Workshop on PBN airspace Design

31 May - 04 June 2021

Airspace Design and CDO

(Doc. 9992, Airspace Design Manual)
Doc. 9993, CCO Manual

Content

- General on SIDs
- Continuous Climb Operations (CCO)
- CCO Design Examples
- Main difference between CCO and CDO
- Level and speed restrictions
- CCO and Noise Abatement
- Trade-off between CCO and CDO
- Publication and charting issues

Airspace Design

GENERAL ON STANDARD INSTRUMENT DEPARTURE (SID)

Planning the SIDs

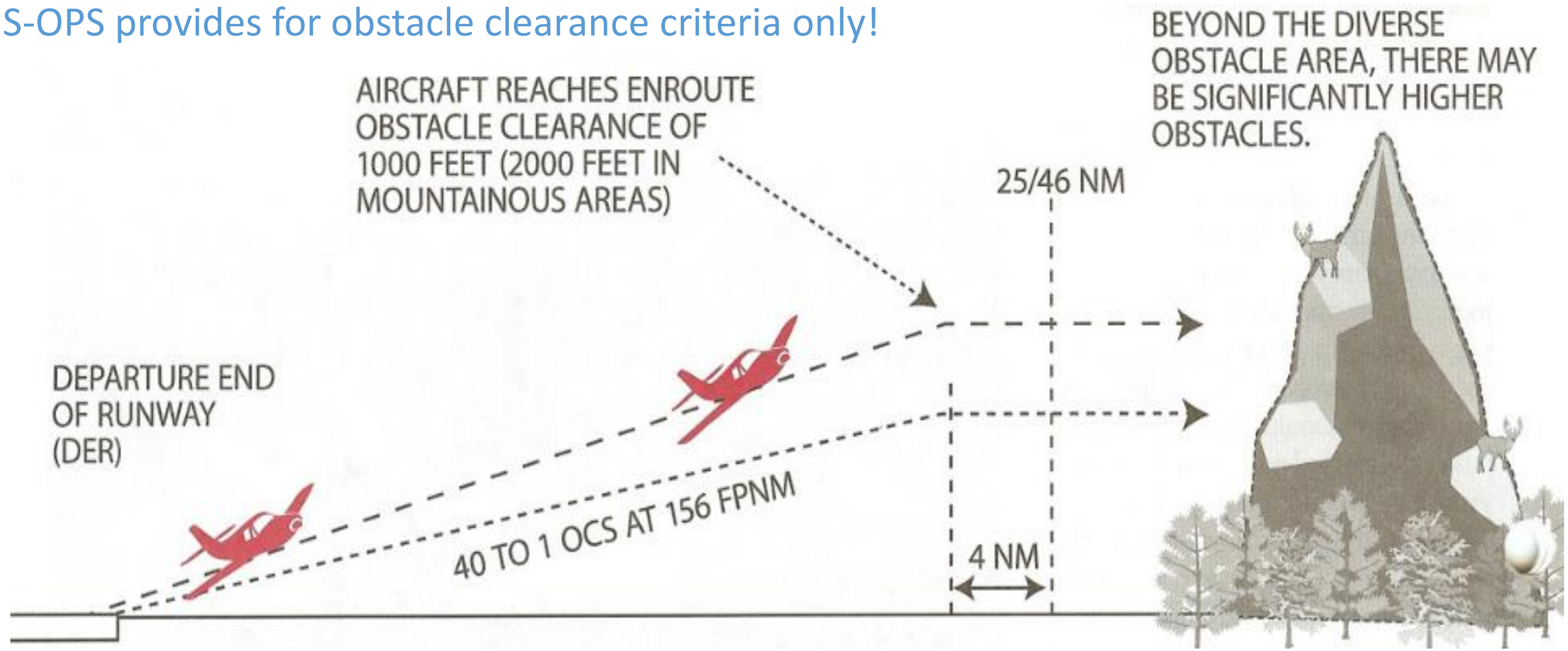
- Ideally, a SID with the shortest track distance and an optimized vertical profile is what the **air operator** wants.
- So the best SID would be the **shortest path** with an **unrestricted climb** to cruise flight level with **no speed restrictions.**

Factors affecting SID planning

- Factors such as other **traffic flows**, terrain, restricted airspace, aircraft performance, and **noise abatement** requirements will all serve to modify the design, or **preventing** the realization of the shortest path or the most efficient climb.
- The instrument procedure design must balance all of these factors to determine an **optimal design**.

