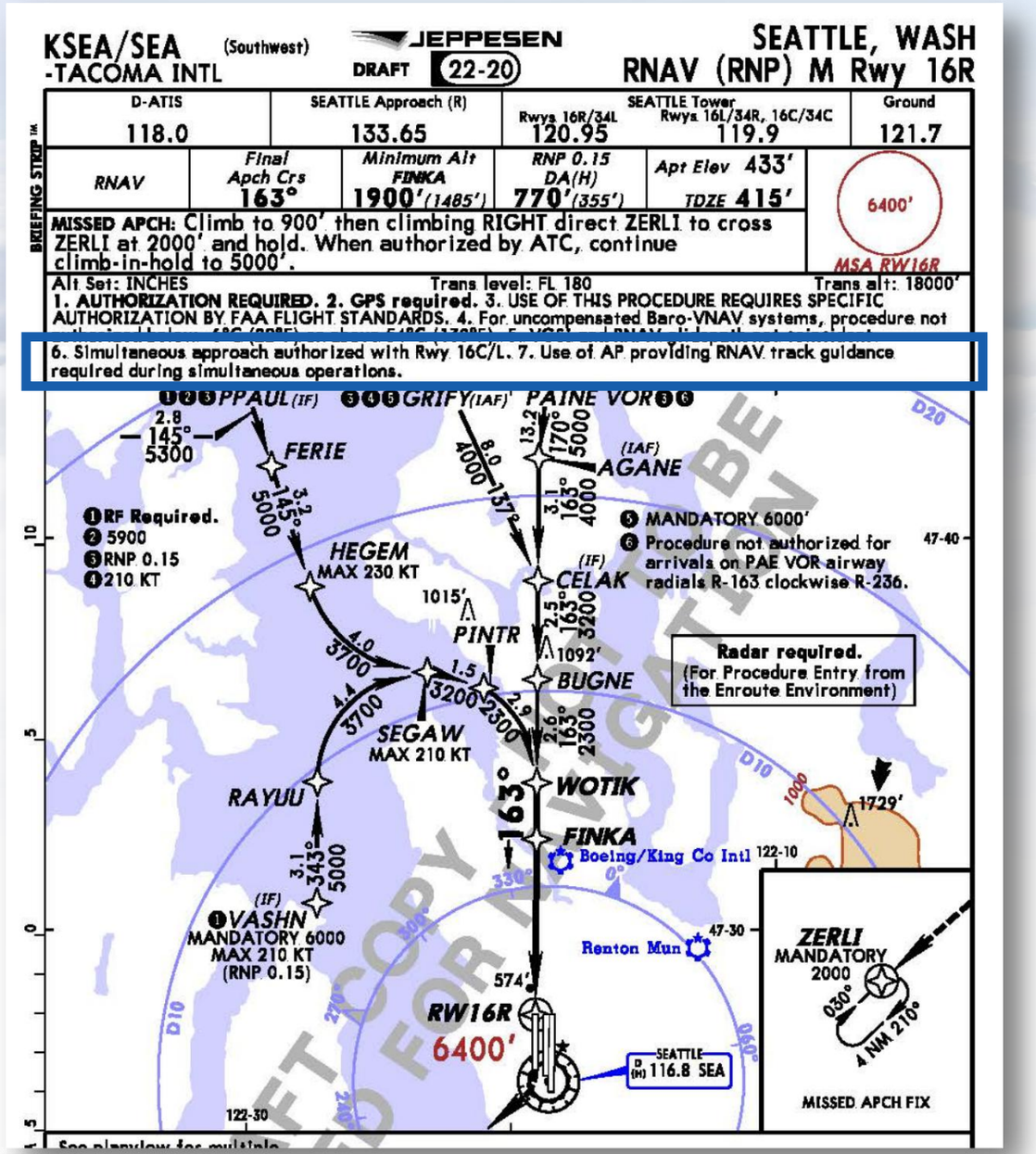


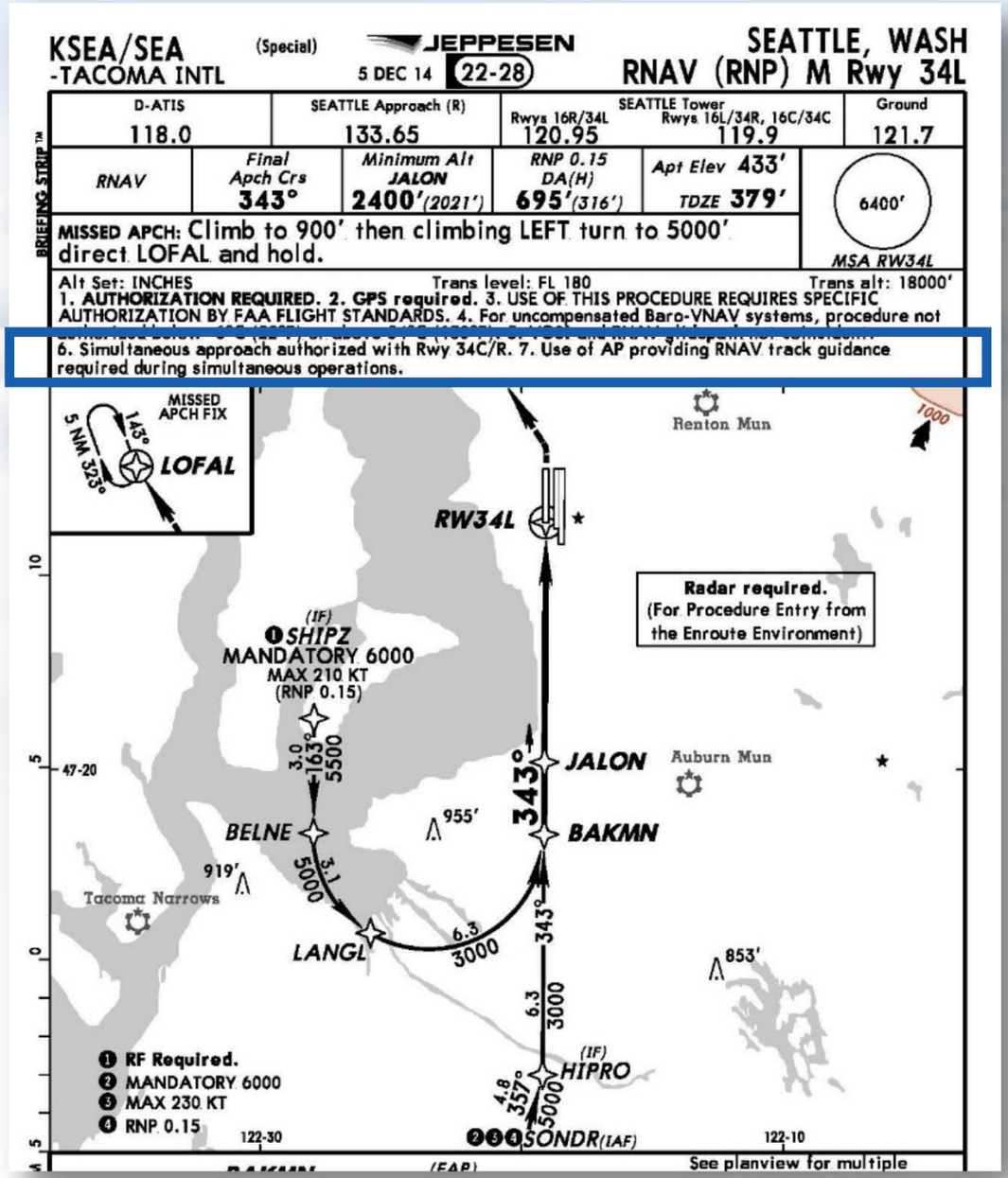
Seattle-Tacoma International Airport 美国西雅图塔克马国际机场





