Design and Application of PBN Ander the Challenges

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BACKGROUND

- **1999-2002 Beijing Tower**
  Controller/Instructor
- **2002-2006 Beijing TMA**
  Controller/Instructor
- **2006-2019 Airspace Management Center Of ATMB**
  Engineer /Deputy Director/Director
- **2019.2 - ICAO APAC RSO**
  Deputy Chief of RSO (Manager of APAC FPP)

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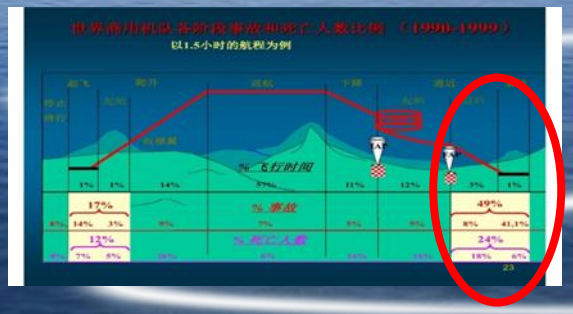
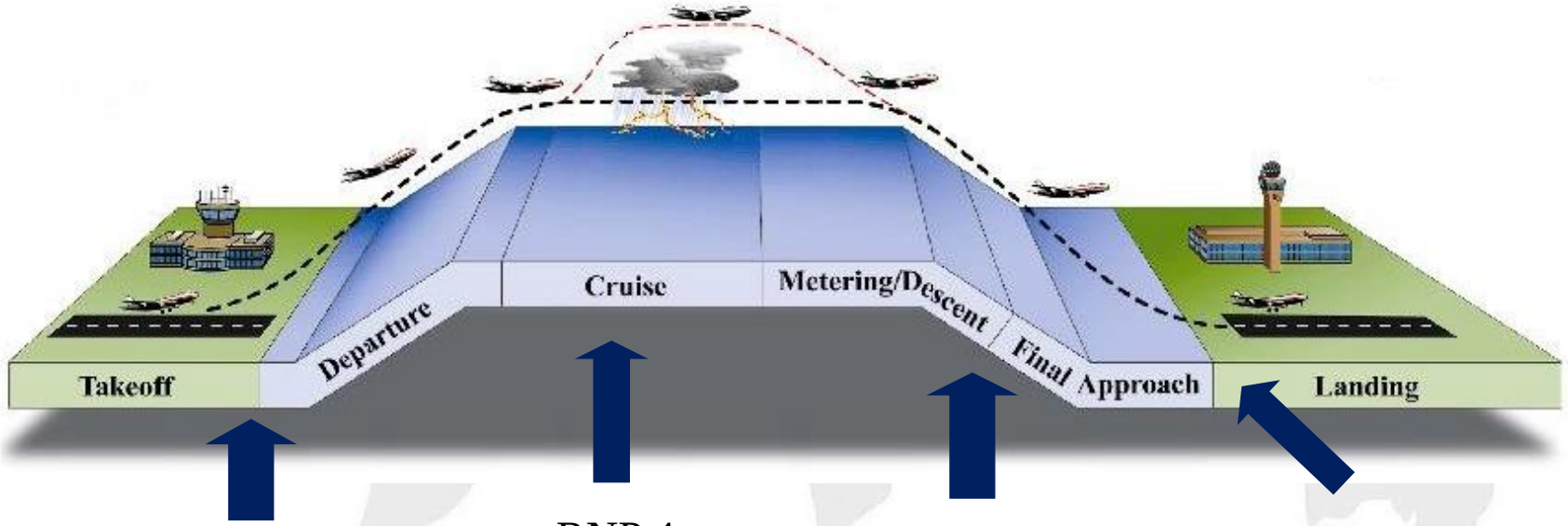
CONTENTS

- **CHALLENGE**
  - Airspace
  - Terrain
  - Weather
  - Emergency
  - Capacity
  - Efficiency
  - Humanity factor
- **ANALYSIS**
  - Why/ How/Where/When to use ?
- **SOLUTION**
  - RNAV(MVA/Visual APP/ communication failure etc.)
  - HUD
  - RNP-AR
  - CCO/CDO



PBN CONCEPT

But How/Where/When/What to use in real case?



RNP 1/RNAV1 SIDs

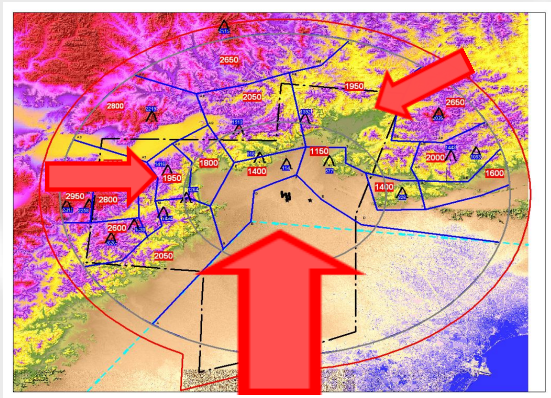
RNP 4
RNP 2

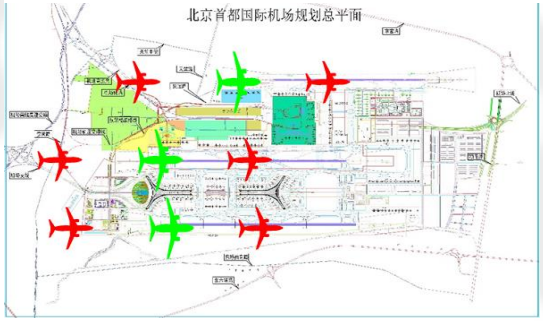
RNP 1/RNAV 1 STARs

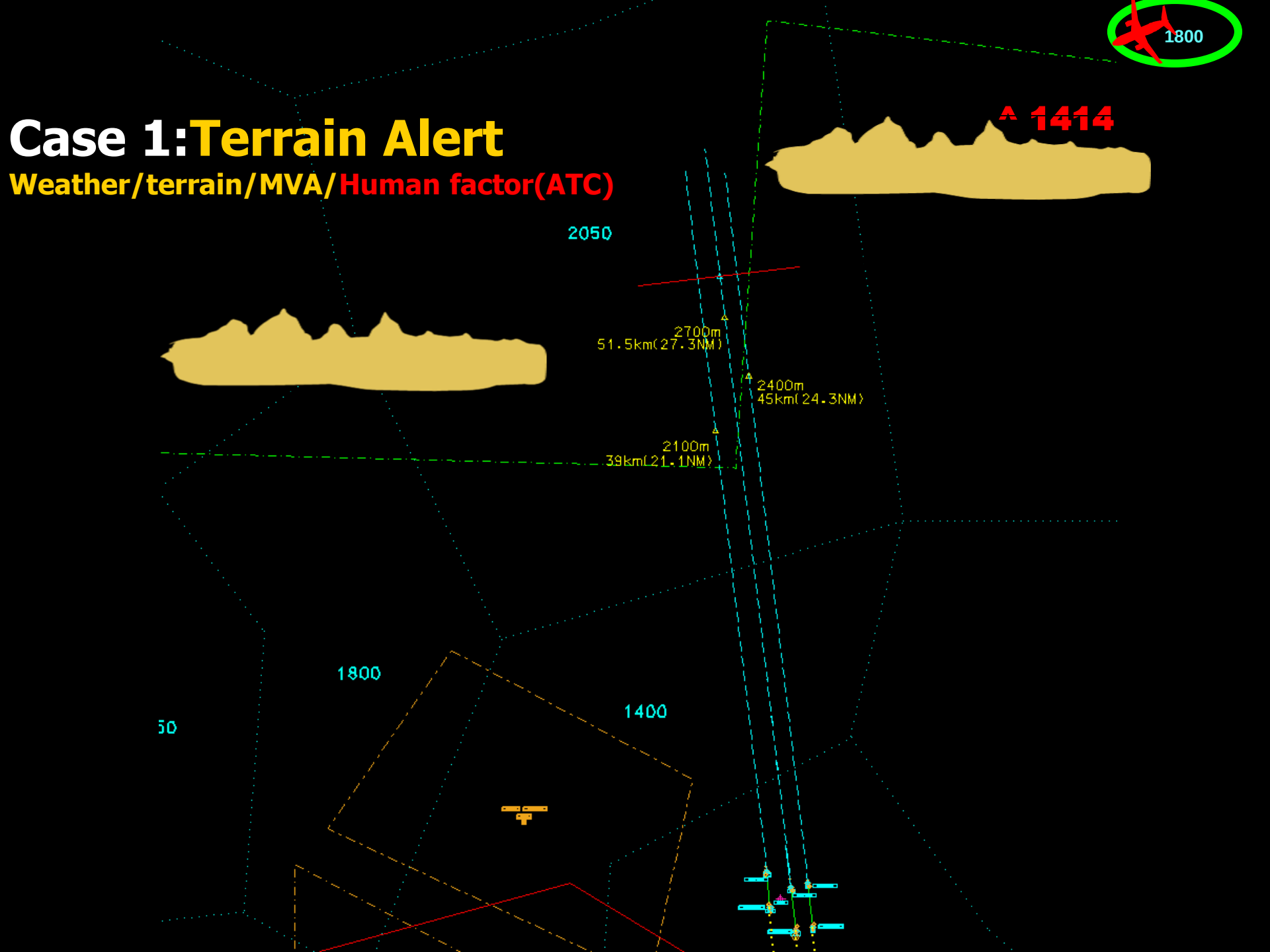
RNP APCH
or
RNP AR APCH

CHALLENGES

- **Humanity**
  - **Terrain Alert**
  - **Communication Failure**
- **Nature**
  - **Weather**
  - **Interception upon the GP**
- **Develop**
  - **Capacity improving**
  - **Airspace restriction**
  - **Efficiency requirement**





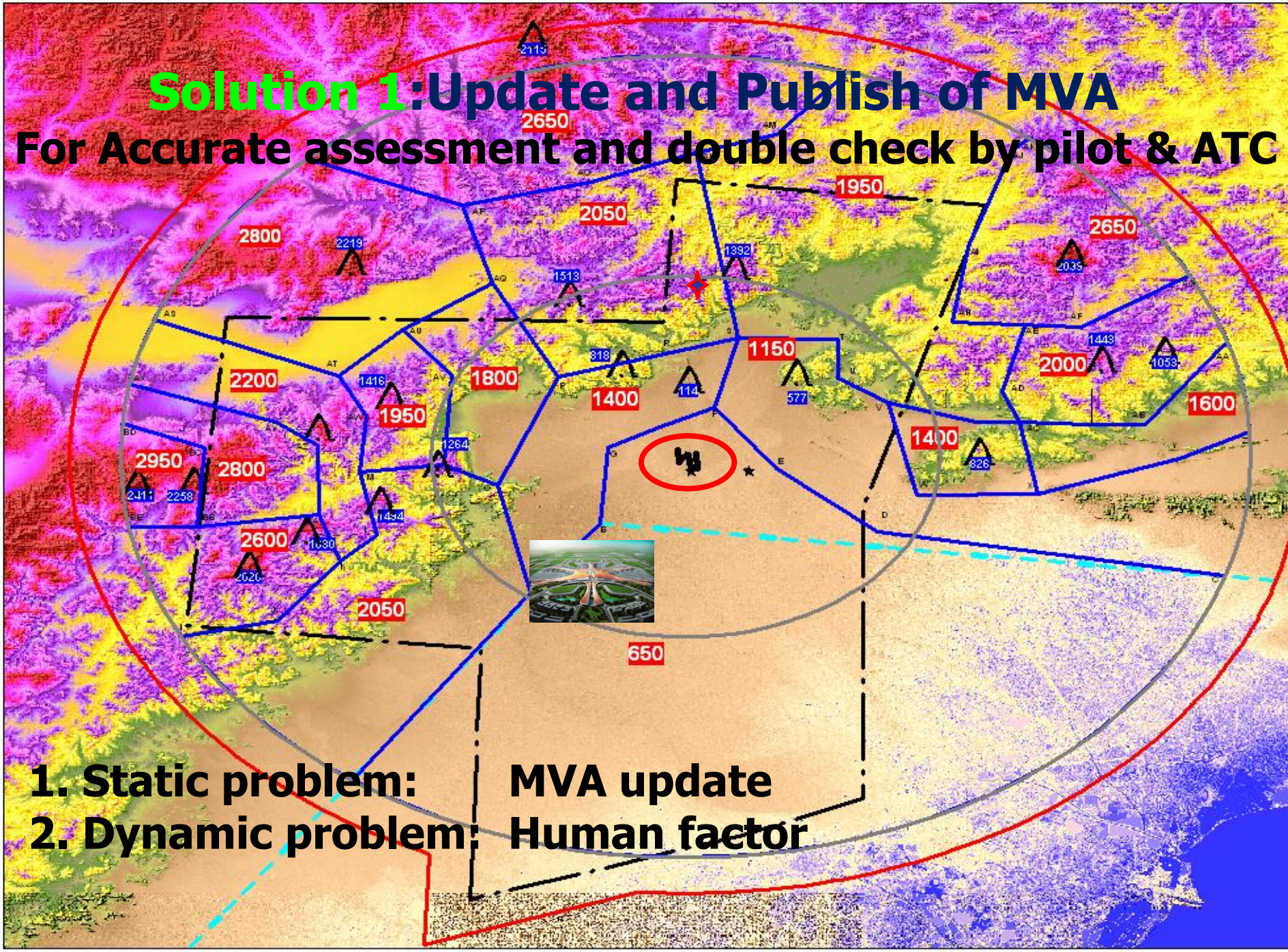


Case 1:Terrain Alert

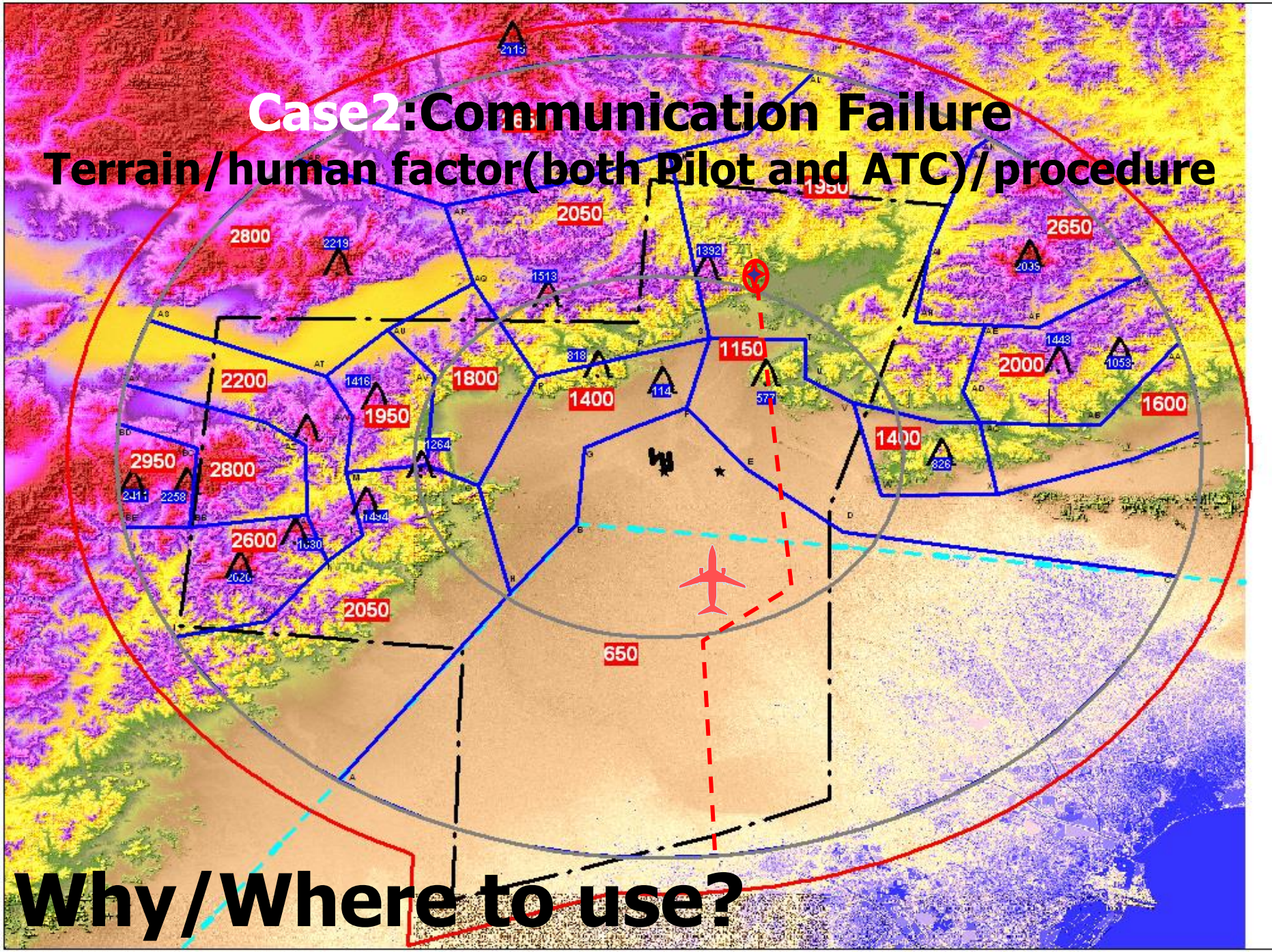
Weather/terrain/MVA/Human factor(ATC)