Design Criteria

- SIDs must be designed according PANS-OPS (Doc 8168);
- However, PANS-OPS provides for obstacle clearance criteria only!



General on SIDs

Design criteria

- SID Criteria:
  - ☞The shortest path with an unrestricted climb to cruise flight level with no speed restrictions.
- Can we tell if these SIDs will serve an optimum TMA design?
- What is missing?
- For ATM purposes, how should the SIDs be presented?

Factors affecting SID planning

- SID planning process may therefore require modifications to the STARs!
- Therefore, the STAR and SID design process requires many compromises to achieve the right balance with the goal to reach the most optimized operational airspace model possible.
- And… it must be noted that, as all factors are taken into account, the shortest flight paths may not always result in the best design.

Factors affecting SID planning

- While STARs really have only one main objective, that being minimizing fuel burn...
- SIDs have two objectives:
  - One is also minimizing the fuel burn to get departures to optimum cruise altitudes as quickly as possible:
    - Top of Cruise (TOC).
  - The second is to **minimize noise**, up to 5 dB per aircraft.
- Therefore SIDs should also be planned for noise abatement.

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CONTINUOUS CLIMB OPERATION (CCO)

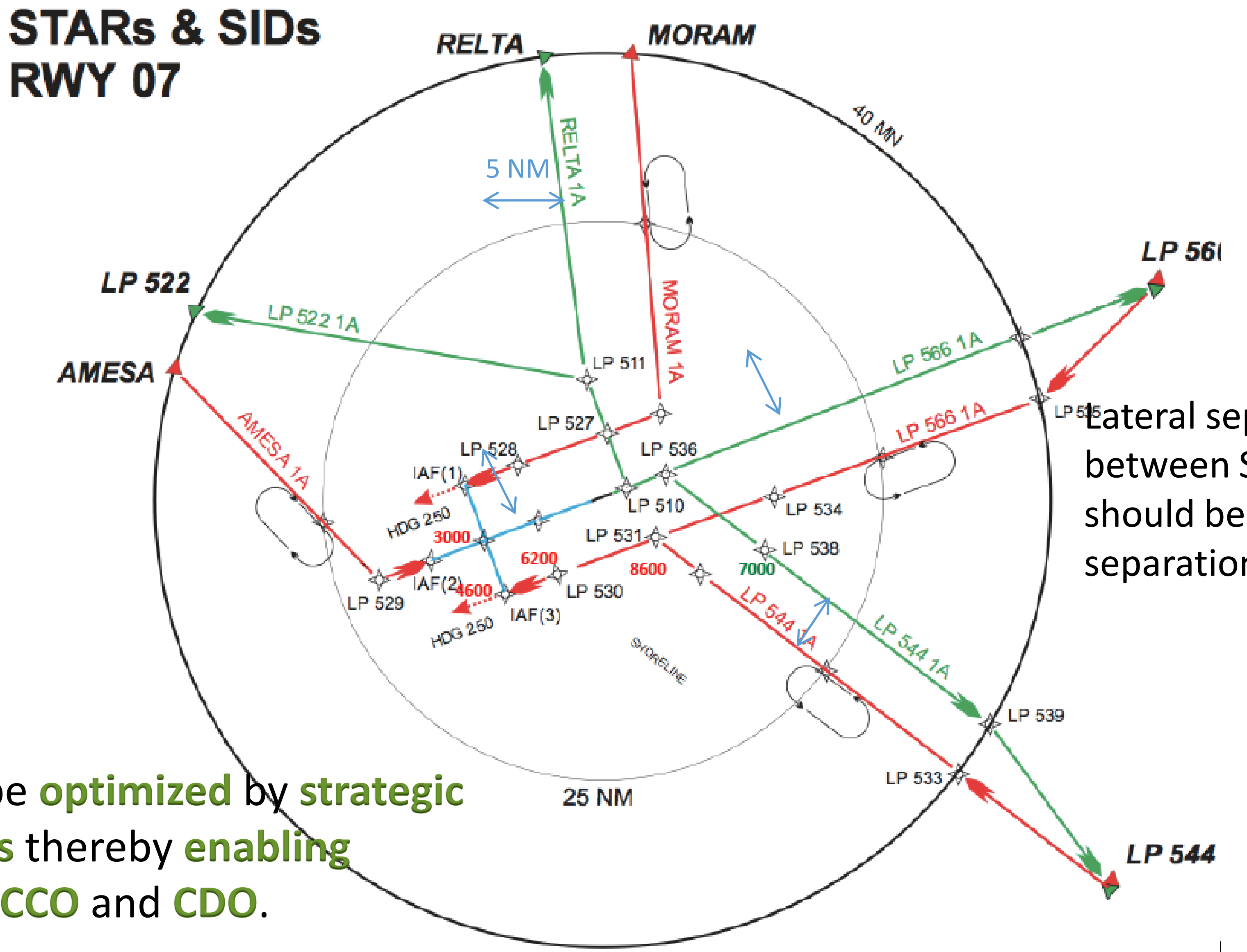
Continuous Climb Operations

CCO Benefits

- CCO offers the following advantages:
  a. More fuel efficient operations – reduced fuel burn;
  b. Reduction in both flight crew and controller workload through the design of procedures, requiring less ATC intervention;
  c. Reduction in the number of required radio transmissions;
  d. Potential aircraft noise mitigation through thrust and height optimization;
     1. Potential authorization of operations where noise limitations would otherwise result in operations being curtailed or restricted.

Lateral separation

gramme (AFPP)



Lateral separation between STARs and SIDs should be **5 NM** if radar separation is **3 NM**

The benefits of **CCO** will be **optimized** by **strategic separation** of **traffic flows** thereby **enabling** concurrent operations of **CCO** and **CDO**.

The Art of the Possible

- CCO should be considered as being "**the art of the possible**" and, while highly desirable, it is not to be achieved at any cost.
- The achievement of CCO for one operation must be balanced with its effect on other operations.

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CCO DESIGN EXAMPLES

Two CCO Design Examples

- There are two examples of CCO procedure designs, Basic and Enhanced:
  - ☞ Basic CCO design allows for unrestricted climb rates for all aircraft:
  - ☞ It requires that a significant amount of vertical airspace be set aside to protect the various climb performances and therefore may also extend the route in order to give lower performing aircraft the distance necessary to clear obstacles.