Seattle-Tacoma International Airport 美国西雅图塔克马国际机场

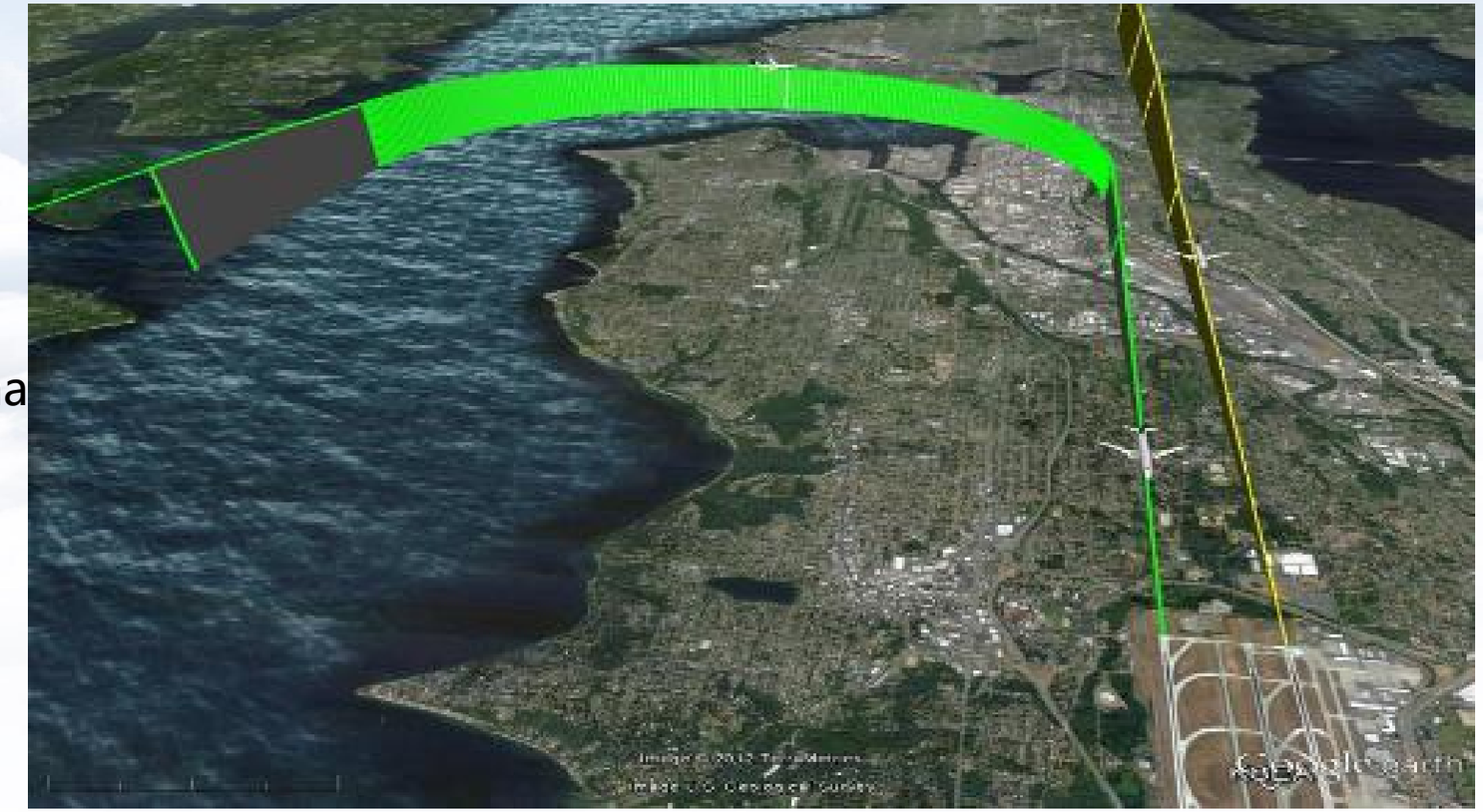




Seattle-Tacoma International Airport 美国西雅图塔克马国际机场

First Experiences & Expectations

- Stable Approaches
- Fewer Track Miles
- Idle descents
- Aircraft are higher longer
- Lower Fuel Burn
- Less Emissions
- Noise moved over less people
- Highlights Design Details and "gotcha



"What we are doing in Seattle can serve as a template for advancing the FAA's NextGen air traffic control and airspace modernization plan"
– Bill Ayer, CEO Alaska (retired)

Progress and plans

- Seattle "Greener Skies" - Dependent spacing – April 2015 waiver for RNP AR and ILS use based on Boeing safety and operational assessment
- Transition to GLS final is projected to begin in 2018