Solution 1:Update and Publish of MVA

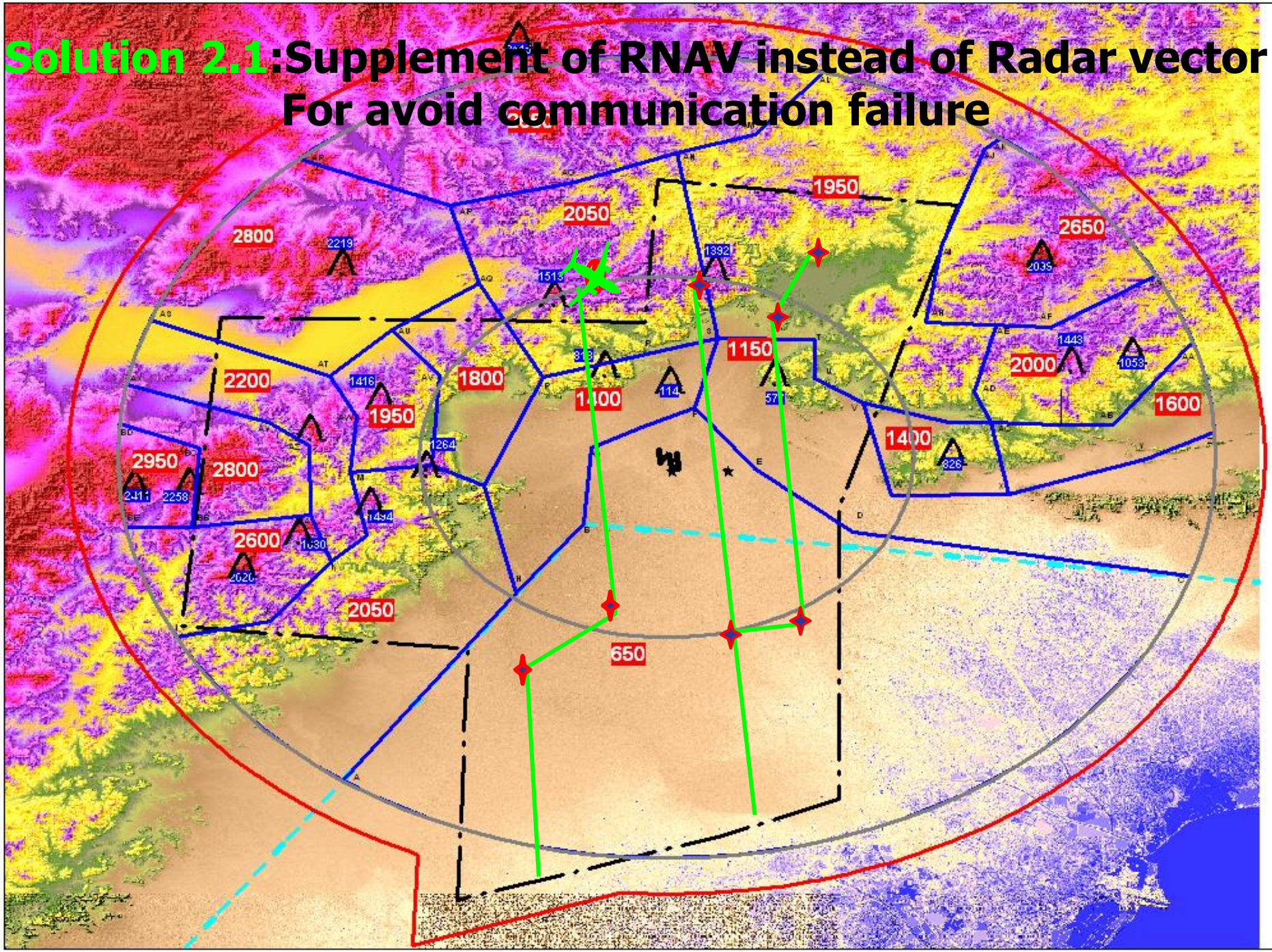
For Accurate assessment and double check by pilot & ATC



1. Static problem: MVA update
2. Dynamic problem: Human factor


Case2:Communication Failure
Terrain/human factor(both Pilot and ATC)/procedure
2800
2050
2650
2200
1800
1400
1150
2000
1600
1950
2950
2800
1400
2600
2050
650
Why/Where to use?

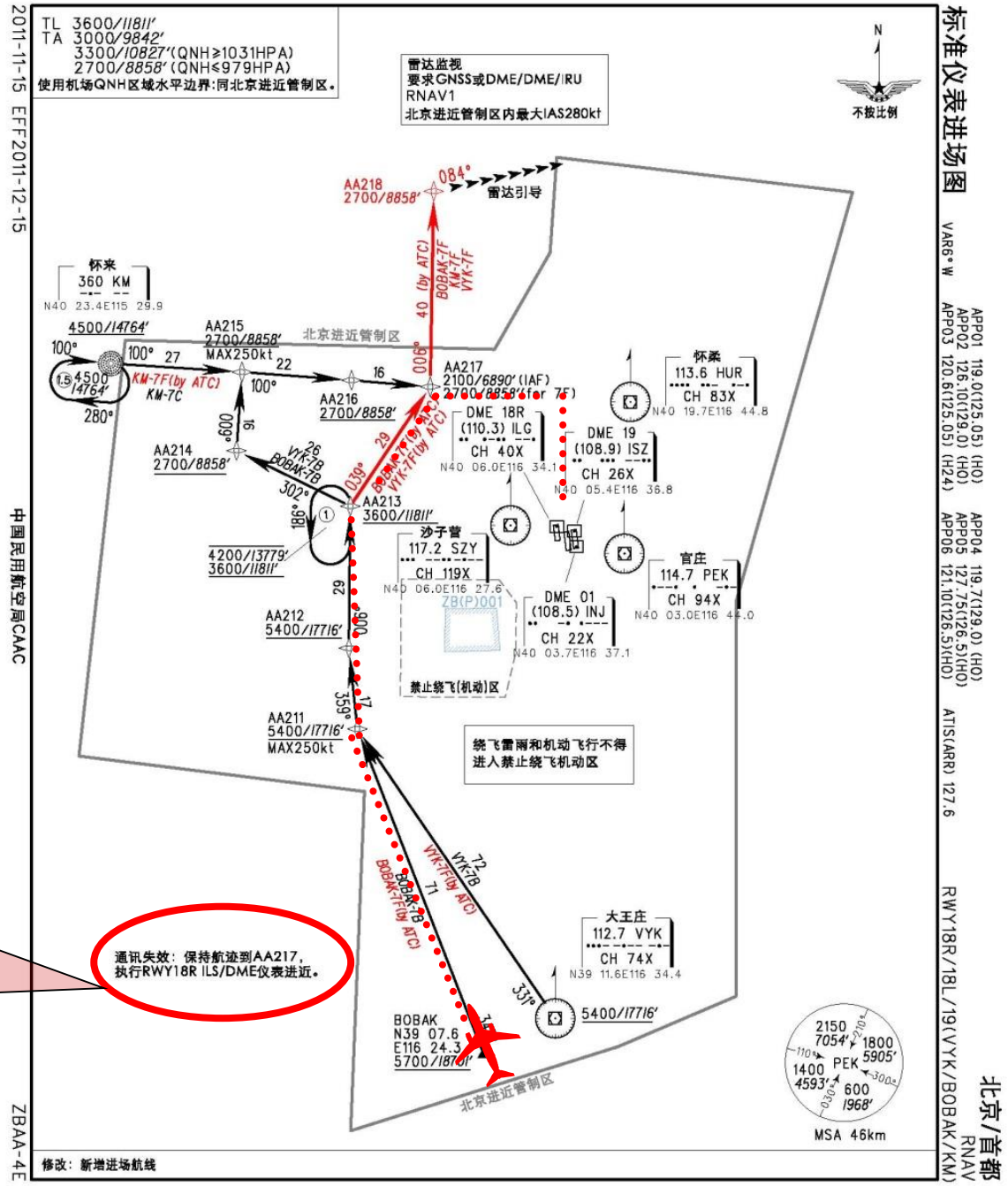
Solution 2.1:Supplement of RNAV instead of Radar vector For avoid communication failure



Solution 2.2:

A. Combination of Communication Failure procedure and RNAV-1

B. make ATC like PBN than RV(How?)

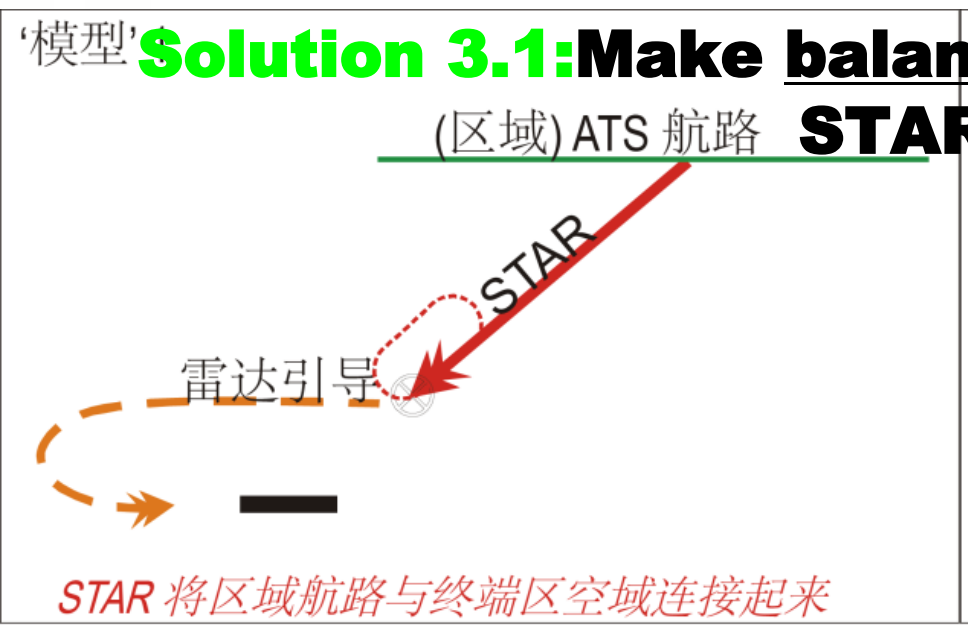


In case communication failure, follow STAR till AA217,then clear for RWY18R ILS/DME Approach.

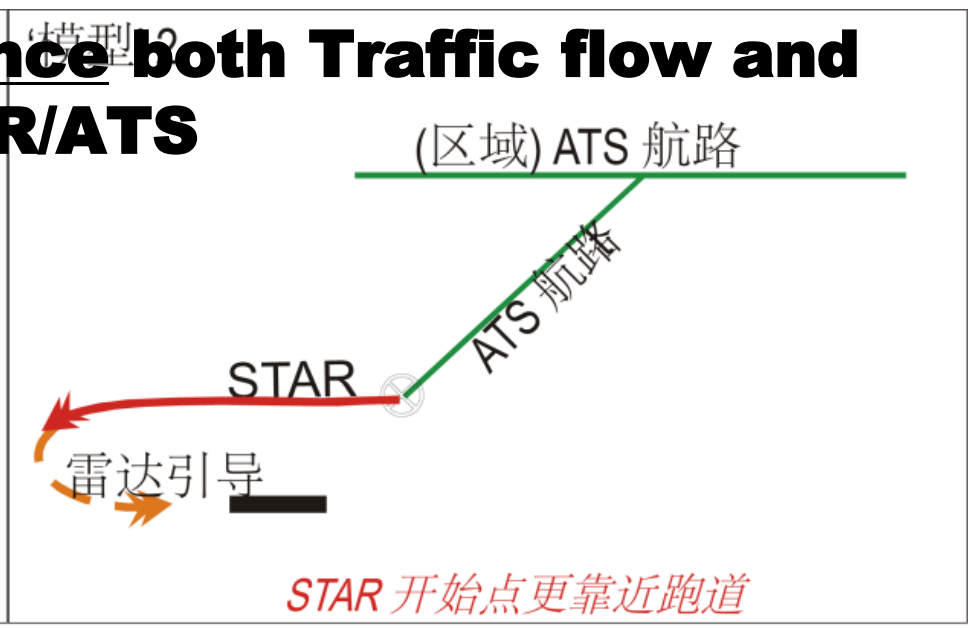
Case3:Capacity improving requirement

capacity/airspace/terrain/human factors

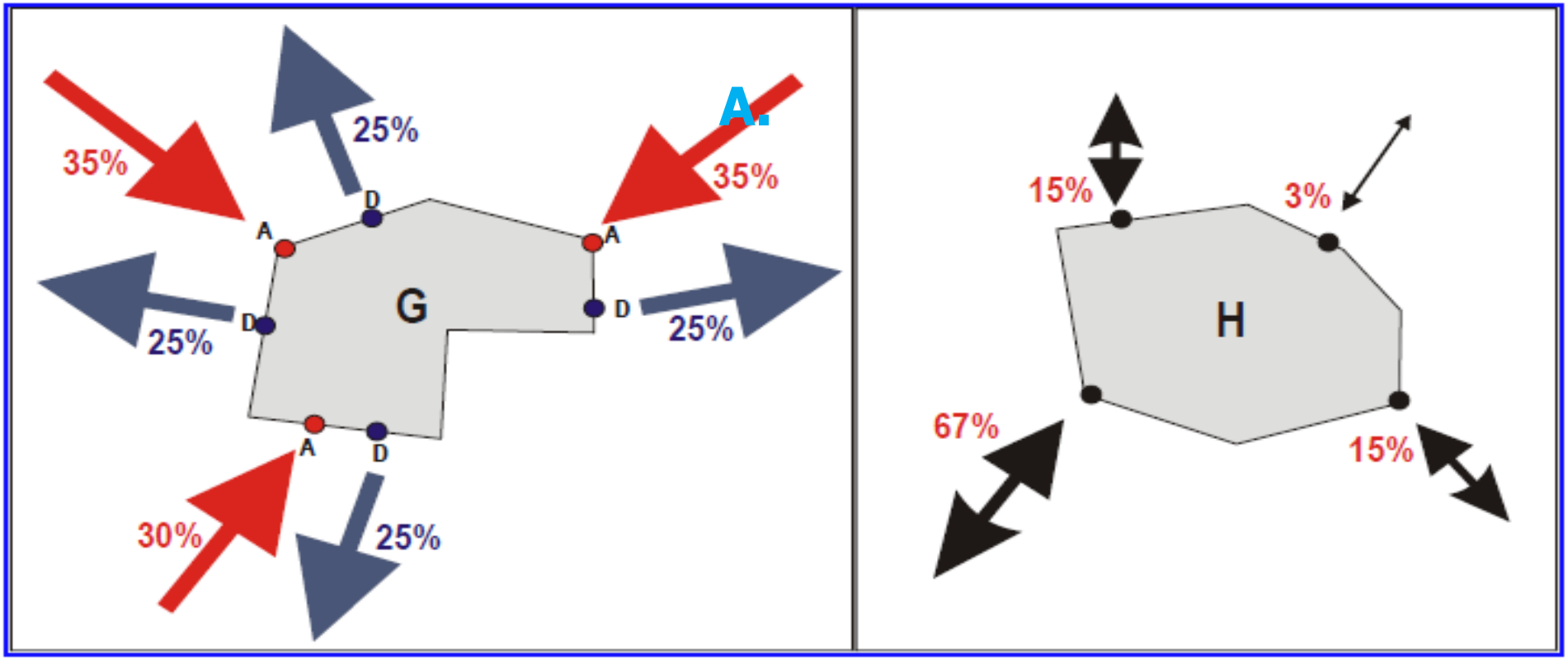
Solution 3.1: Make balance both Traffic flow and STAR/ATS



STAR 将区域航路与终端区空域连接起来

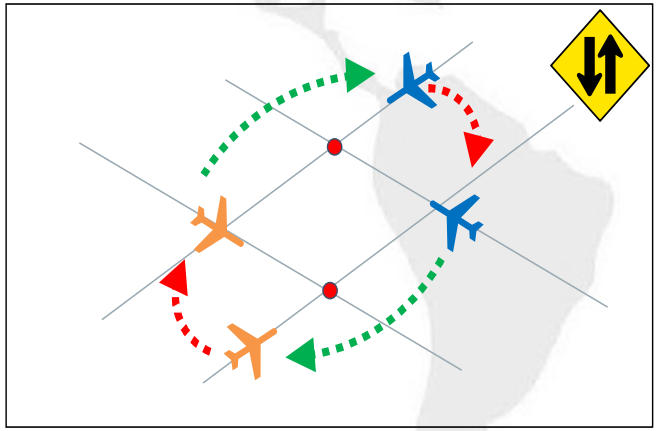


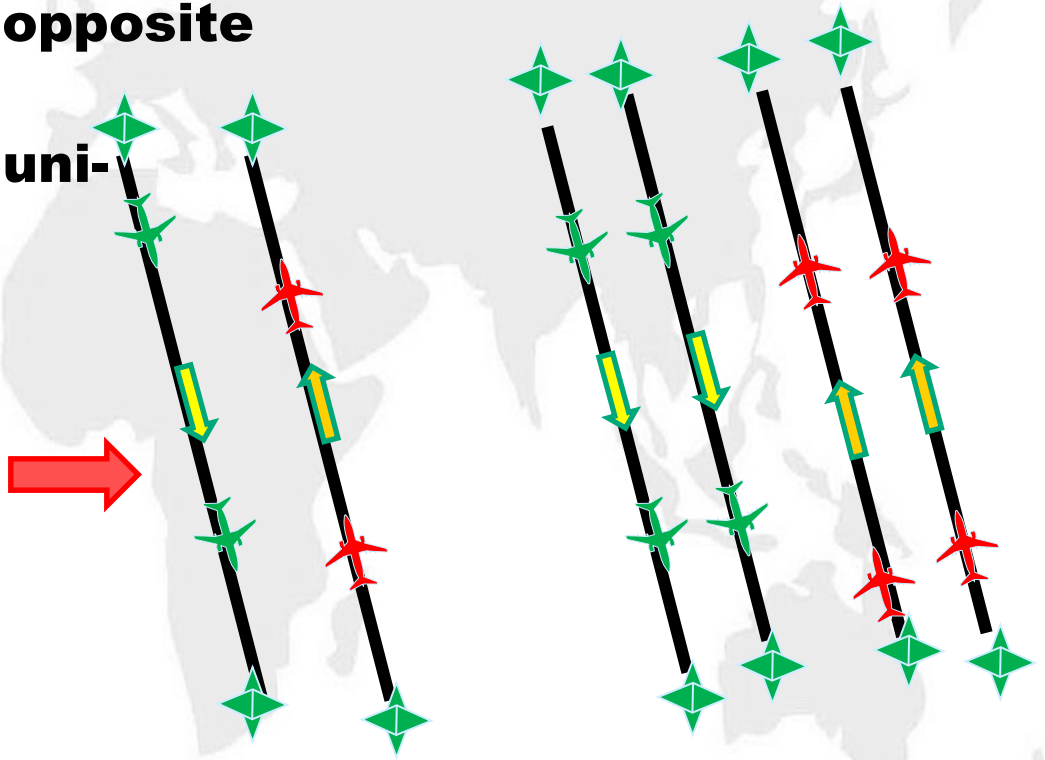
STAR 开始点更靠近跑道



Solution 3.2:Make Plan parallel routes according to traffic flow

- paralleled routes with opposite -direction
- paralleled routes with uni-direction