CCO design examples

Two CCO Design Examples

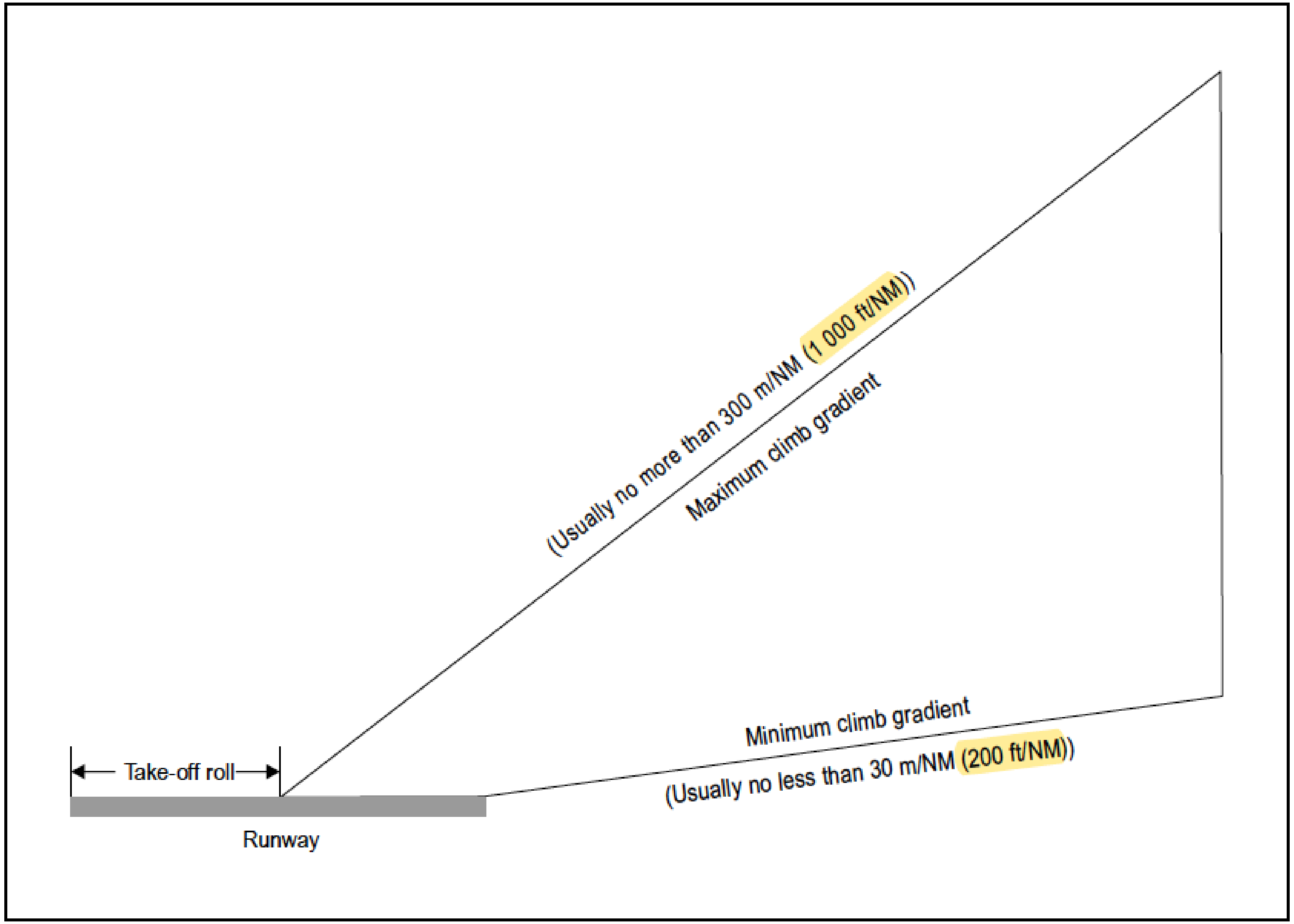
- There are two examples of CCO procedure designs, **Basic** and **Enhanced (Cont'd):**
  - ☞**Enhanced CCO** designs with **multiple** climb gradients:
    - Due to terrain or airspace limitations, it may be necessary to specify **increased** minimum climb rates for a portion or all of the SID.
      - For example a 7% gradient
    - This can enable design of a **shorter SID** for those aircraft that are capable of **higher climb rates**.

Two CCO Design Examples

- There are two examples of CCO procedure designs, **Basic** and **Enhanced (Cont'd):**
  - ☞**Enhanced CCO** designs with **multiple** climb gradients (contd):
    - In such cases, one solution is to design **two SIDs** that both proceed to the **same exit point**; one for **better performing** aircraft and one for aircraft that require **extra distance to gain altitude**.
    - Another alternative is to develop different SIDs to **different exit points** based on aircraft performance.