~ 1/3 of approach fuel saved per Greener Skies Approach

SHENZHEN/BAOAN International Airport 深圳EoR设计思路

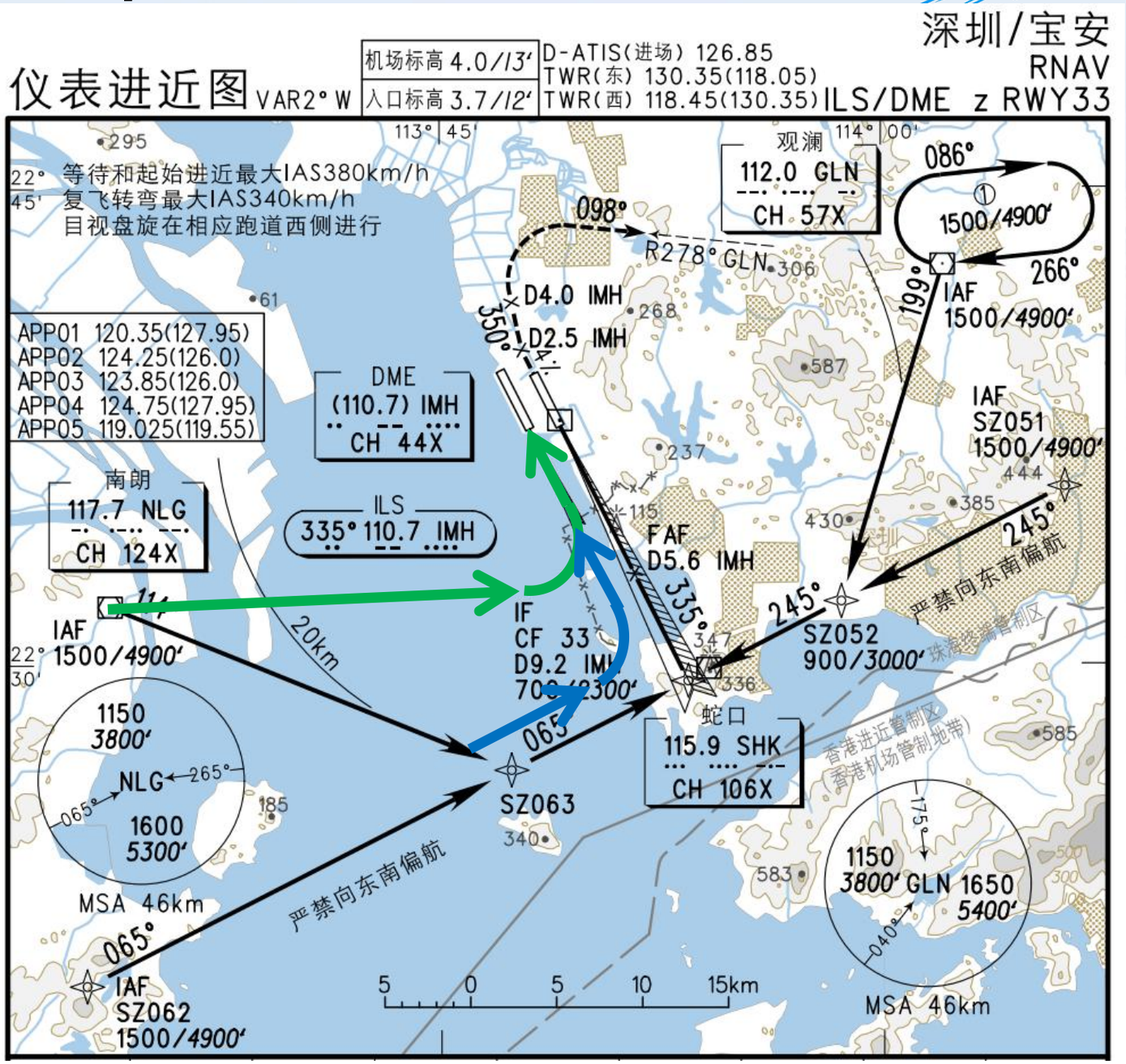
RWY 33 - Published RNAV to ILS Final

RWY 34 - Proposed RNP AR to ILS Final

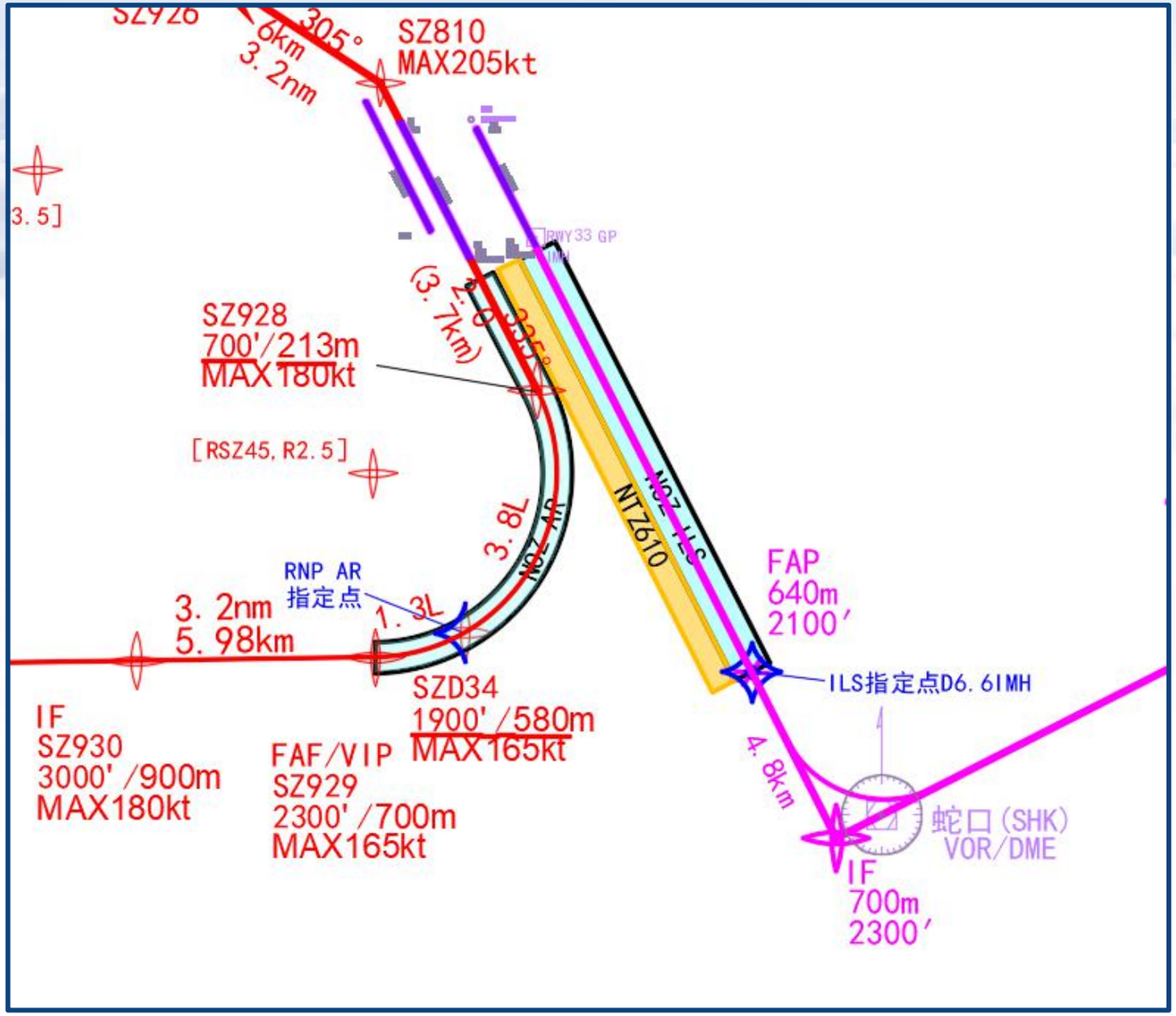
RWY 34 - Proposed RNP AR APCH

RWY34 THR 5.6km TOWERS 78.2m, +150m MOC, MIN waypoint altitude 223.2m733ft，roll up to 800ft。

Set RF roll out point FAF/VIP 700m/2300ft after the flight simulation.