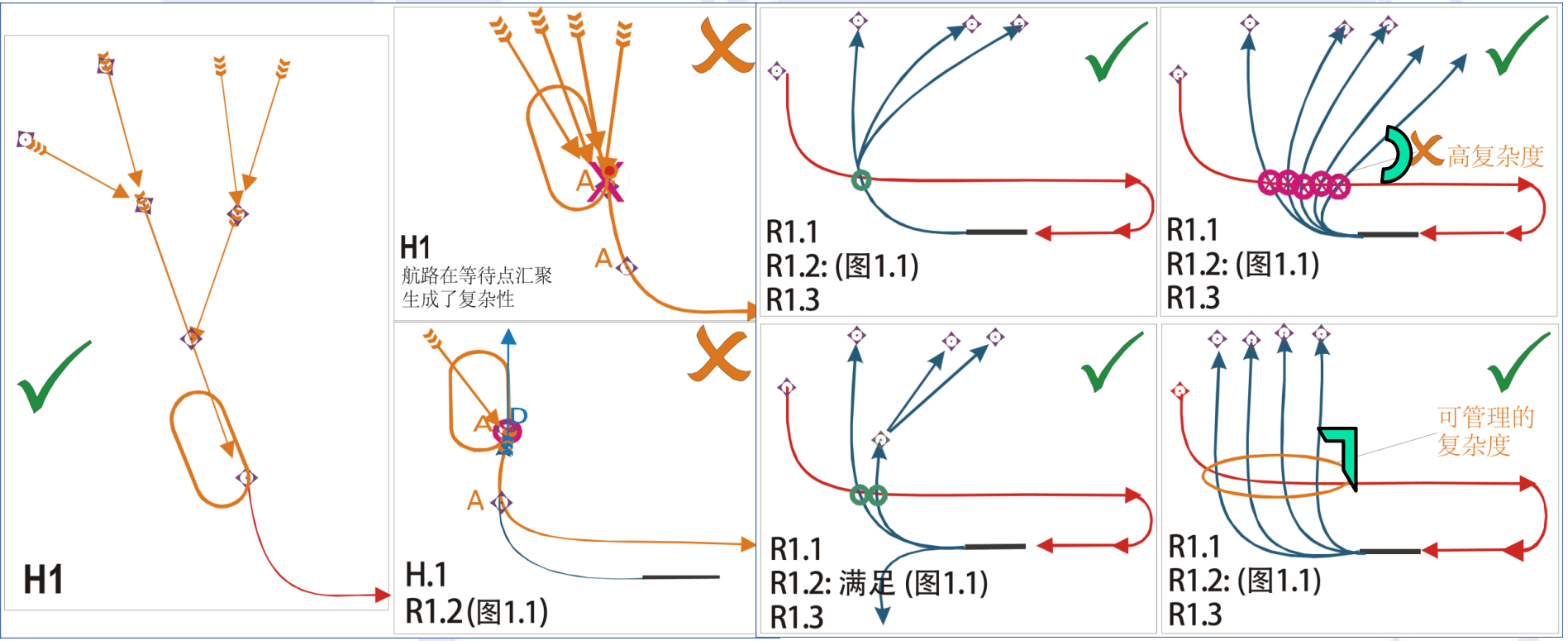




opposite -direction

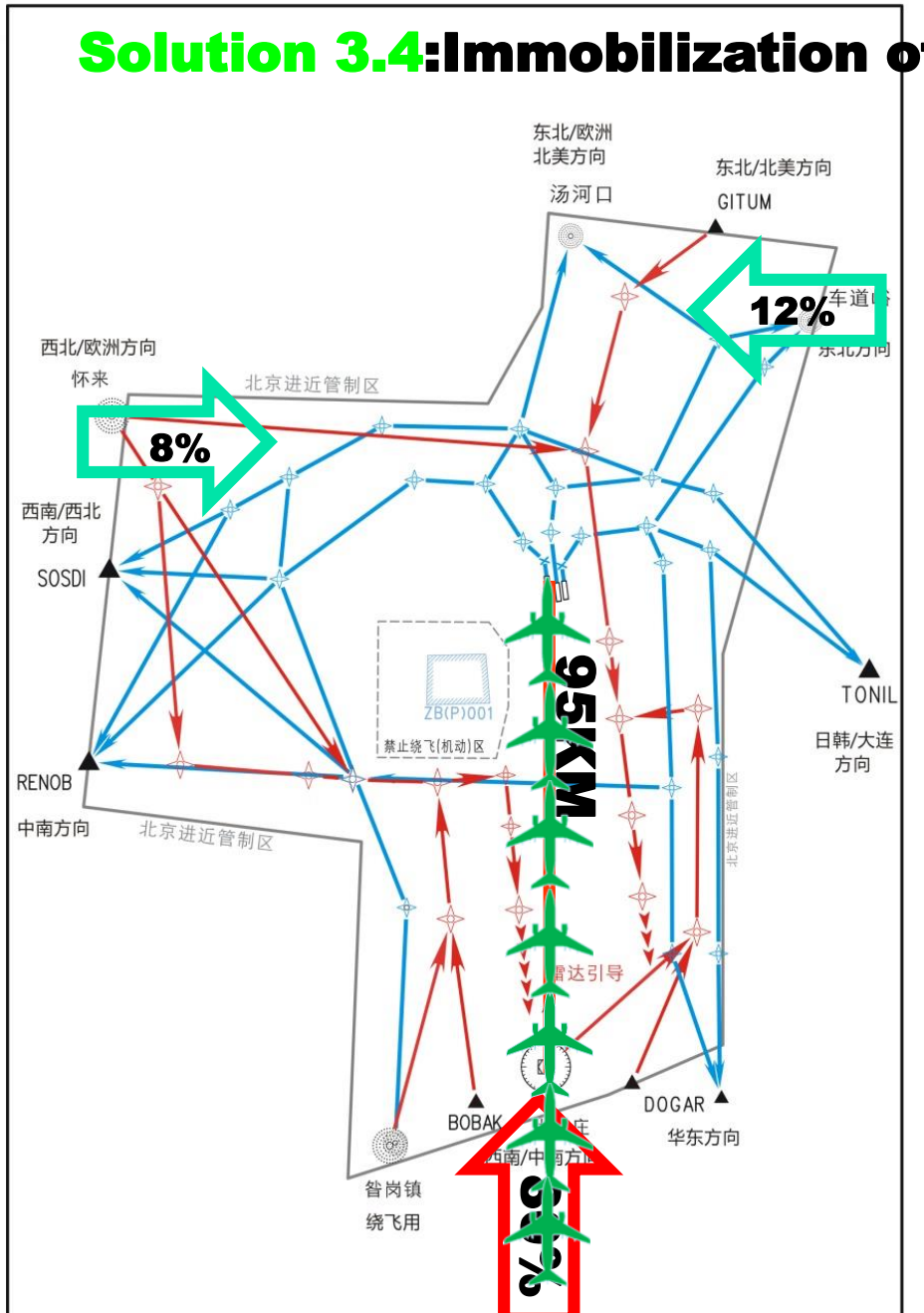
uni-direction

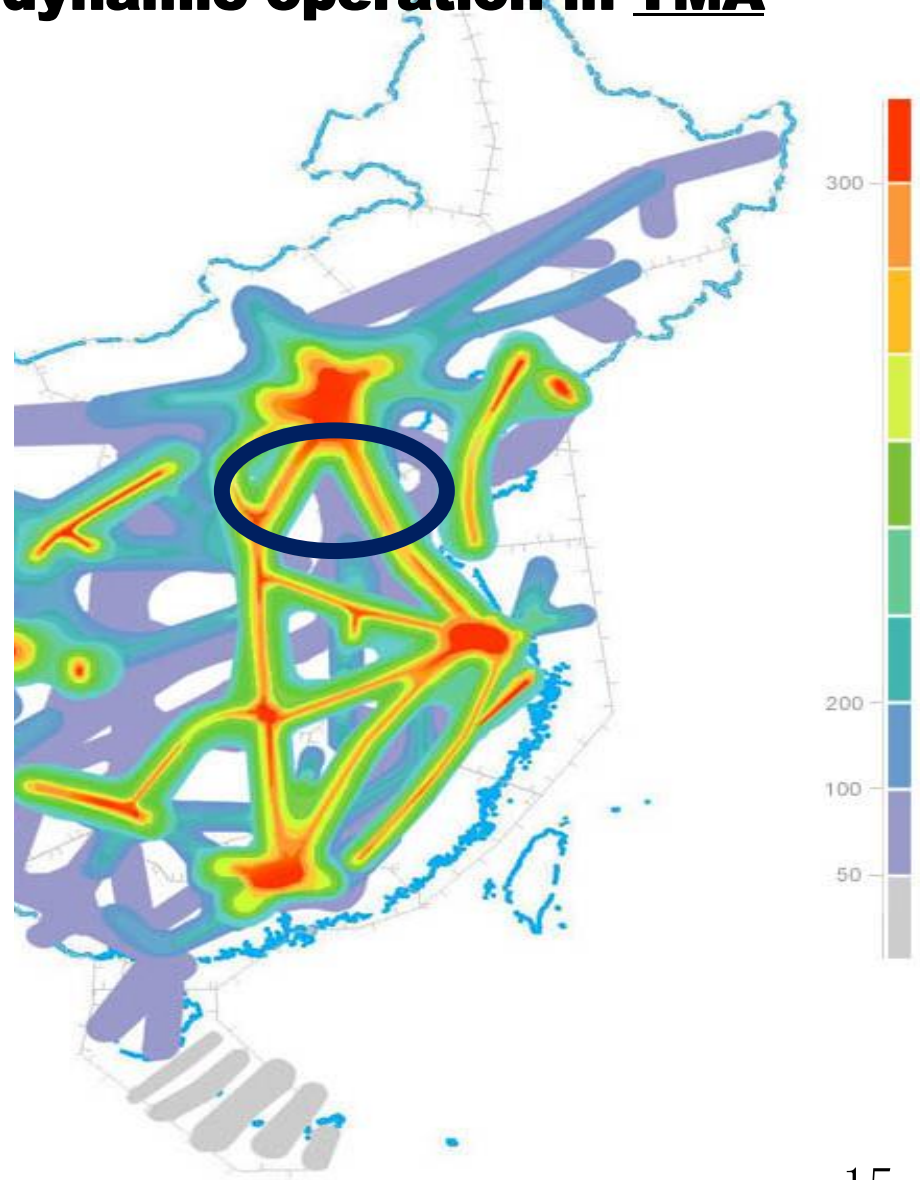
Solution 3.3: Convergence and divergence of intersections