Two CCO Design Examples

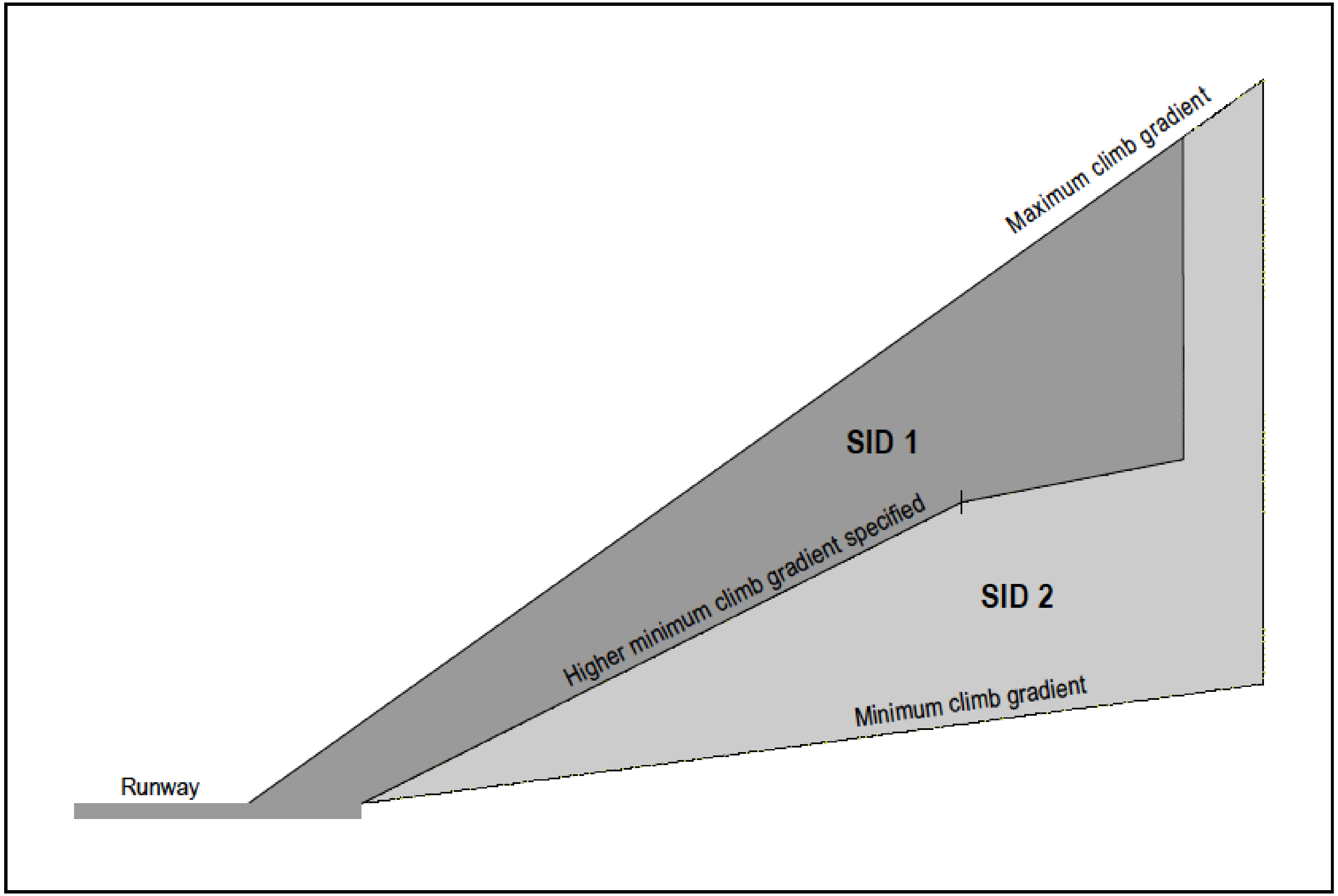
African Flight Procedure Programme (AFPP)



Basic CCO :

- Allows for **unrestricted** climb rates for **all aircraft**
- Requires a **significant amount** of vertical airspace!
- May also **extend the SID length** to allow for lower performing aircraft.

Two CCO Design Examples



African Flight Procedure Programme (AFPP)