ZGSZ RWY34 RNP AR APCH



NTZ

- Width - 610m(2000ft)
- Length - 11.825Km
- Origin- RWY33 THR

NOZ

- RNP AR 34,
- Width - 740m(0.2nm*2)
- ILS 33
- Width - 990m(1600-610)

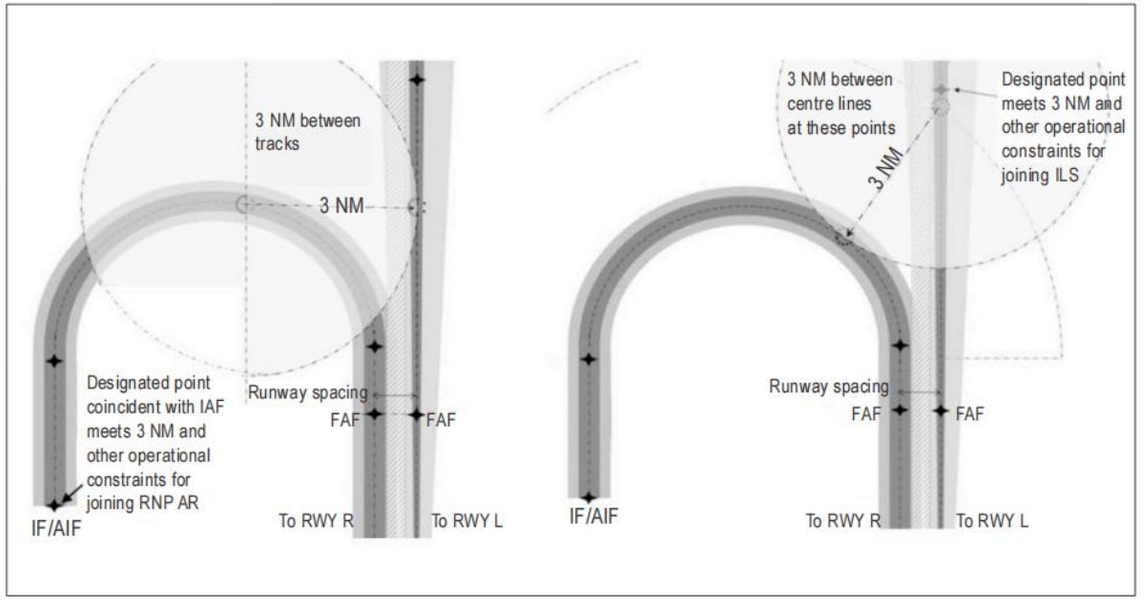
DESIGNATED POINT

2.2.5.2 An aircraft conducting an RNP AR APCH procedure (designed to criteria in 2.2.1.5) is considered eligible for SOIR when established after the IAF/IF provided that:

a) the aircraft confirms that it is established on the RNP AR APCH procedure prior to a **designated point**, the location of such point to be determined by the appropriate ATS authority;

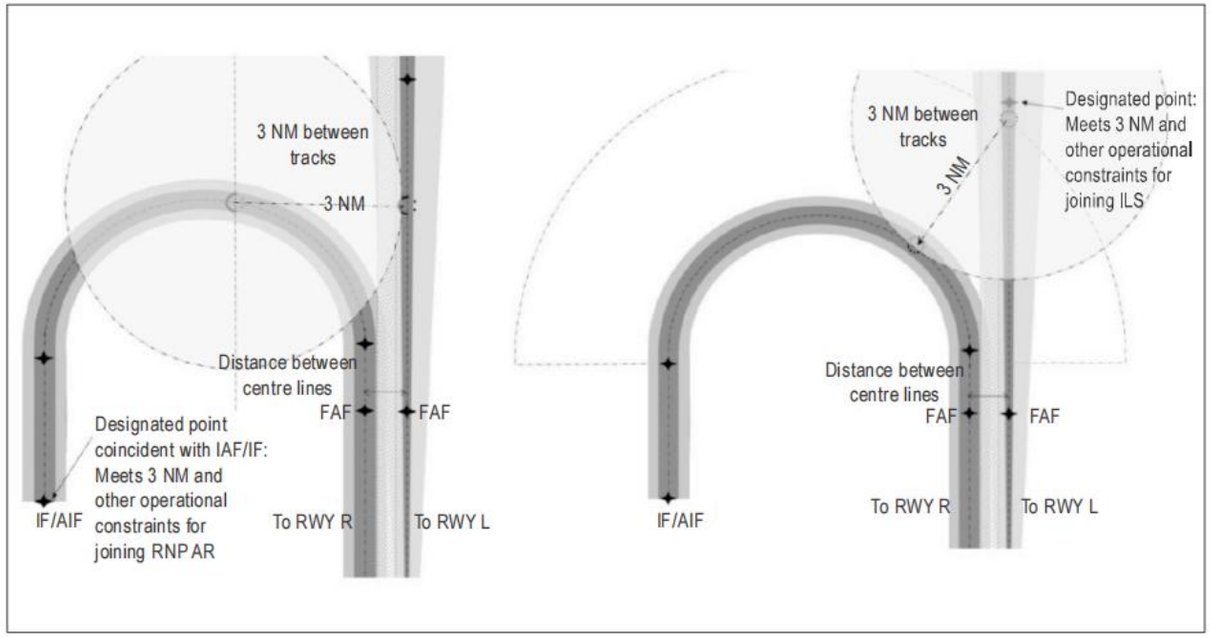
b) the **designated point** is positioned on the RNP AR APCH to ensure the applicable horizontal separation minimum (e.g. 5.6 km (3 NM)) from the adjacent approach procedure .The **designated point** may normally be coincident with the IAF/IF; and

c) the **designated point** is readily apparent to the approach and monitoring controllers. The **esignated point** may be depicted on the situation display.