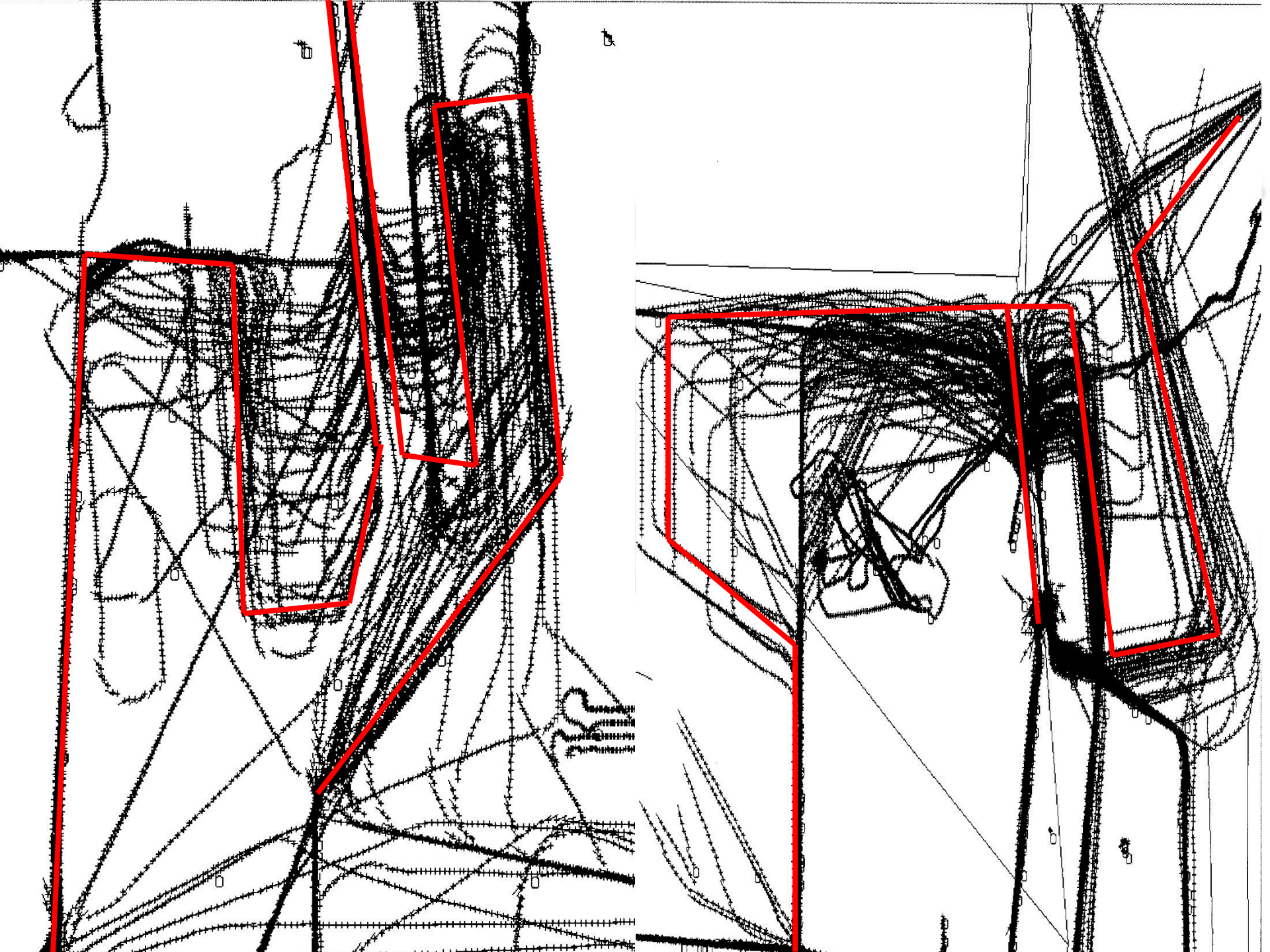


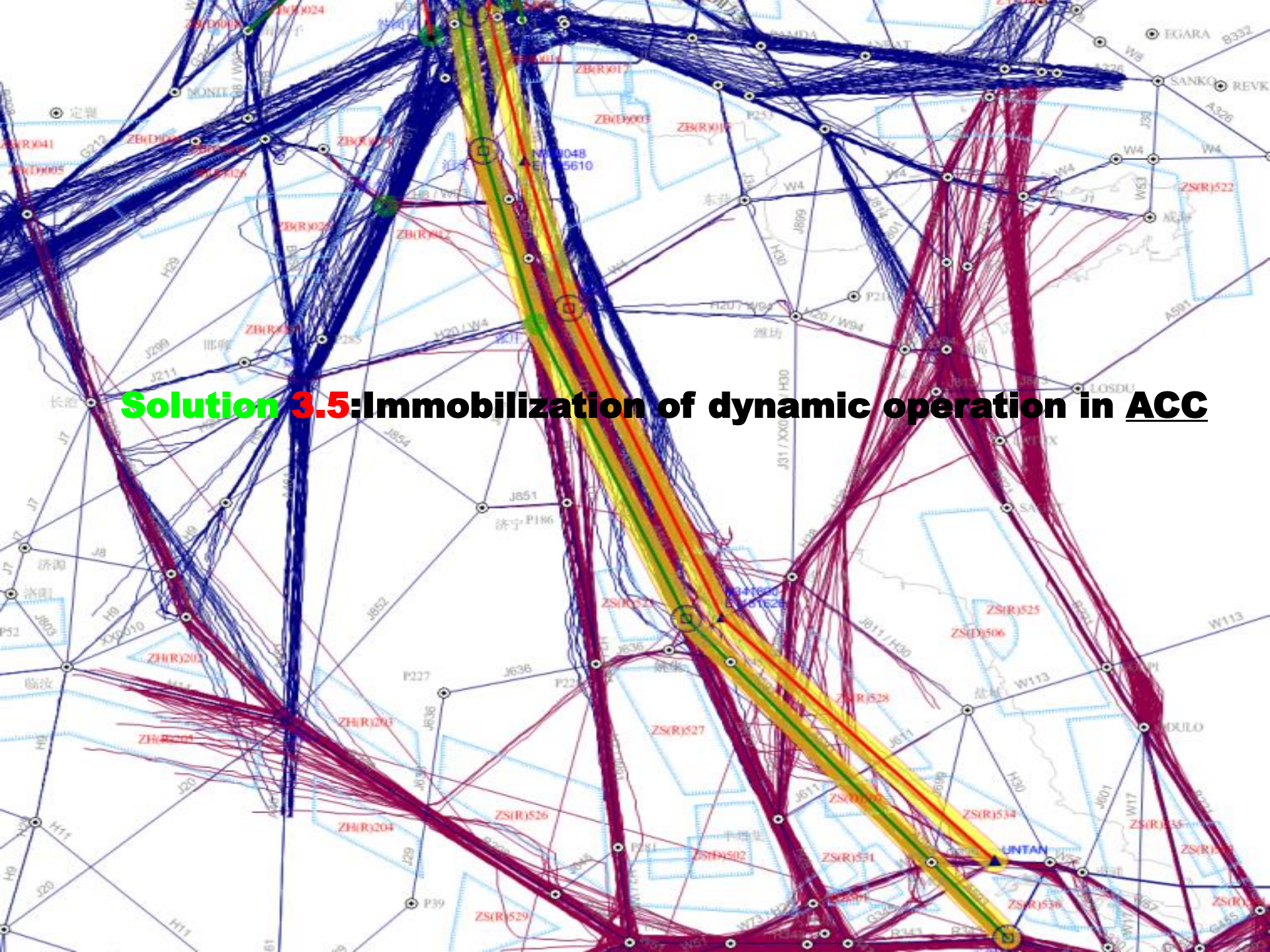
北京 首都
RNAV
RWY36L/36R/01

Solution 3.4:Immobilization of dynamic operation in TMA

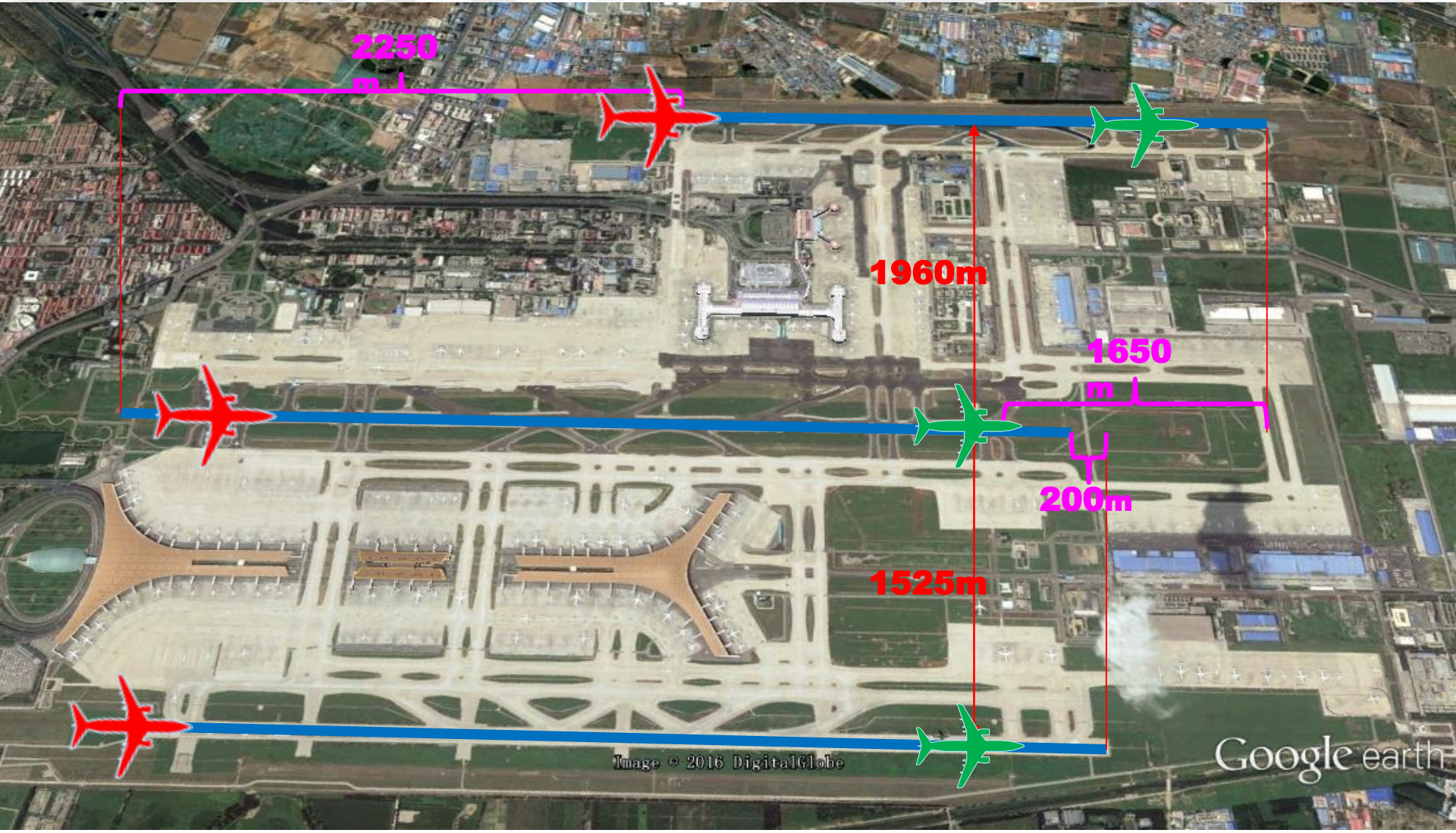




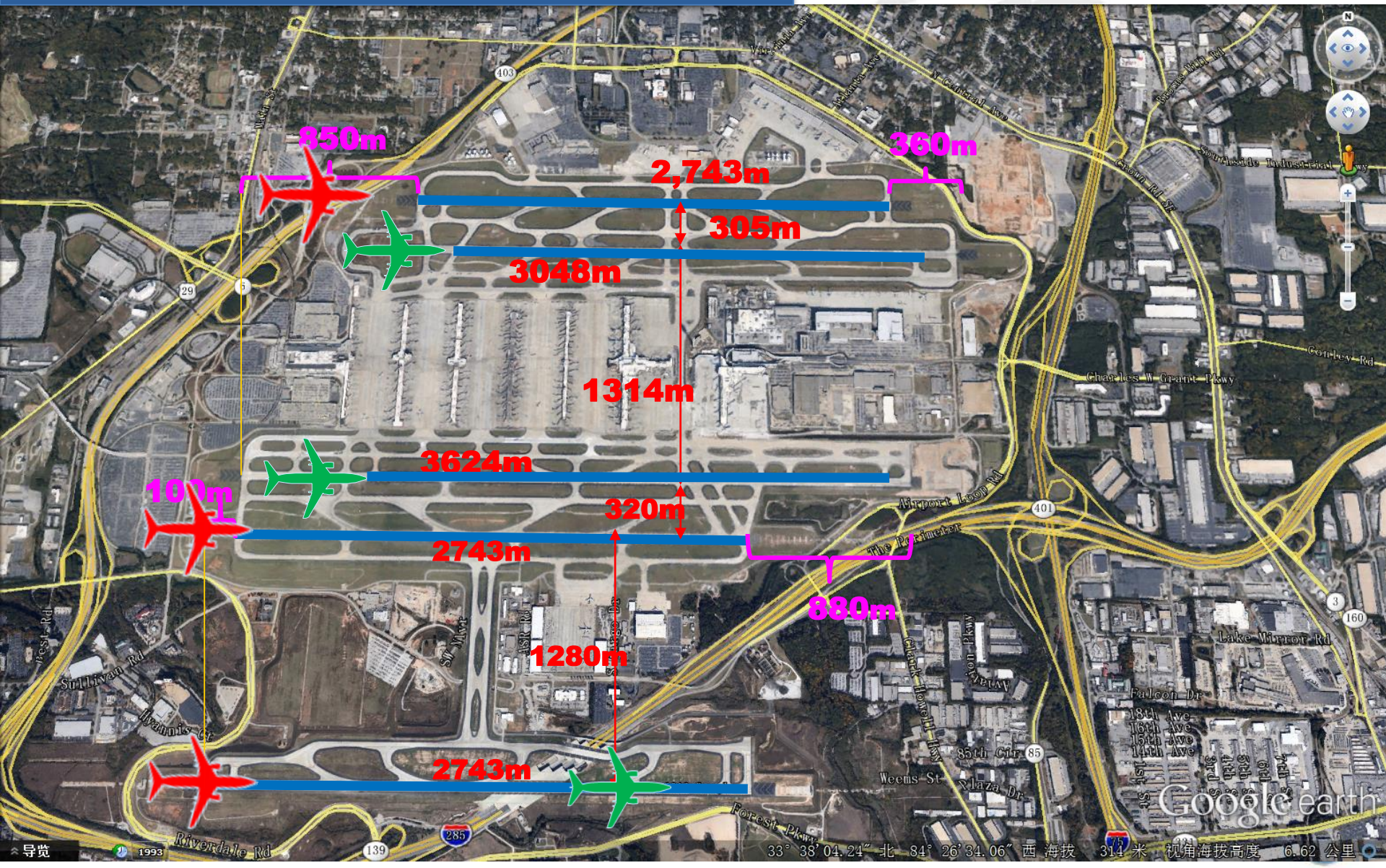



Solution 3.5:Immobilization of dynamic operation in ACC

Beijing capital airport

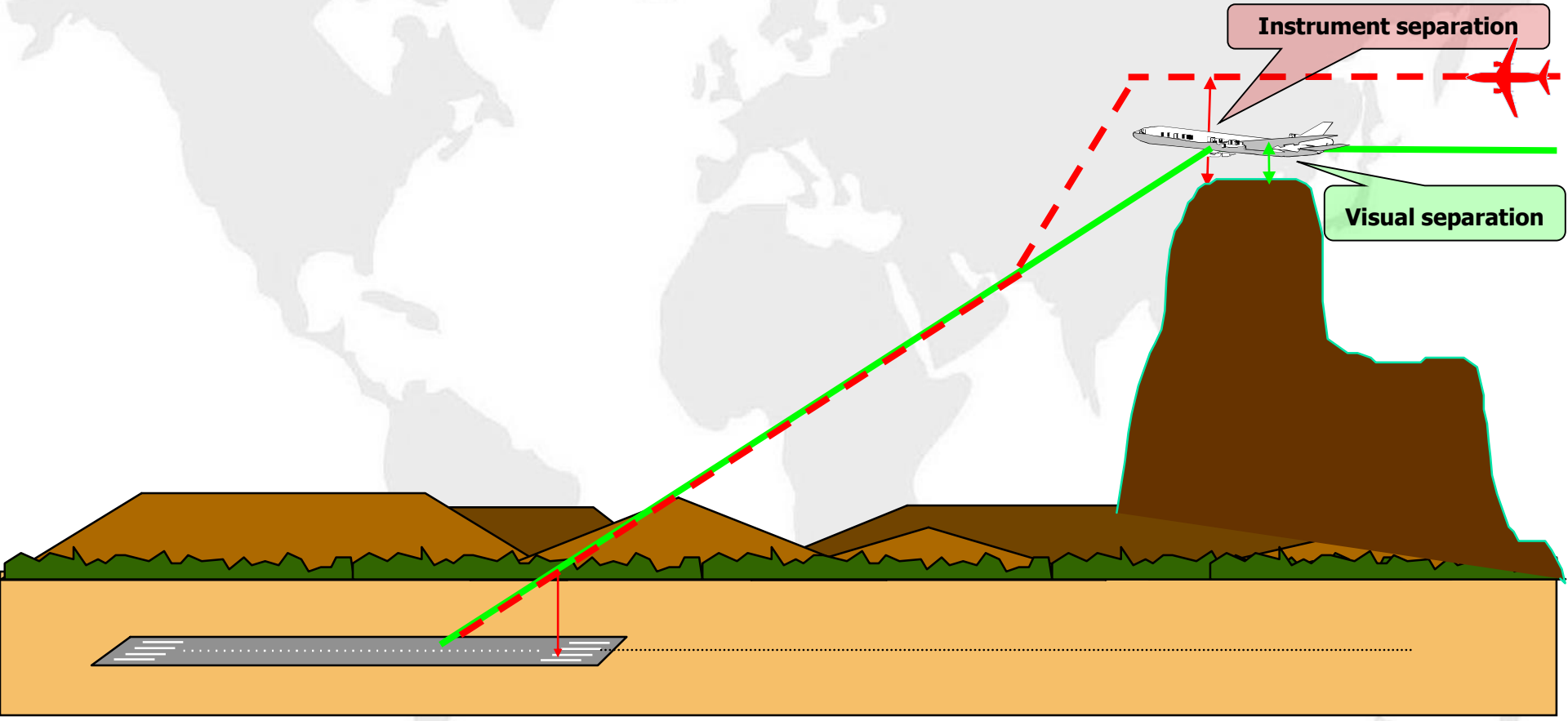


Atlanta Hartsfield Jackson airport

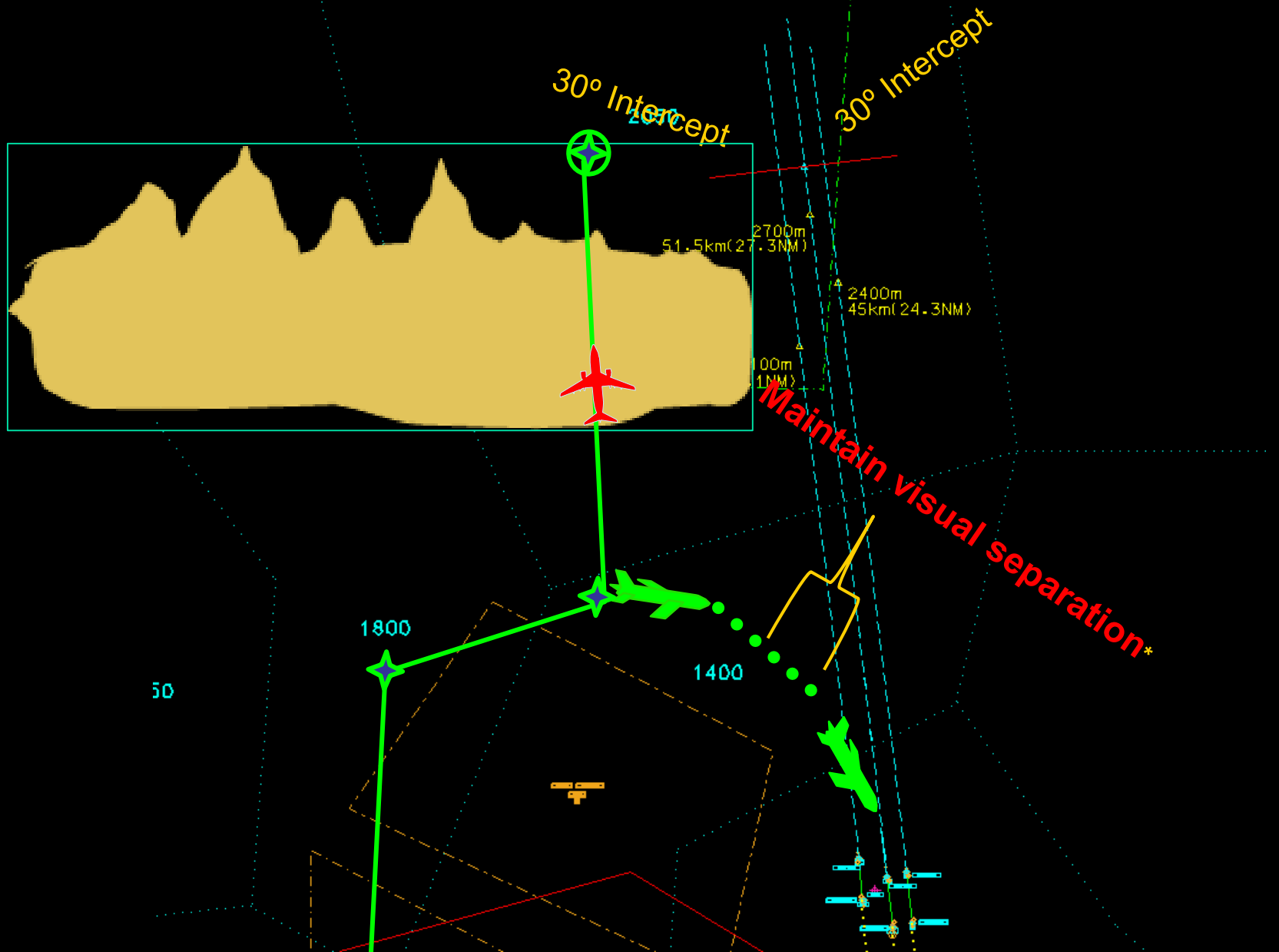


Case 4:interception upon the GP due terrain

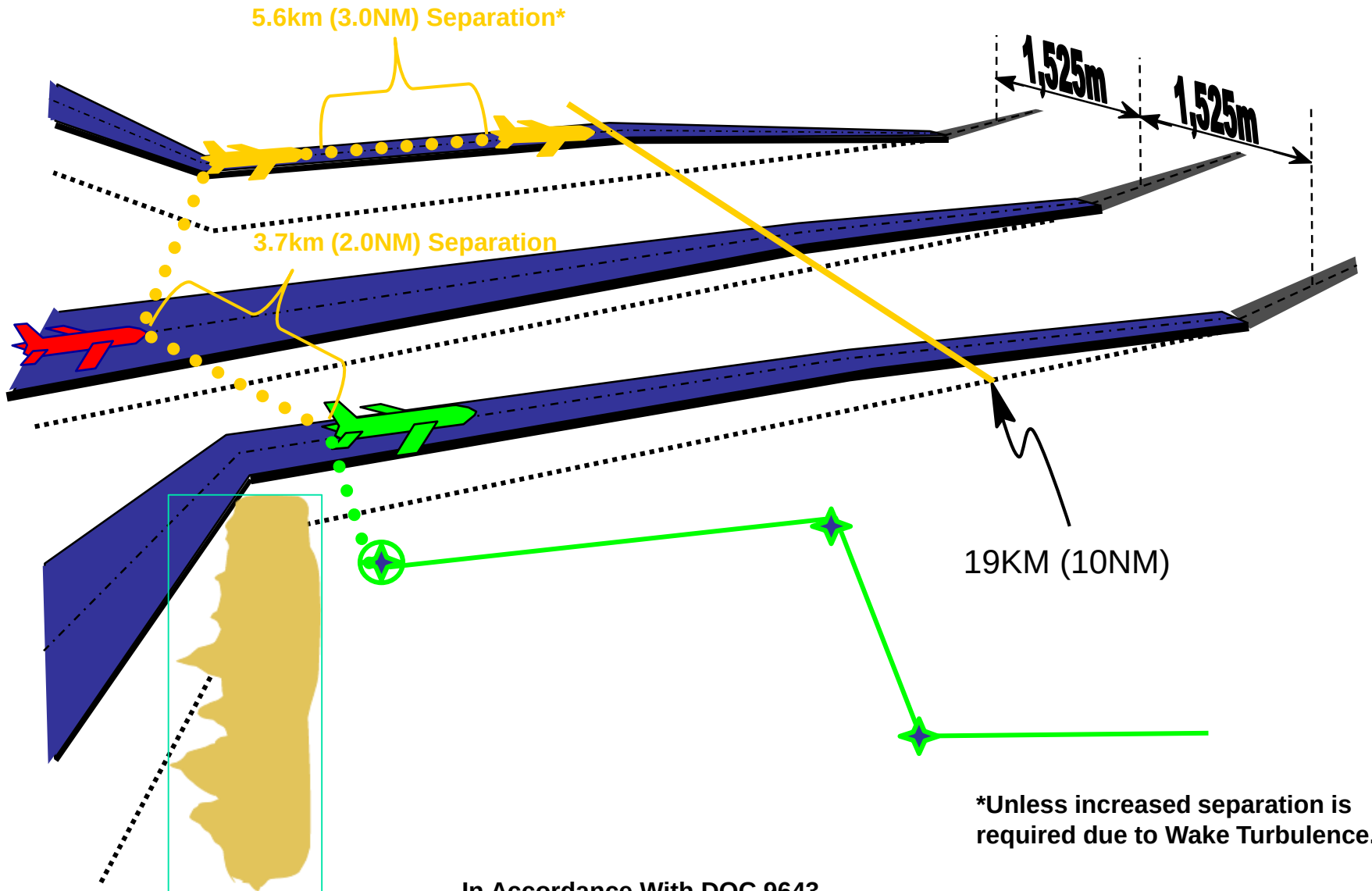
Terrain/procedure/human factor



Solution 4: Combine PBN and Visual APP



Solution 4: Combine PBN and Visual APP in Parallel Runways



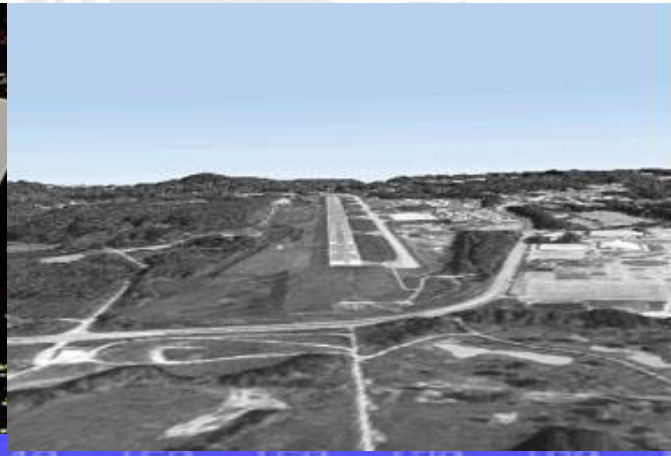
*Unless increased separation is required due to Wake Turbulence.