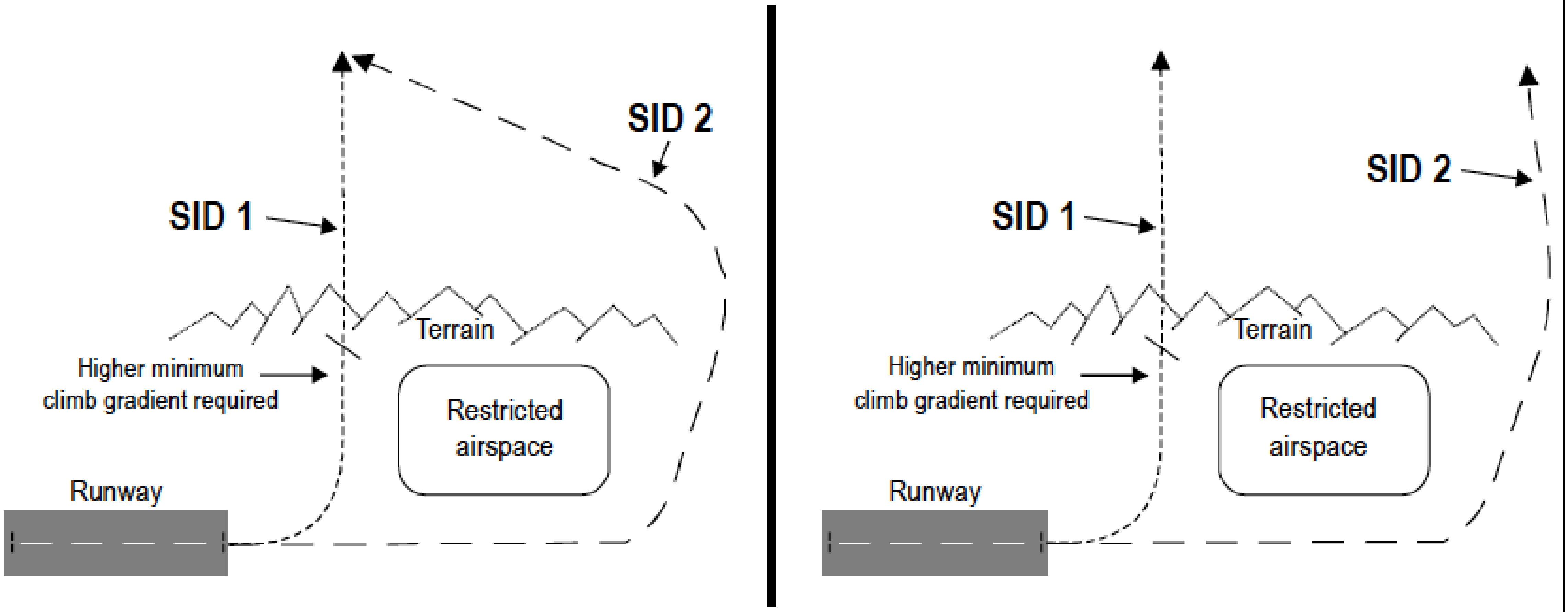
Enhanced CCO :

- May specify **increased** minimum climb rates (7%) or about 425'/NM
- Will enable a **shorter route** for higher performing aircraft

One solution is **two SIDs** Either to the **same exit** point or to **two different exit** points.

Two CCO Design Examples

Same exit point | **Two different** exit points



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MAIN DIFFERENCE BETWEEN CDO AND CCO

Main difference between CDOs and CCOs

- There are number of differences: a Table showing these will be presented for summary;
- However there is **one main ideology**, that separates CDOs from CCOs, and an **important teaching point** of this lesson!
- It is recommended to design departure routes that provide initial **"strategic"** separation from the STARs.
- This is the **overriding** design difference between CDO and CCO!