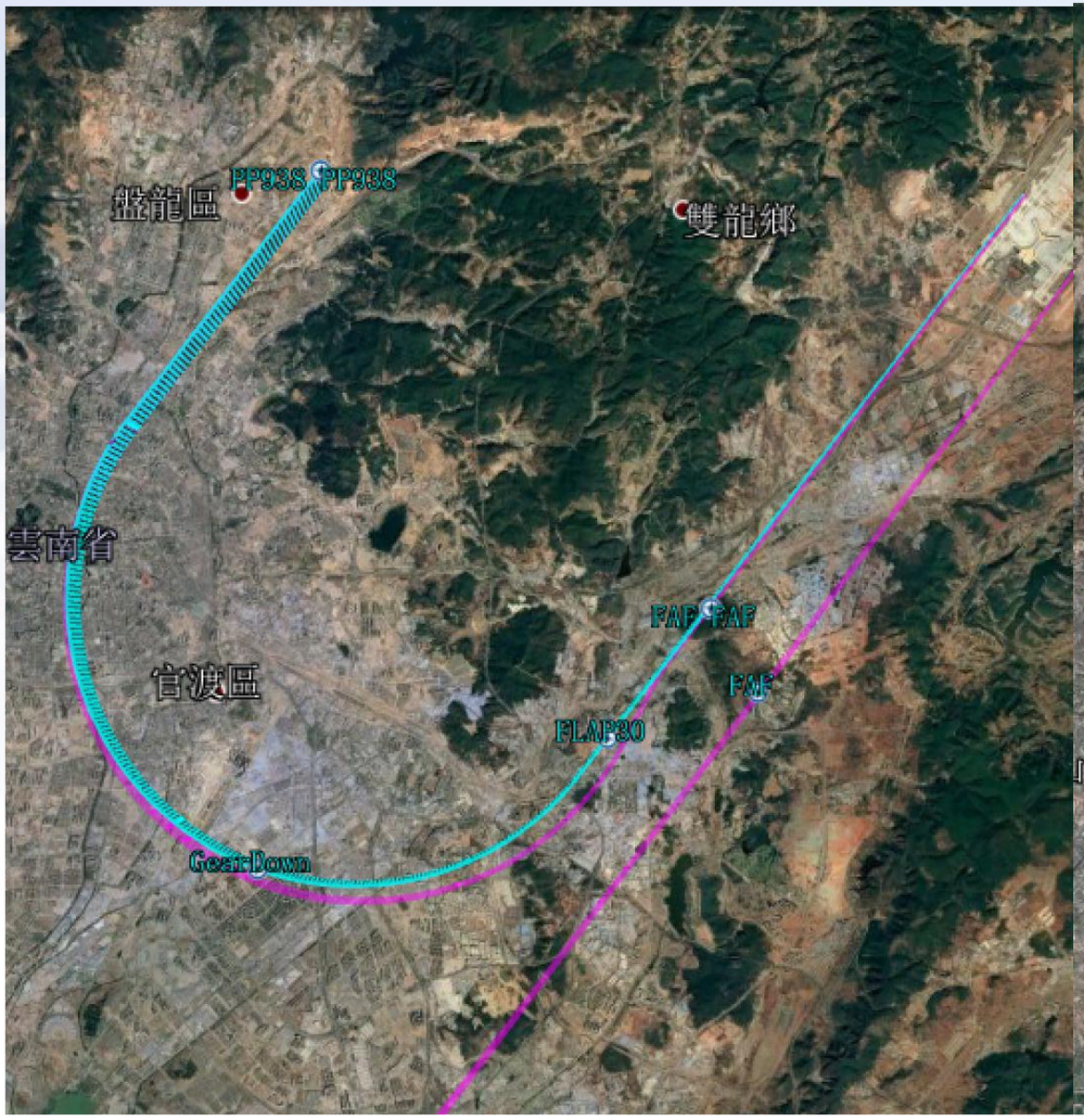


DESIGNATED POINT

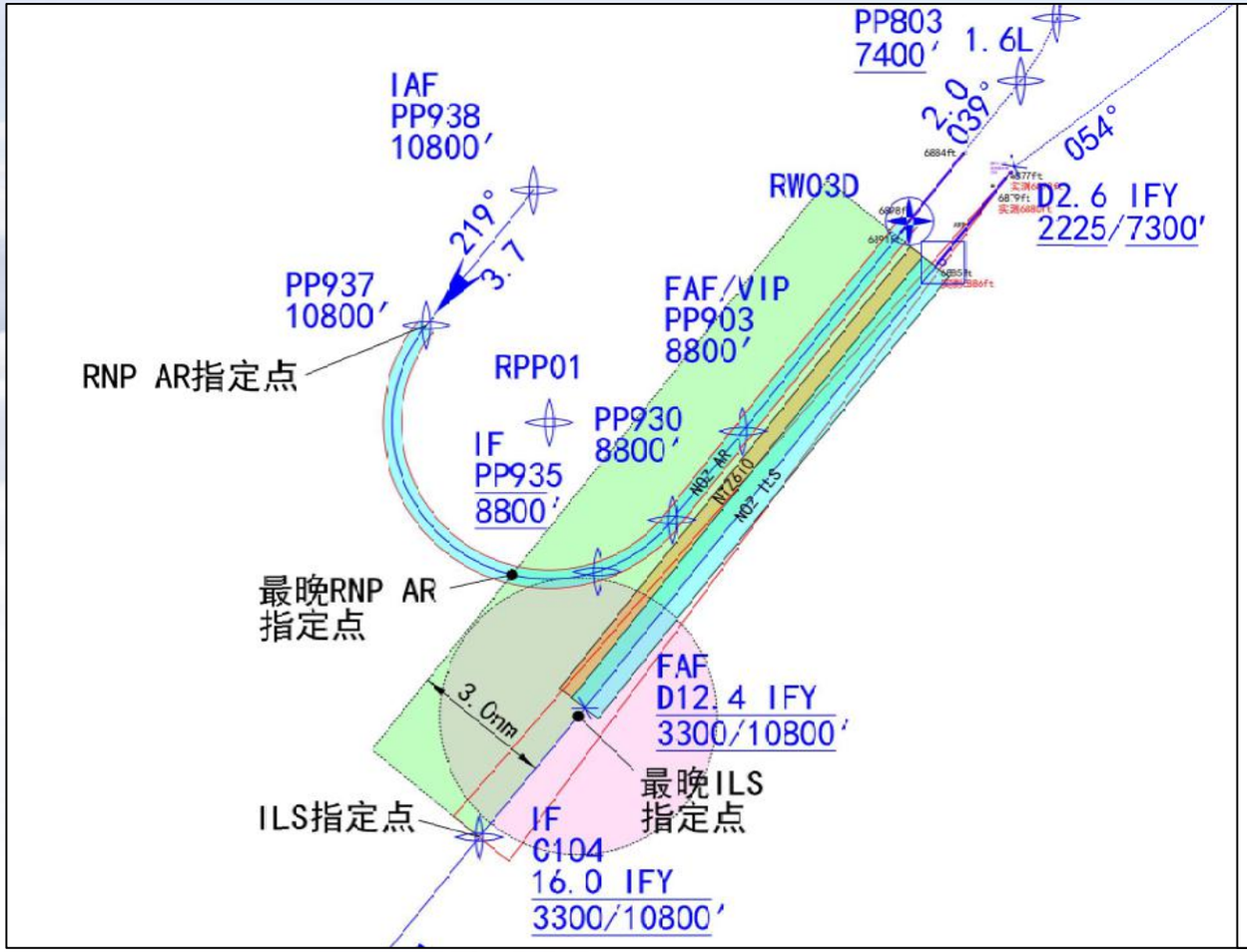
3.3 To show where these **designated points** might be placed, Figure A-3 shows the edge of 5.6 km (3 NM) boundaries from their respective centre lines. If a circle were to follow an aircraft progressing on its procedure during a simultaneous approach operation, this circle will trace a 5.6 km (3 NM) arc on either side of centre line as shown. This boundary will eventually intersect with the centre line of the other approach, identifying where on both procedures 5.6 km (3 NM) separation is no longer applicable. If the approach procedures are not symmetrical, as shown in the figures, a circle tracing along the other centre line can create different 5.6 km (3 NM) intercept points dependent on which aircraft leads the other. These intersections will define the points by which, at the very latest, an alternative form of separation must be achieved and identify the concept of designated points. See Figure A-4.