In Accordance With DOC 9643

Case 5:haze affects Visual APP sometimes in Winter

weather/terrain/efficiency/capacity

Solution 5.1: HUD operation(RVR 90m take off/RVR175 IIIA landing)

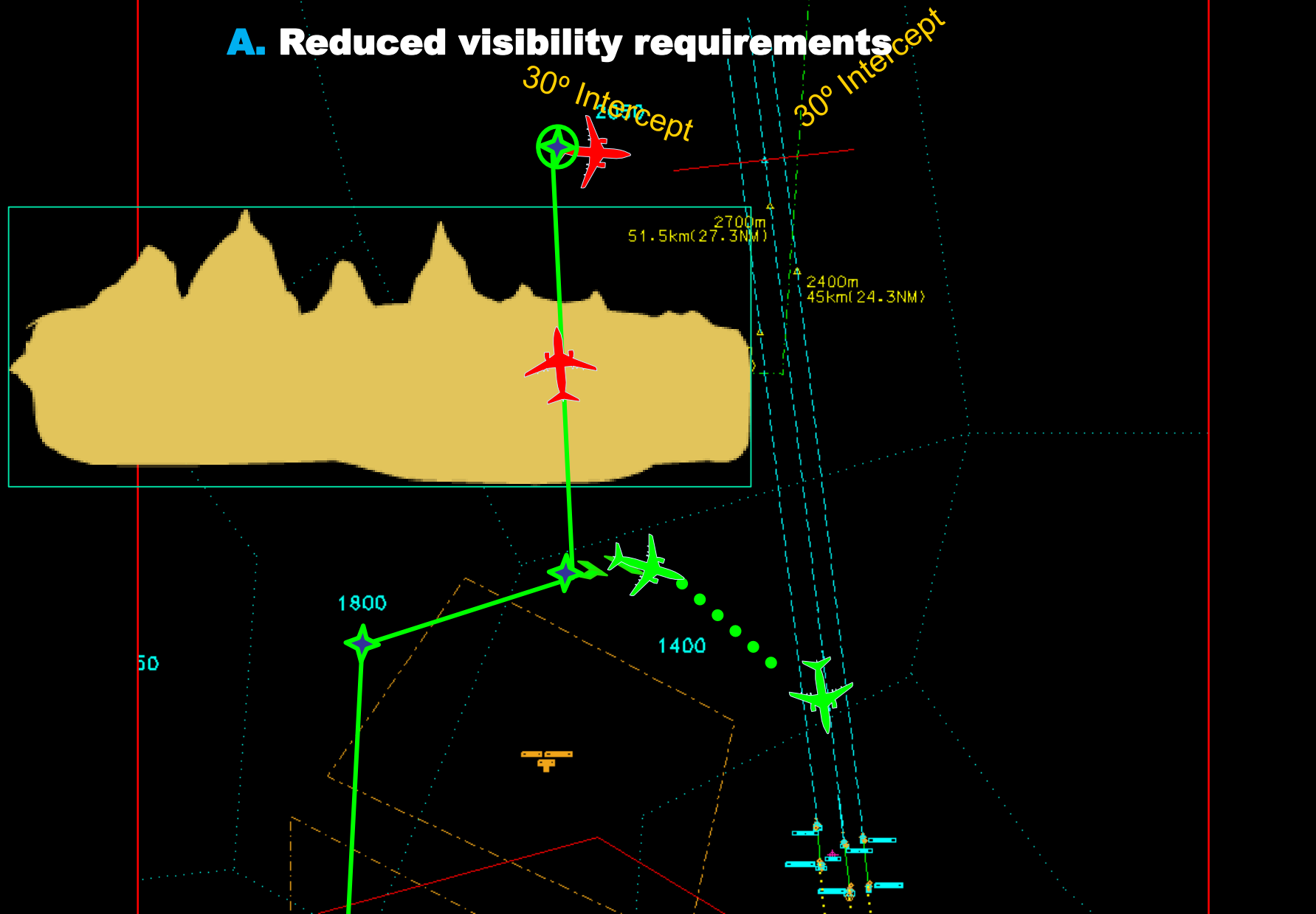


HUD +Far-infrared imaging= EFVS

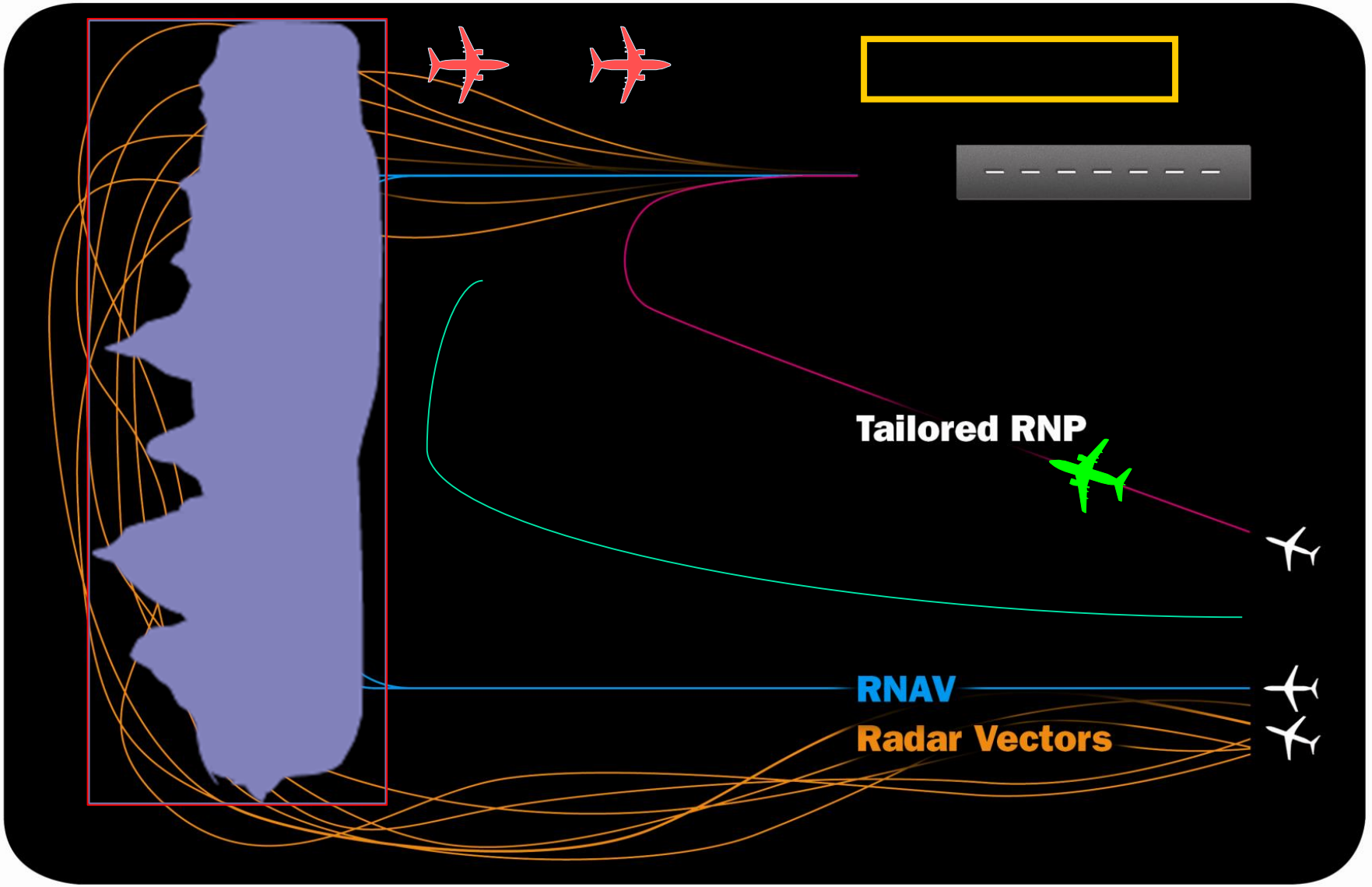
Terrain database + virtual view=SVS

Solution 5.2:Supplement Published RNP-AR（soon）

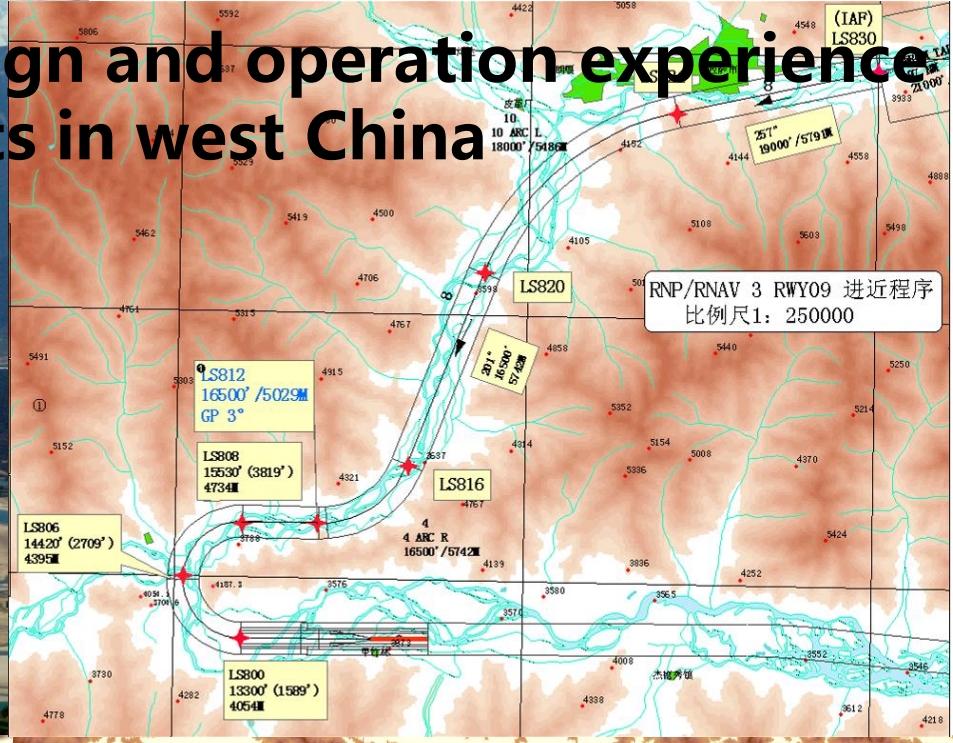
A. Reduced visibility requirements

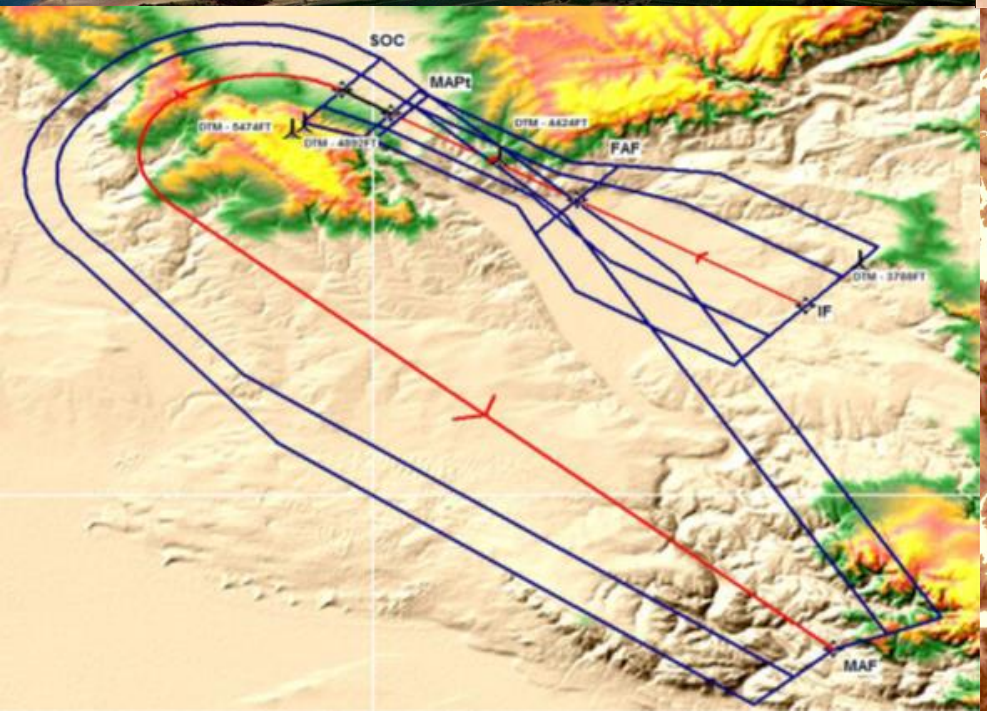


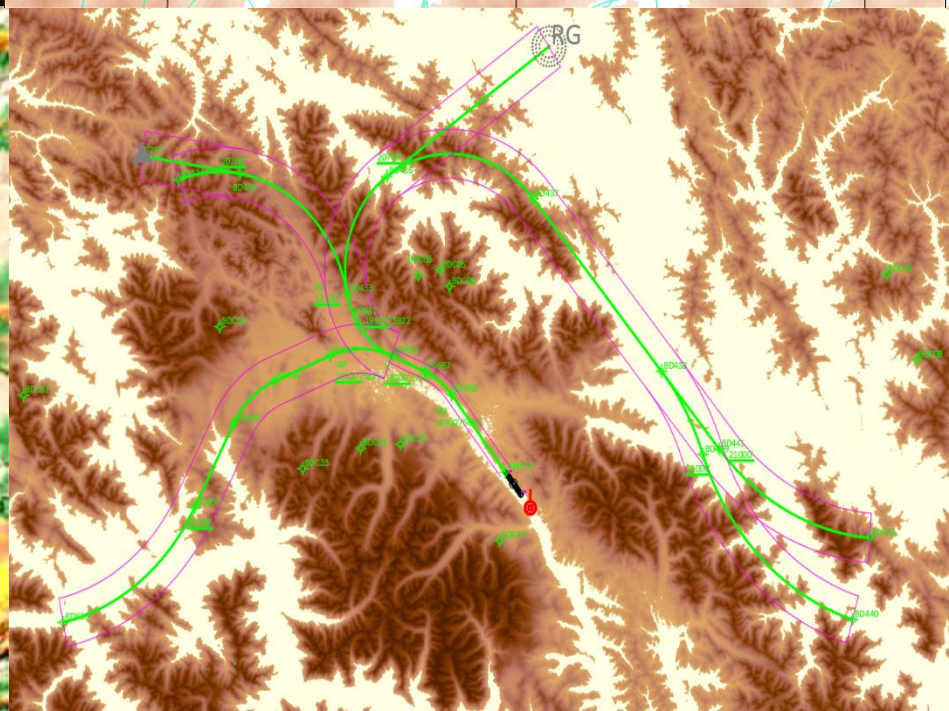
B. Shorten the final to avoid the terrain



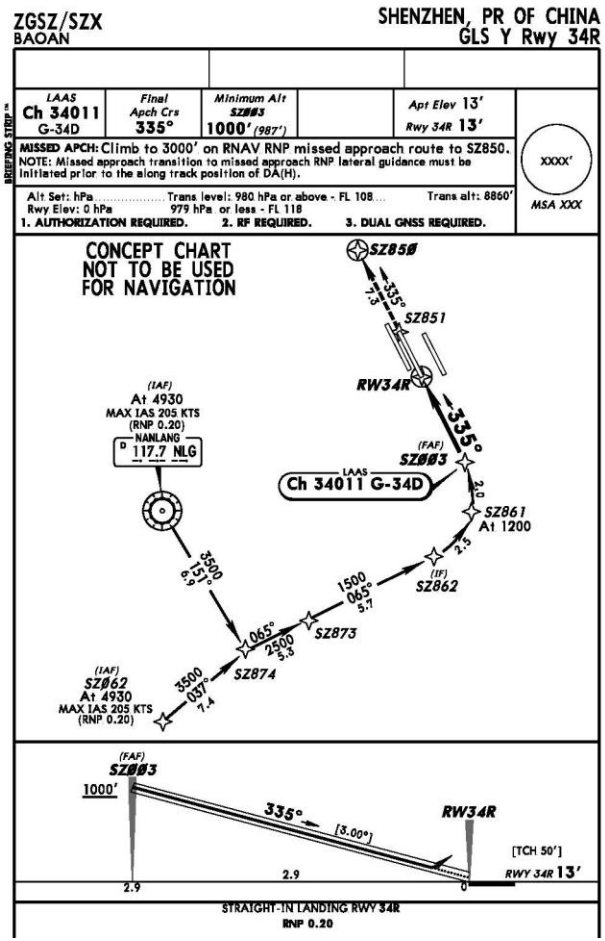
C:Draw lessons from the design and operation experience of small airports in west China