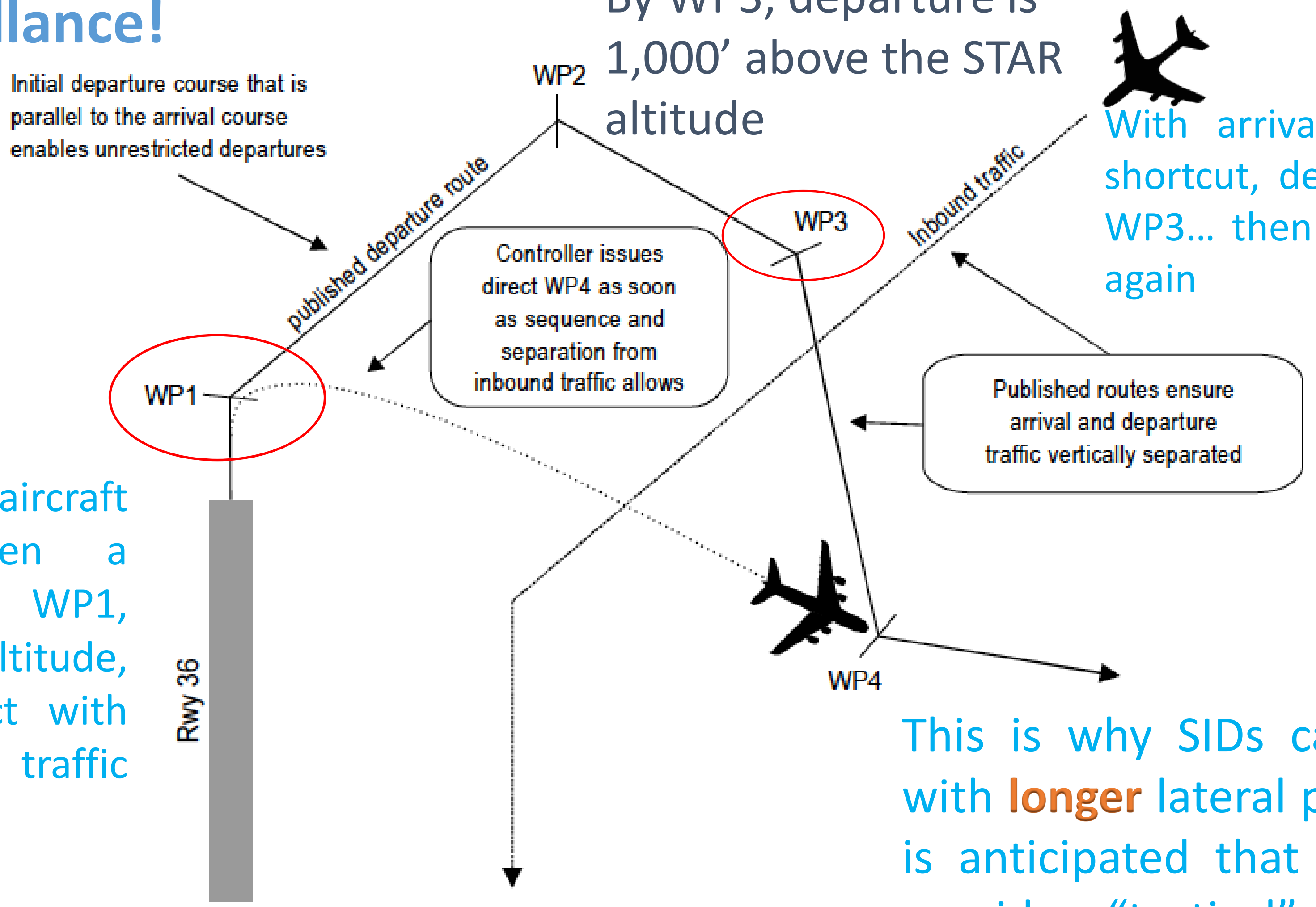
Main difference between CDOs and CCOs

- In general, CDO aircraft should be left on the designed route and not given a "shortcut" because a CDO is already in idle descent:
  - ☞A shortcut would require a steeper angle which may lead to an unstable approach.
- **In contrast**, tactical shortcutting of a CCO departure to take advantage of observed aircraft performance **is desirable!**
- Sending an aircraft **direct to a subsequent fix** to **reduce flight distance** has the potential to produce a significant additional benefit with the least additional workload to both the controller and flight crew!

Difference between CCO/CDO

Need surveillance!