DESIGNATED POINT

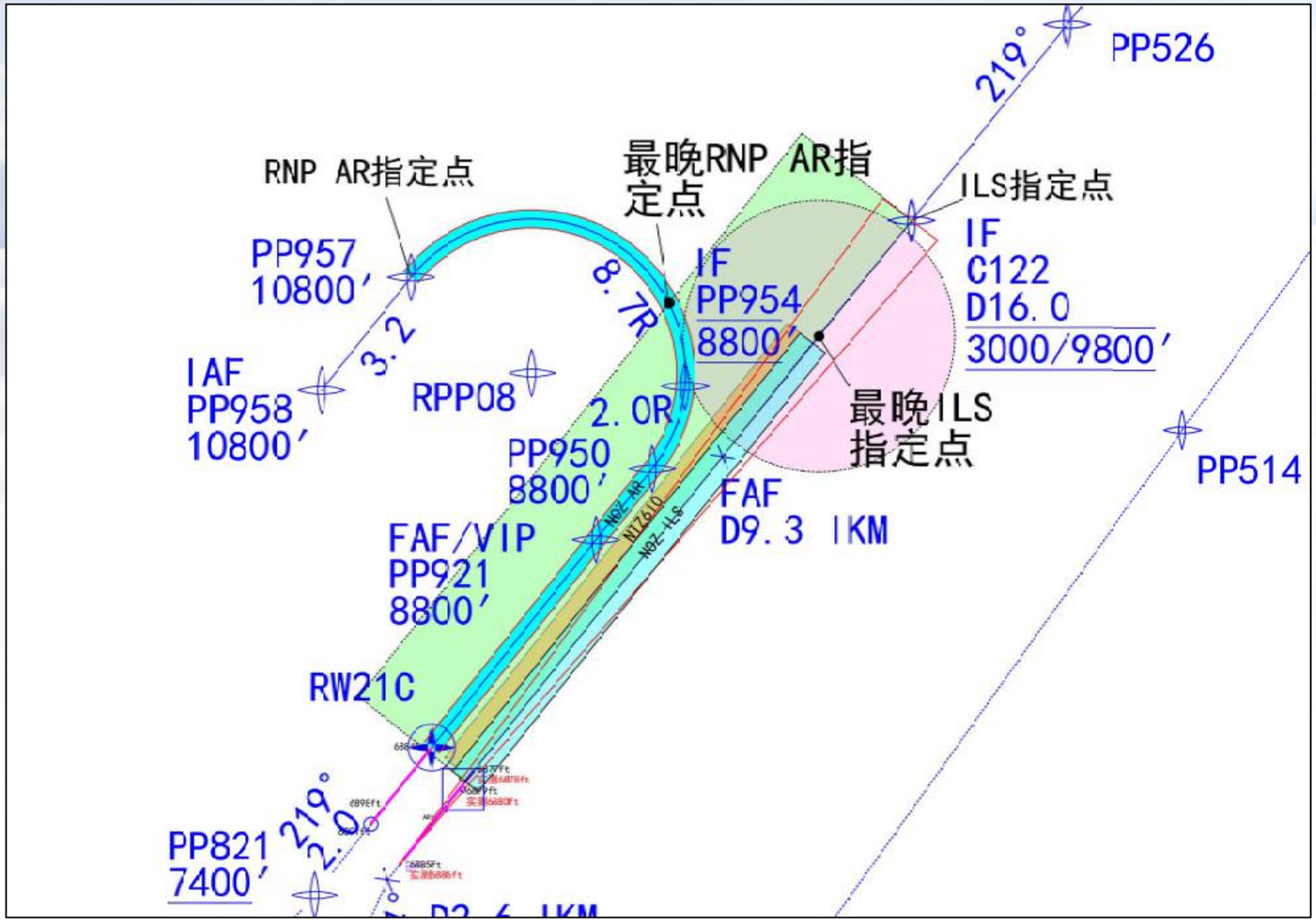


DESIGNATED POINT



- RWY03 RNP AR APCH – PP937 (RF Rollout)
- RWY03 ILS – CI03 D16.0 IZL (IF)
- RWY04 ILS – CI04 D16.0 IFY (IF)
- RWY04 RNP AR APCH – PP943 (RF Rollout)