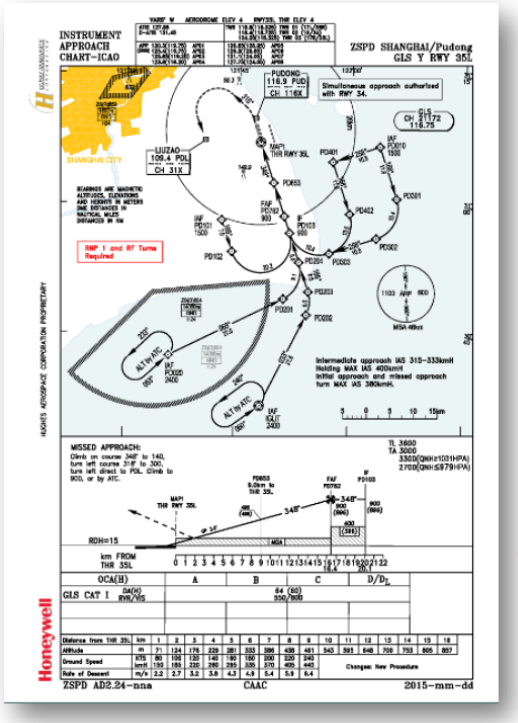




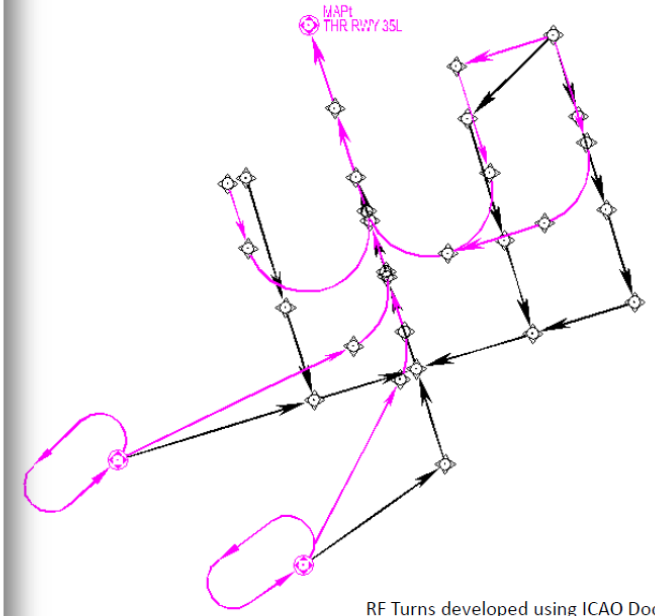
D:Draw lessons from the design and operation experience of big airports



RWY 35L GLS CURVED PATH (RF) DEVELOPMENT



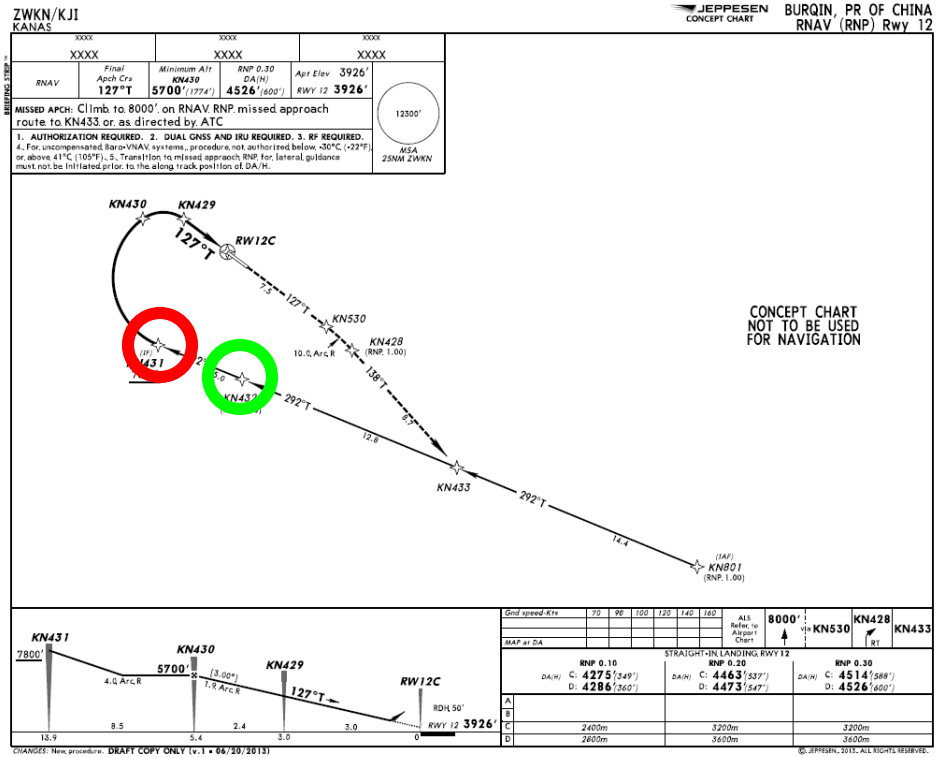
GLS Z vs GLS Y RWY 35L



RF Turns developed using ICAO Doc 8168, Vol II, Part III, Section 2, Chapter 2, Article 2.4, RF Turn Method.

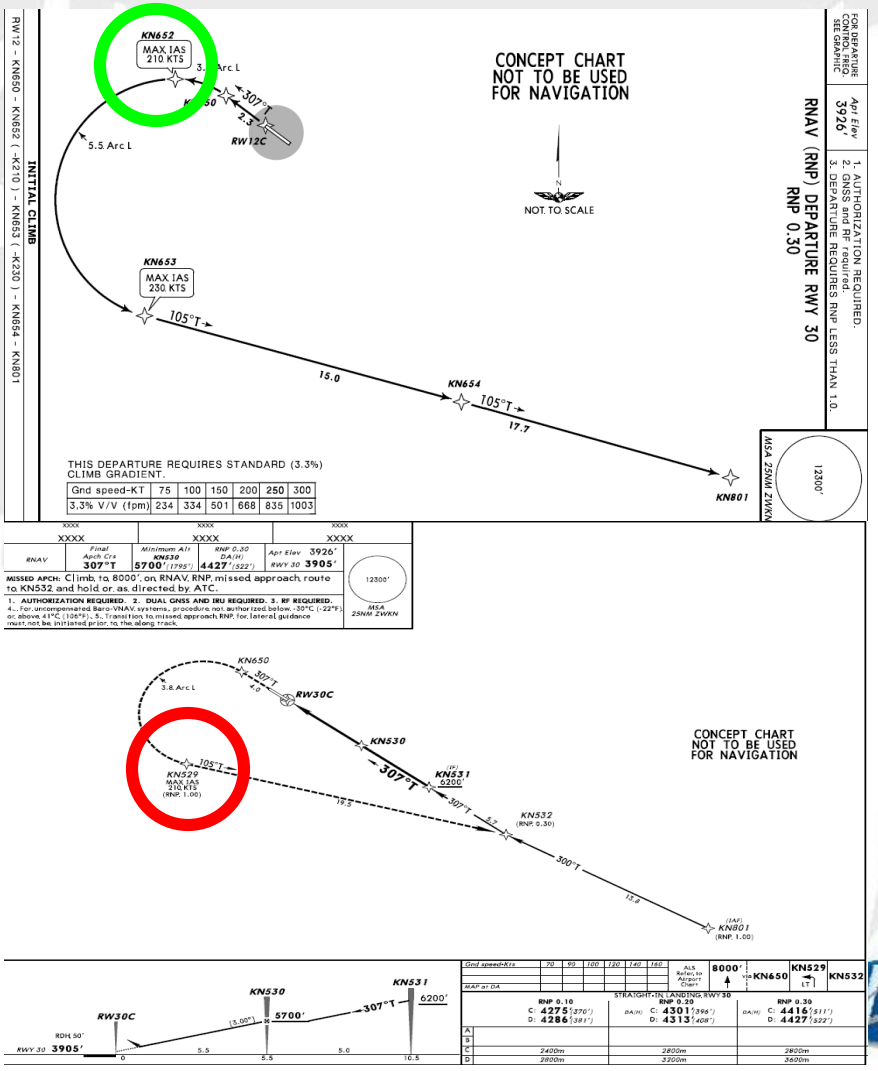
How to control(principles)?

- **Radar vector (base on MVA)**
  - Cleared，but do this before the first waypoint of RF leg, and follow the MVA.
  - Intercept the waypoint with
    - At least **3**NM Level mantaining
    - Angel Within **45°**

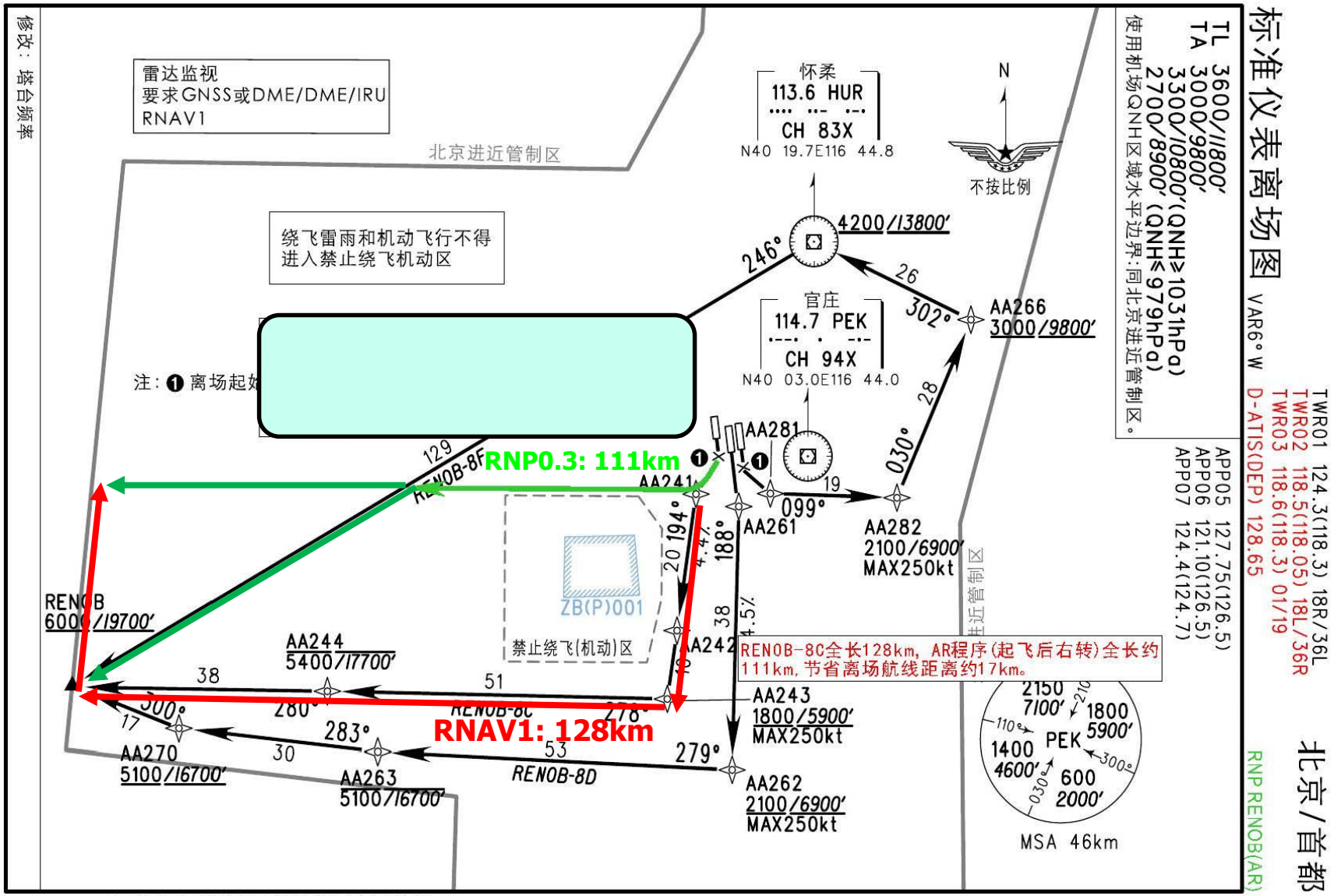


How to control (principles)?

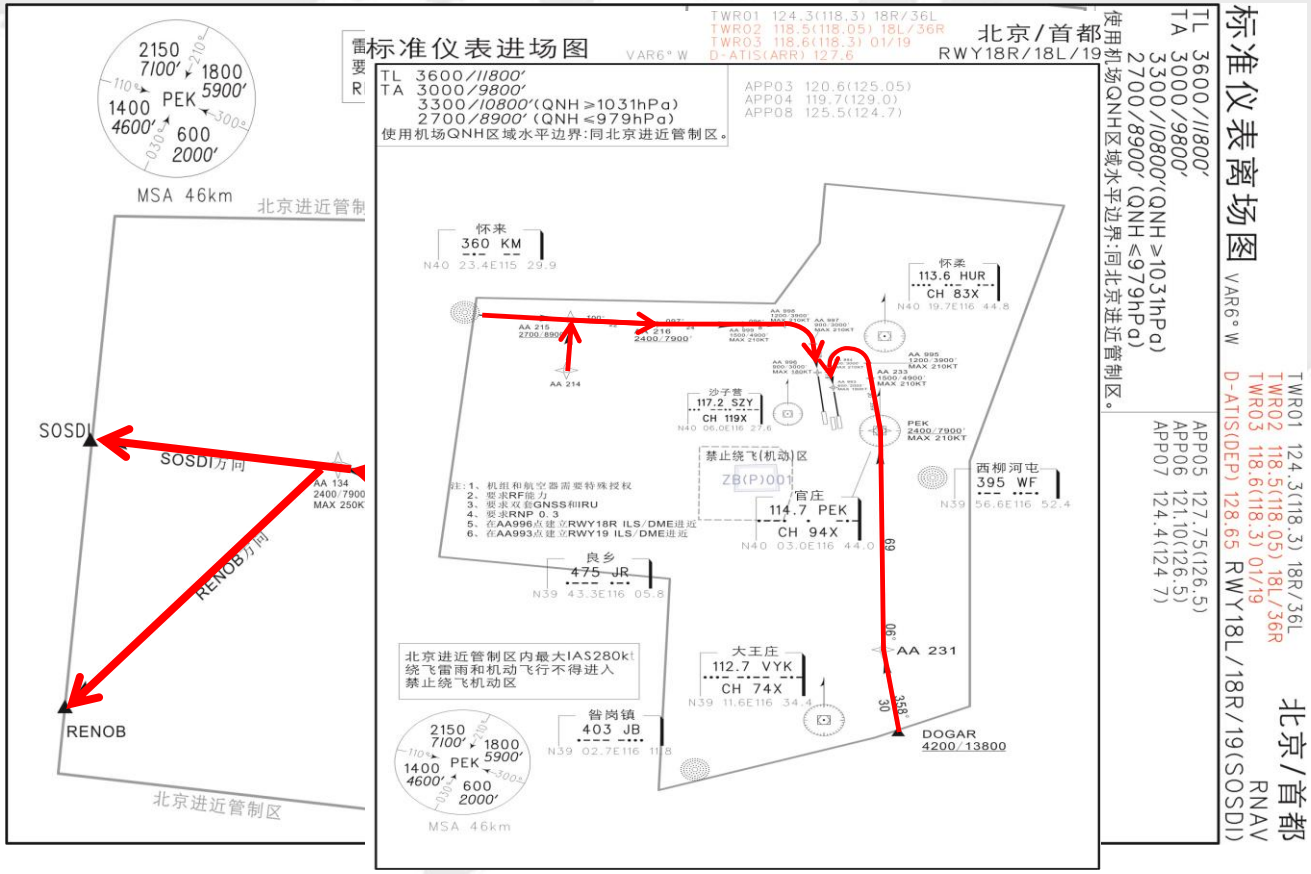
- Speed adjustment
  - Cleared， but don't do this in RF leg and caution
    - The speed limited, don't increase speed
    - Not too harder
    - Not too many times
    - Listen to the pilot



Case 6:Airspace restriction(prohibited area)

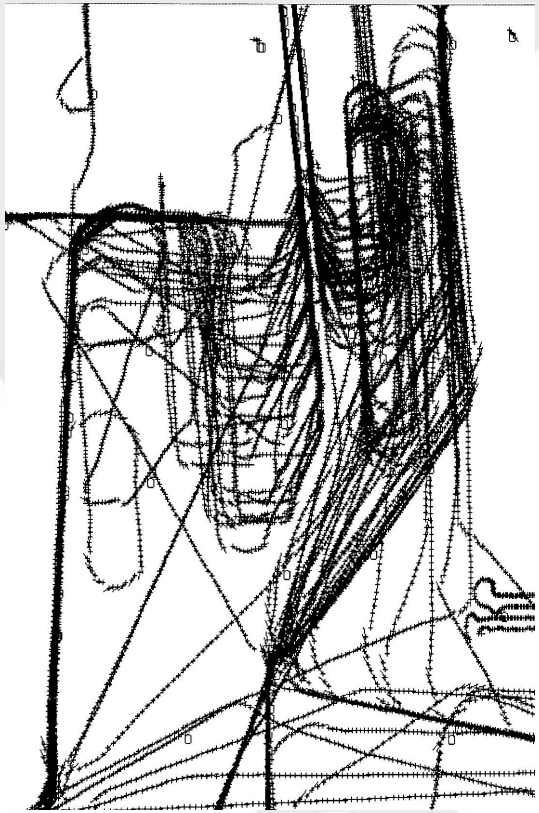


Solution6:RNP-AR for Sequencing/Airspace/Terrain

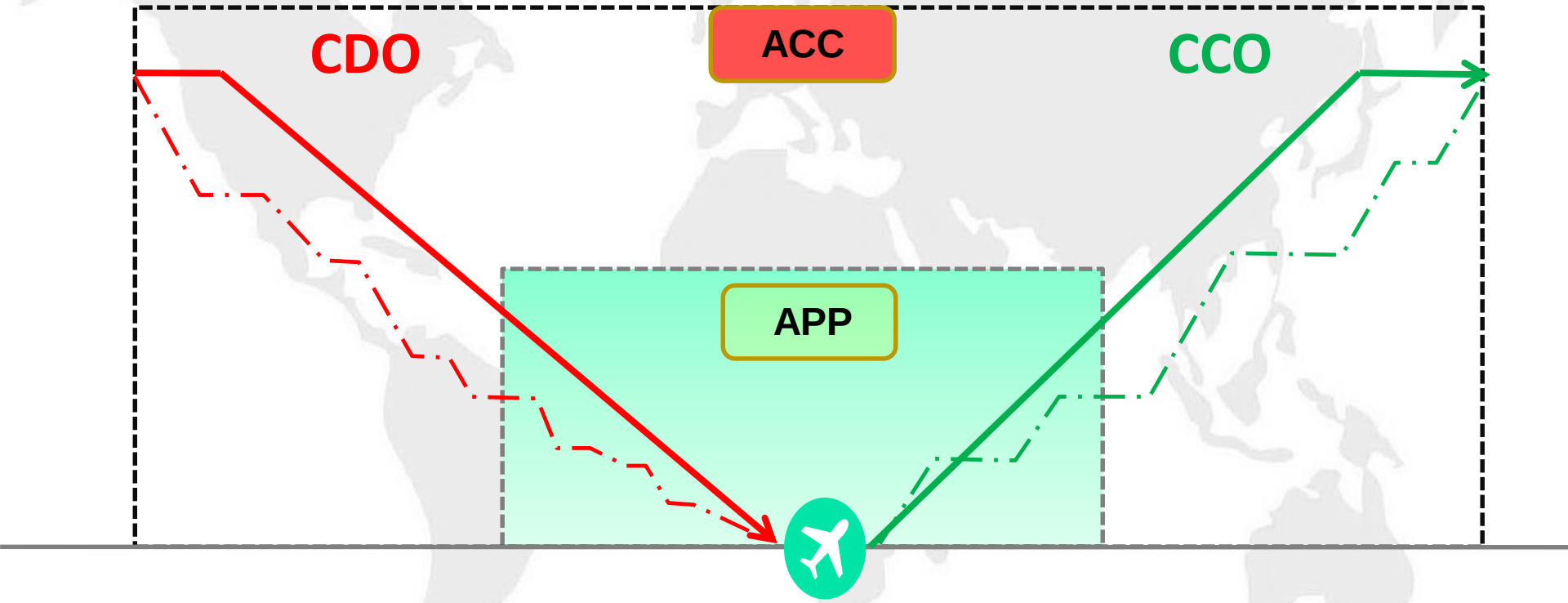


Case 7:Efficiency requirement from Airlines

- **Principles of balance between capacity and efficiency**
  - **Sequence and Capacity during day time （RNAV-1 for Horizontal ）**
  - **Fuel saving and Noise reduction during night time （CCO/CDO for Vertical ）**



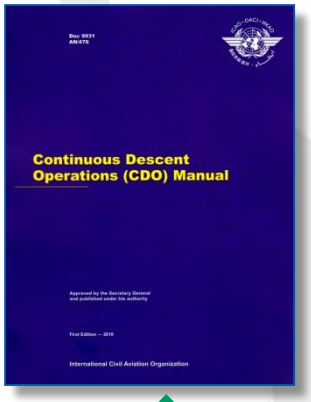
Solution 7:Implementation of CCO/CDO during the night



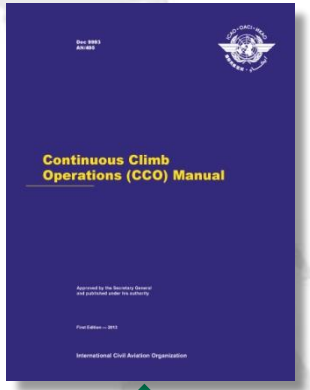
Theory

ICAO Doc 9992/Doc 9613

ICAO Doc 9931



ICAO Doc 9993

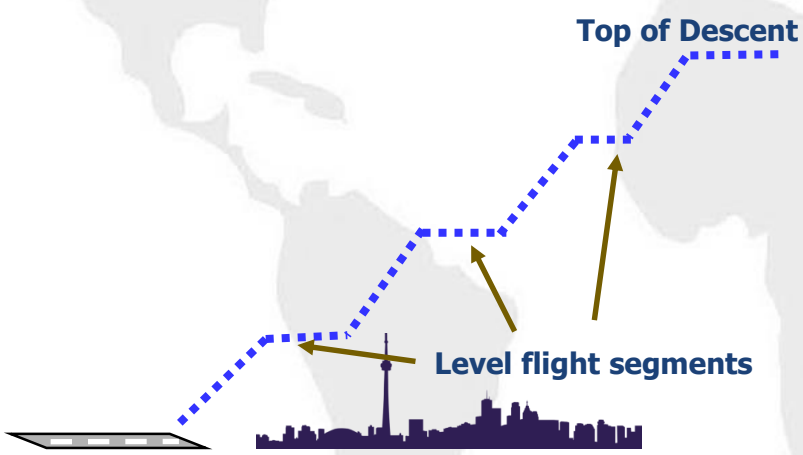


CDO PLAN

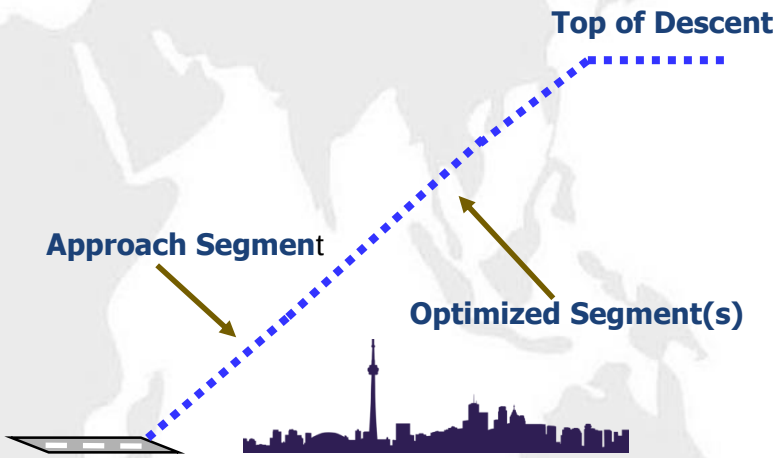
CCO IMPLEMENT

Theory

Conventional Step-down

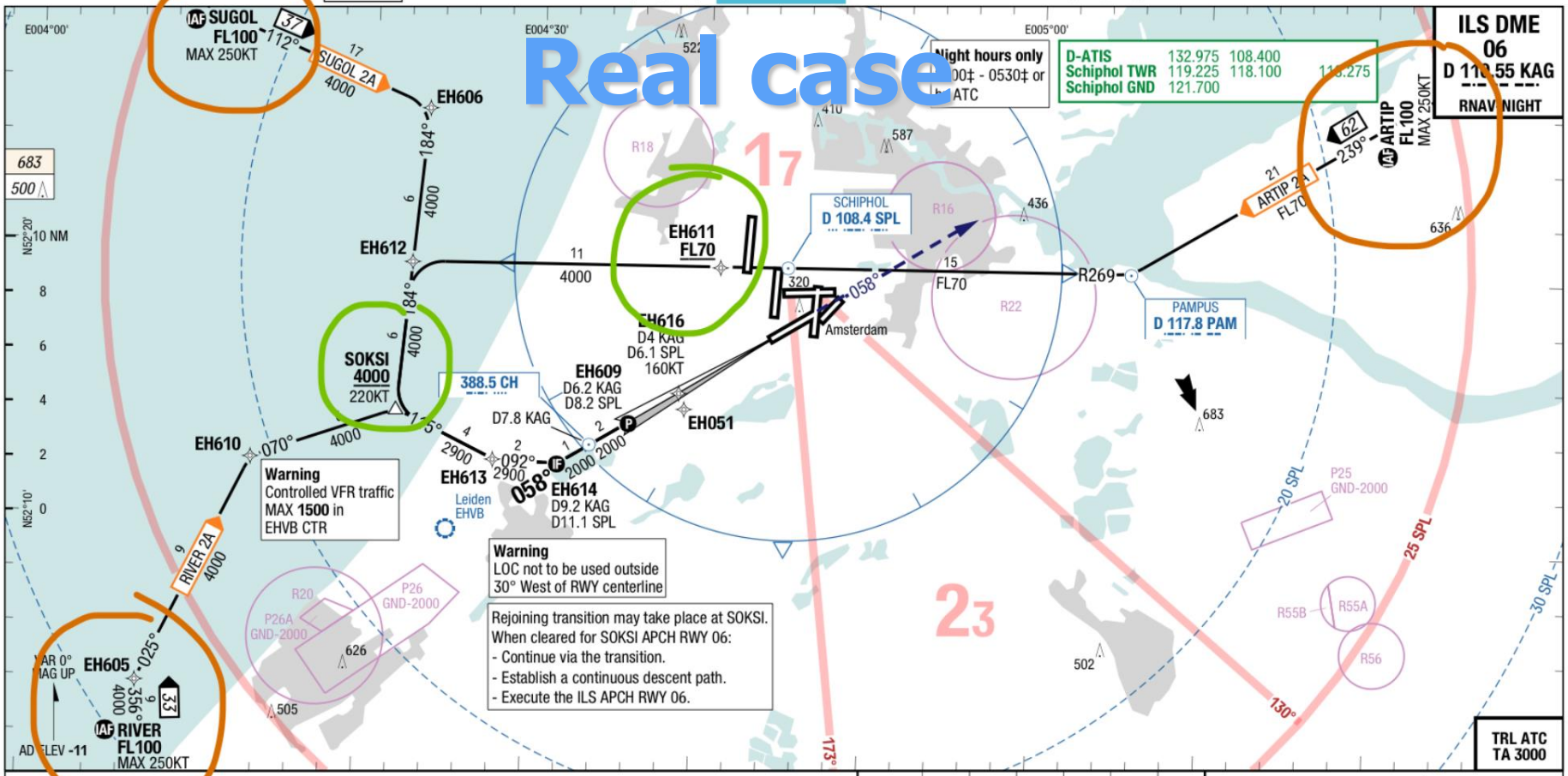


Continuous Descent Operations



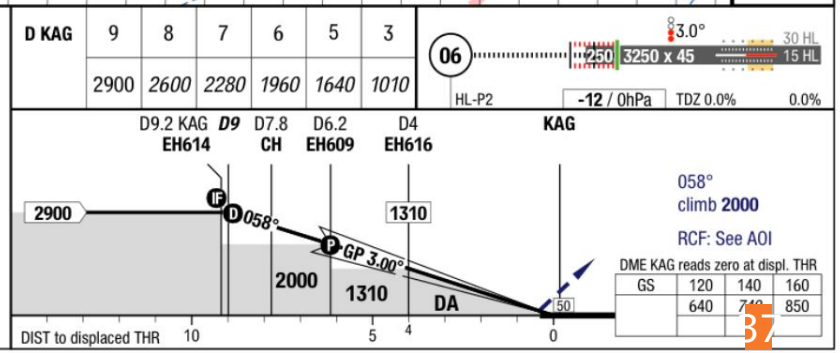
➡ **But in reality long and high-beginning CDOs are VERY DIFFICULT to achieve (why and how?)**

Real case



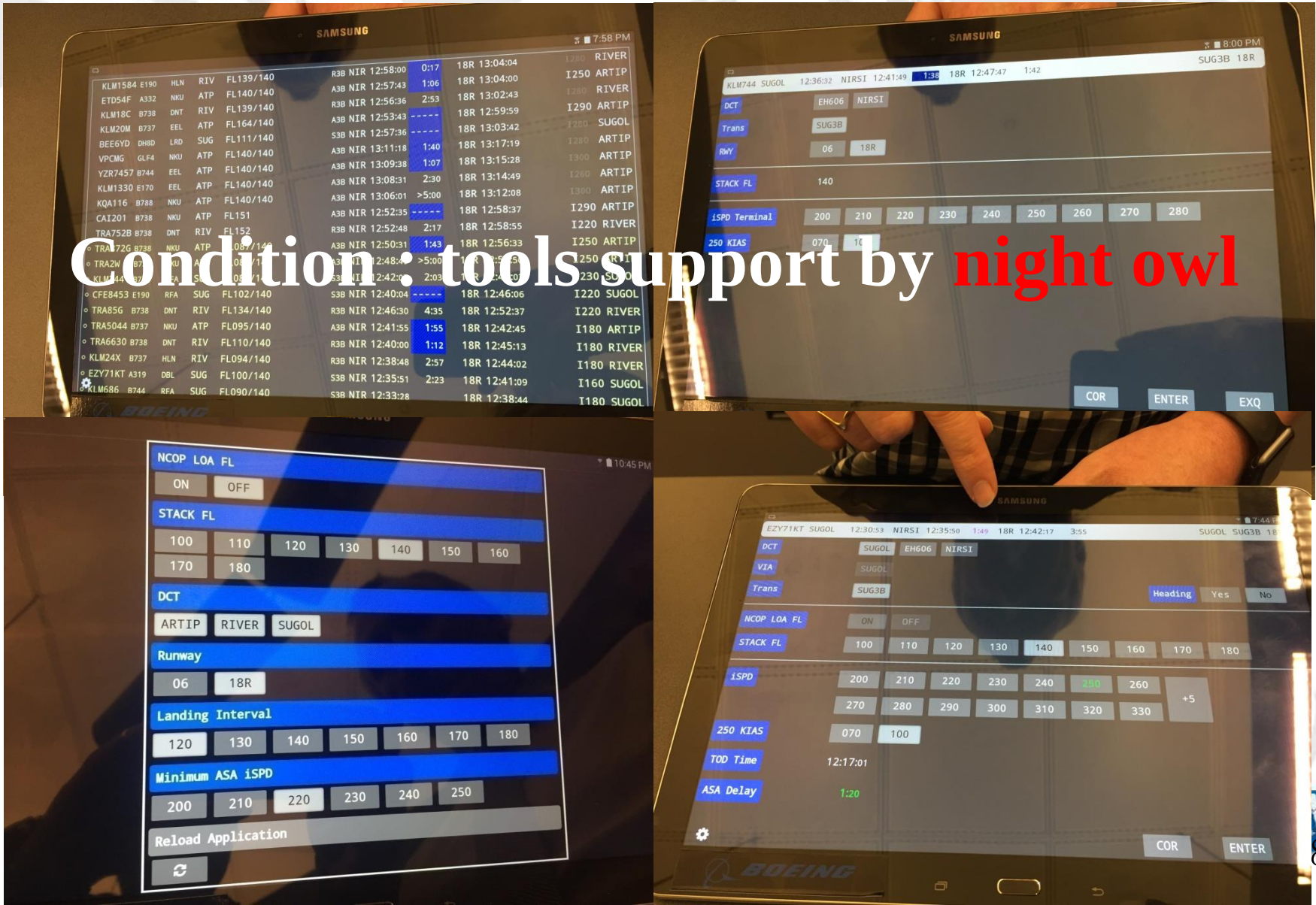
06		Cat 3b DME	Cat 2 DME	Cat 1 DME LTS 1)	Cat 1 DME 1)	LOC DME	Circling 2)
C	ft - m/km ft	0 - 75R **Company**	100 - 300R **101** RA	200 - 400 **190**	200 - 550 **190**	Not authorized	900 - 2.4V **880**
D	ft - m/km ft	0 - 75R **Company**	100 - 300R **101** RA 3)	200 - 400 **190**	200 - 550 **190**	Not authorized	910 - 3.6V **890**

1) With EVS 350m, wo EVS use STD
2) To RWY 18L,36L EMERG only
3) If not conducting autoland RVR 350m required