ZPPP



Flight movements 2019: 357,080

Fuel saving pre RNP AR RF: 700kg = 500$

50% RNP AR APCH

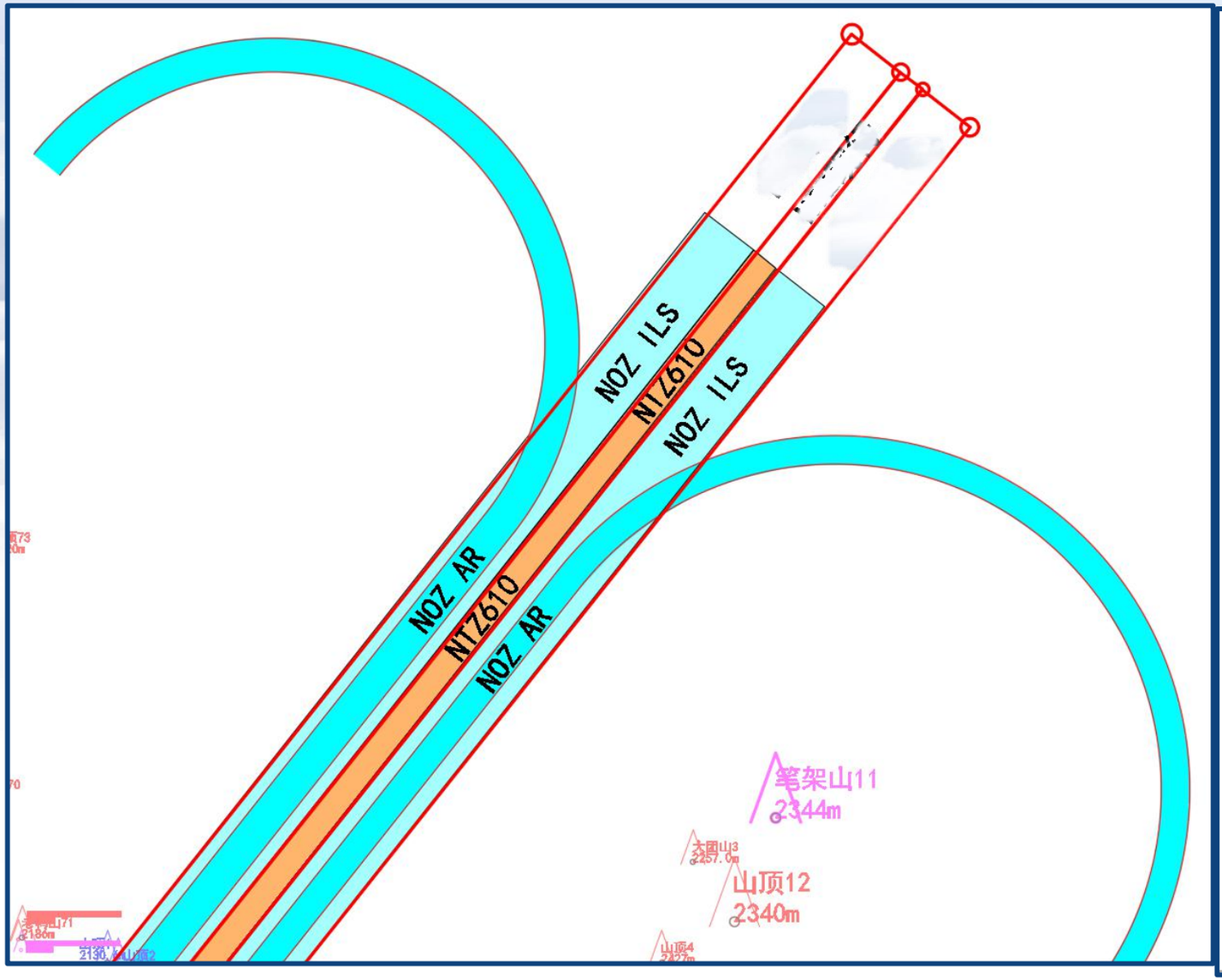
89270 Flight movements

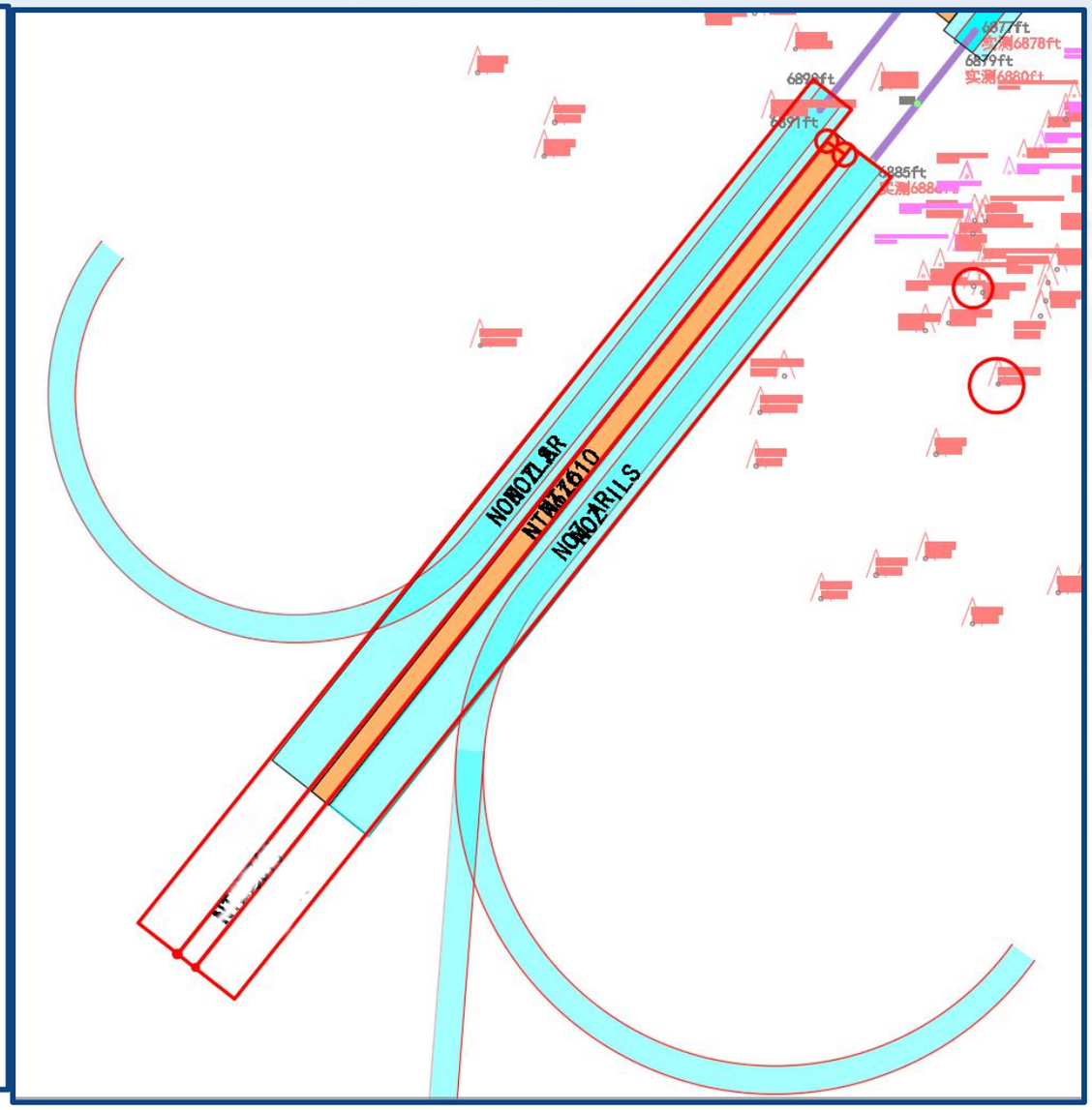
40M$

89,000 metric ton CO2

Dependent ->INDEPENDENT

NTZ/NOZ


NOZ ILS
NTZ610
NOZ ILS
NOZ AR
NTZ610
NOZ AR
笔架山11
2344m
大圆山3
2257.0m
山顶12
2340m


NOZ AR
NTZ610
NOZ ILS

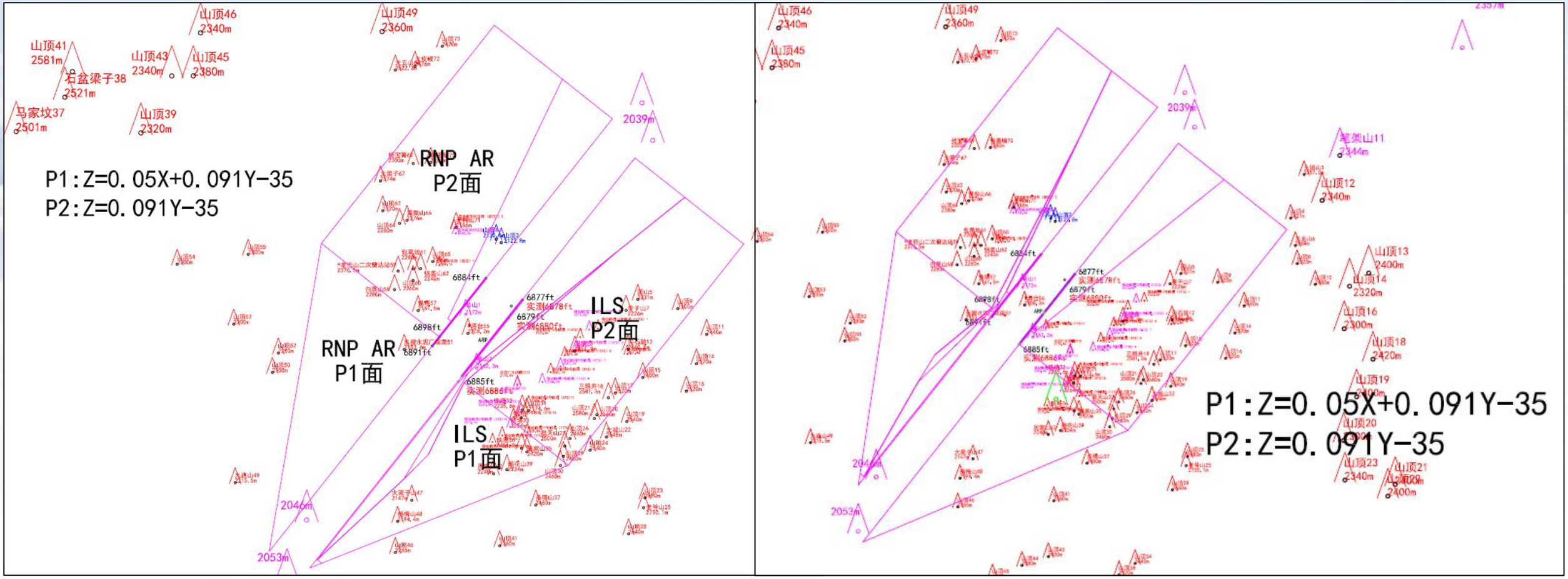
PAOAS

3.4.1 The obstacle elevation/height in the area to be considered shall be less than the PAOAS height as specified in 3.2, “Definition of surfaces,” above. Obstacles below the Z surface, or its extension, need not be considered. PAOAS penetrations shall be identified and considered for electronic mapping on controller displays.

3.4.2 If possible, obstacles should be removed. Where obstacle removal is not feasible, air traffic operational rules shall be established to avoid obstacles, and a risk assessment shall be required to provide guidance on whether independent simultaneous ILS/MLS/GLS operations to

PAOAS	A	B	C	B	C
P1	tanθ	0.091	-35	0.091	5
P2	0	0.091	-35	0.091	15
θ = Minimum VPA at the published minimum temperature				ngle or MLS elevation angle	

PAOAS



RWY03/04 ILS/RNP AR APCH PAOAS NO PENETRATION

Brief

01 **Designated Point**

APCH gate

Latest point

Hand-off

NTZ/NOZ

GAP

02

03 **PAOAS**

RNP AR APCH/ILS

TCAS

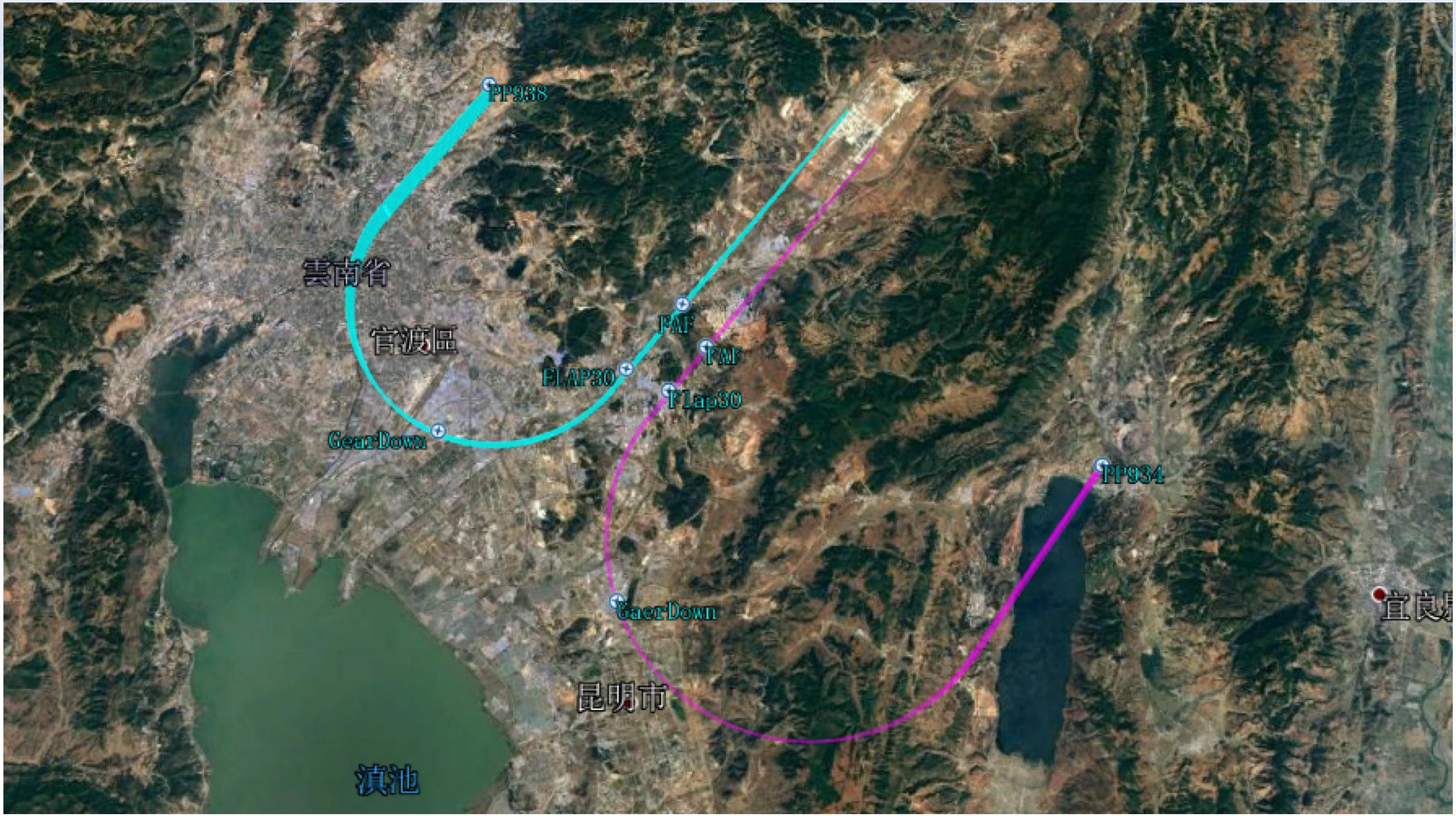
N/S

N/0.2

GS

04

FORCAST


PP938
雲南省
官渡區
FAF
FAF
FLAP30
Flap30
GearDown
PP934
GaerDown
昆明市
滇池

Thanks for listening