Changes: MIN

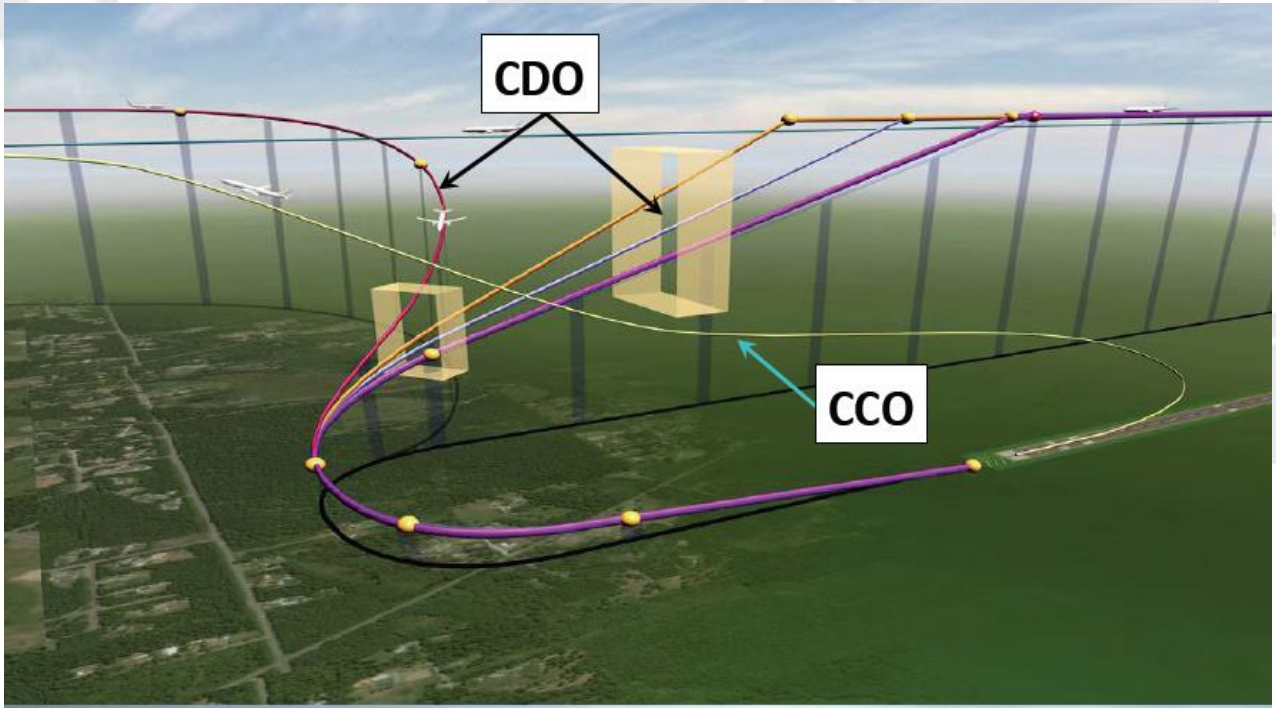
Real case



Condition: tools support by night owl

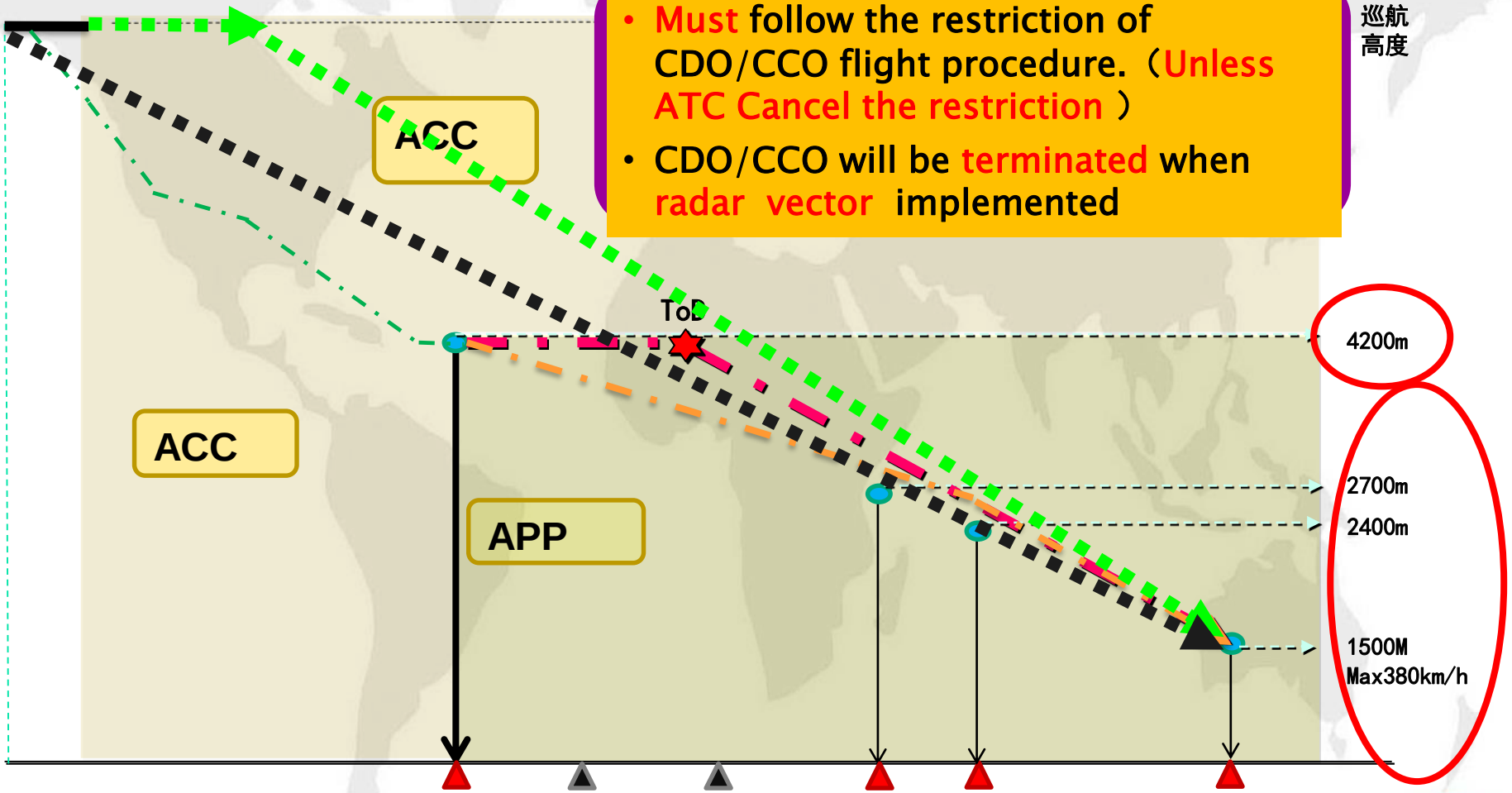
CCO OPRATION

- CCO
  - Optimum climb engine thrust.
  - No altitude restriction till the cruising level.



CDO OPRATION

- Must follow the restriction of CDO/CCO flight procedure.（Unless ATC Cancel the restriction ）
- CDO/CCO will be terminated when radar vector implemented



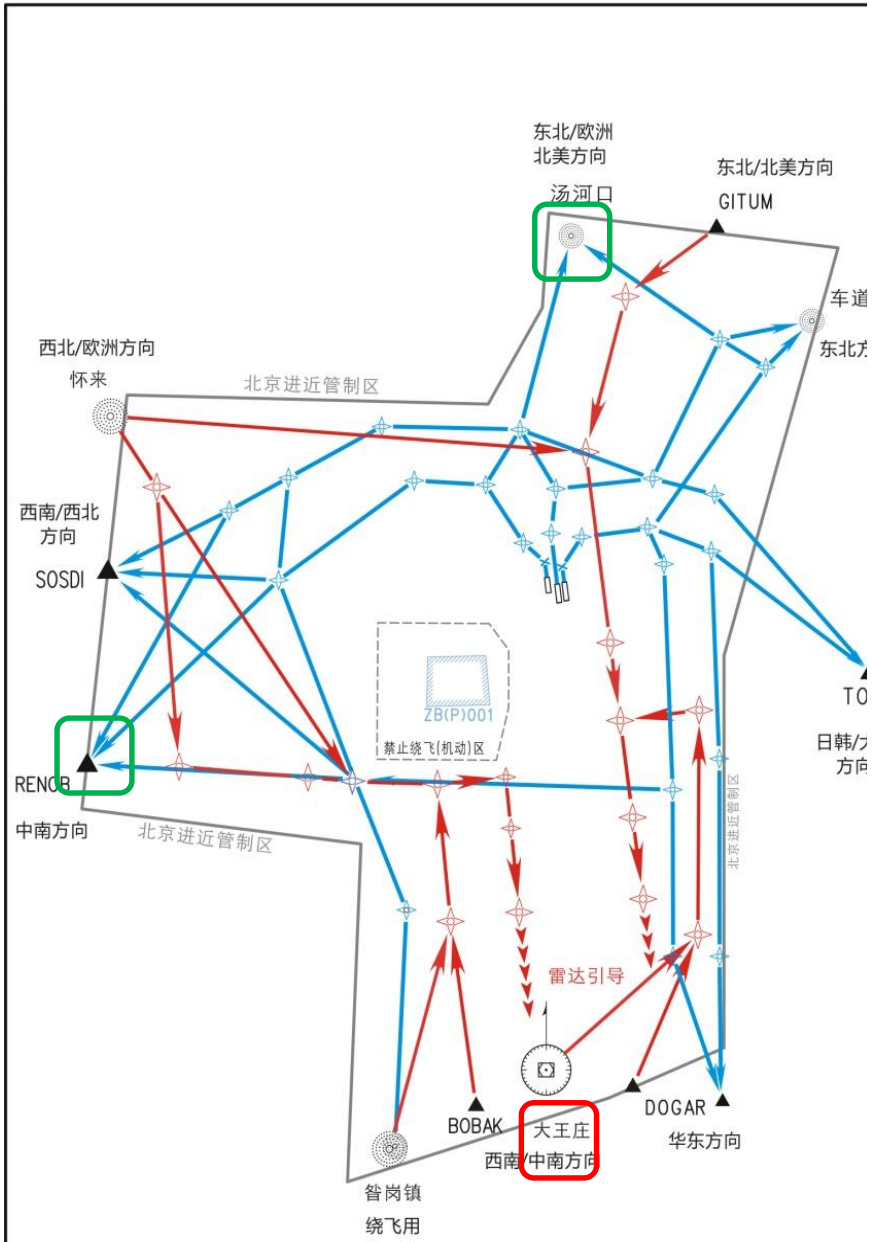
现行

RNAV进离场程序—向北运行

北京 首都

RNA

RWY36L/36R/(



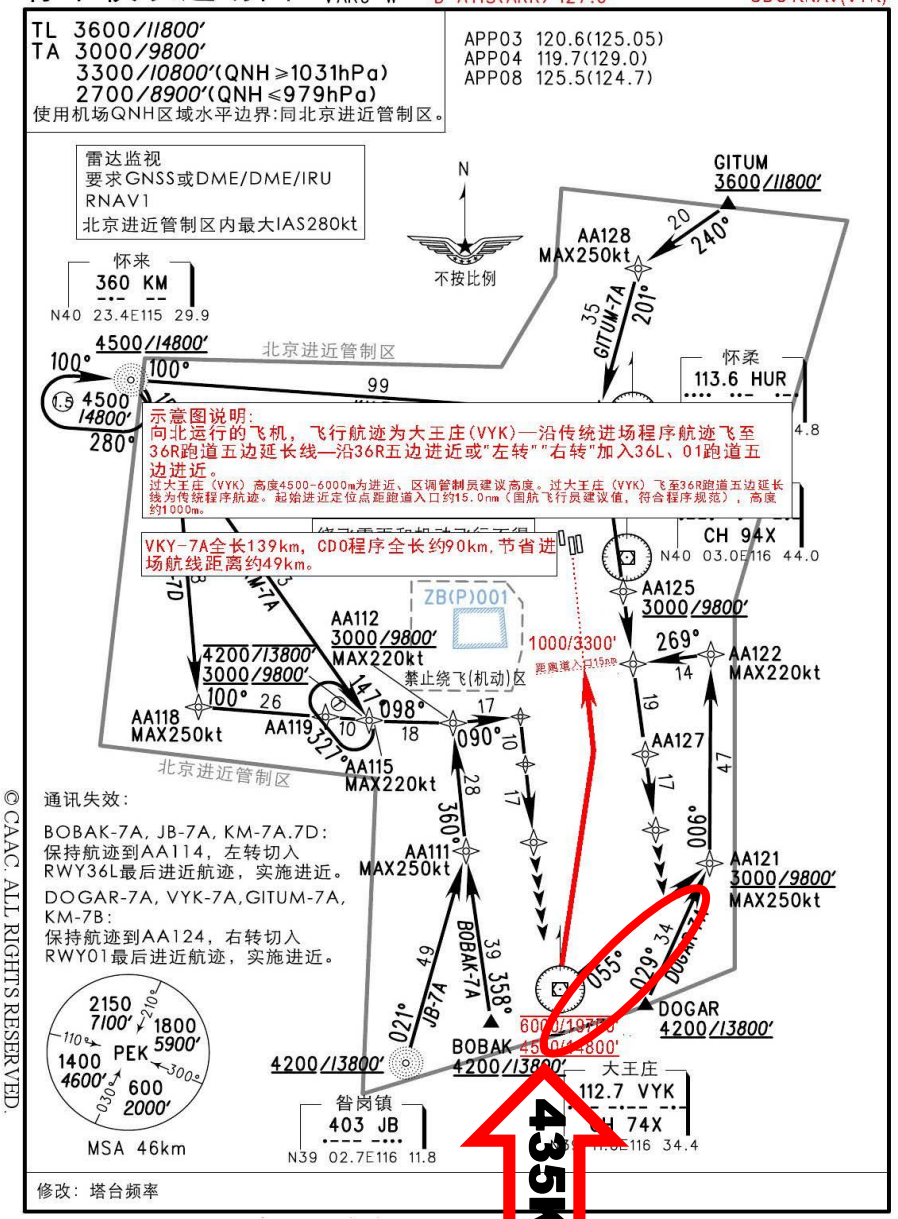
北京/首都

TWR01 124.3(118.3) 18R/36L
TWR02 118.5(118.05) 18L/36R
TWR03 118.6(118.3) 01/19
D-ATIS(ARR) 127.6

CDO RNAV(VYK)

标准仪表进场图

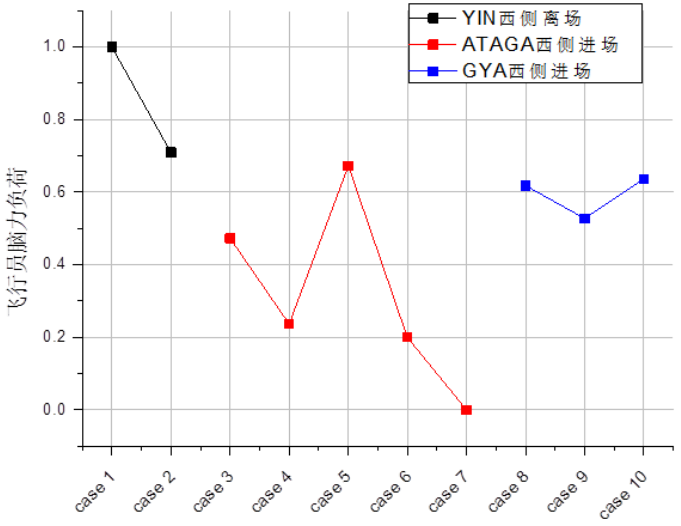
VAR6° W



435KM

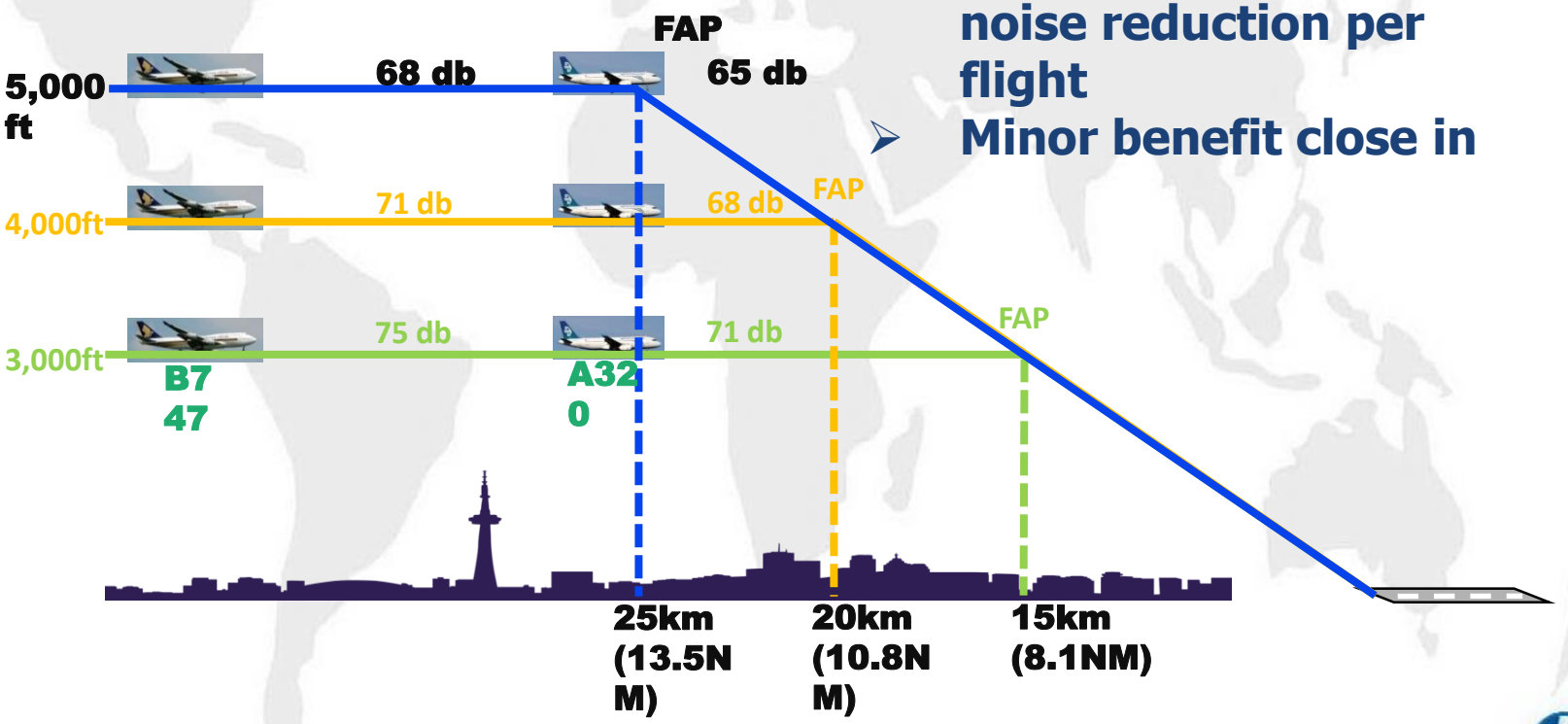
Fuel Saving and Workload Reduction

- Inbound Fuel saving： 1055kg/ac(Max:2274kg by CA B777 435KM's CDO)
- Outbound Fuel saving： 82.5kg/ac
- A/G Communication reduction 40%
- Times of Step Descend from 8 to 2



Noise Reduction(theory)

- **Noise and flight level**



- 15-25km from touchdown, 1-7db noise reduction per flight
- Minor benefit close in

Noise Reduction(real case)

- **Noise abatment**
  - **Reduction of noise range**
  - **Reduction of noise intensity**

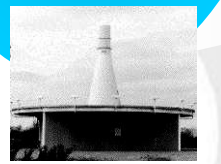
Noise intensity	CCO Reduction (km^2)	CDO Reduction (%)
70 db above	10	50

What to use for PBN ? Flexibility

What to use for PBN ? Accuracy

GNSS

Conventional → RNAV → RNP



Ground aids

Airborne equipment

ICAO

North American Central American and Caribbean (NACC) Office Mexico City

South American (SAM) Office Lima

ICAO Headquarters Montréal

Western and Central African (WACAF) Office Dakar

European and North Atlantic (EUR/NAT) Office Paris

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Welcome to Join APAC FPP

Let's FIND/PLAN/PLAY Together

THANK YOU