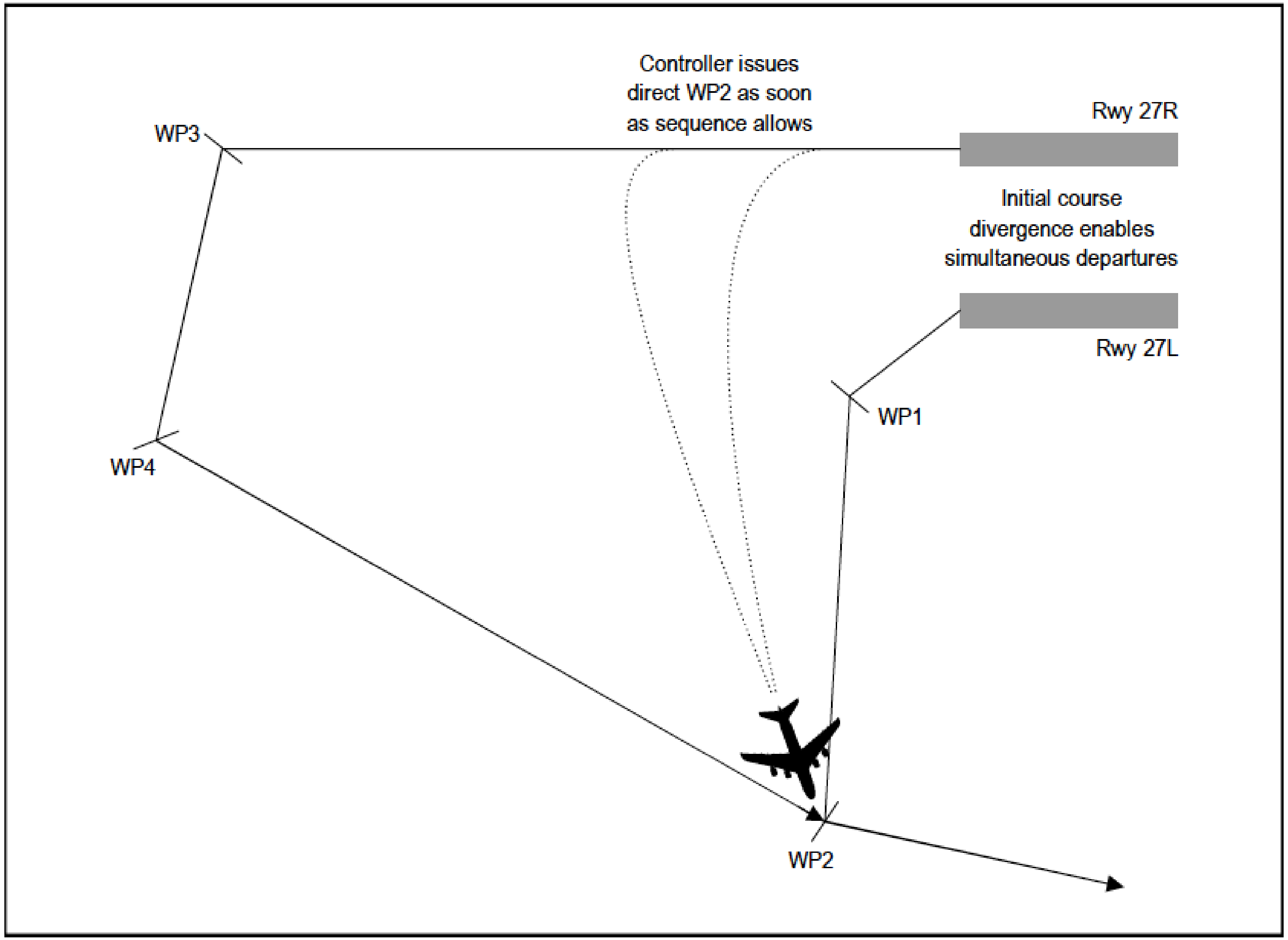
By WP3, departure is 1,000' above the STAR altitude



With arrival on the STAR, no tactical shortcut, departure follows SID to WP2, WP3… then ATC reassesses the situation again

The departing aircraft can be given a shortcut after WP1, when at safe altitude, and no conflict with other (arriving) traffic exists.

This is why SIDs can be planned with **longer** lateral path, because it is anticipated that ATC will often provide a "tactical" shortcut.



Need surveillance!

The teaching point is that ATC is trained to tactically control departures as soon as traffic conditions permit.
Conversely, arrivals are left alone to descend on the STAR.

Difference between CCO/CDO

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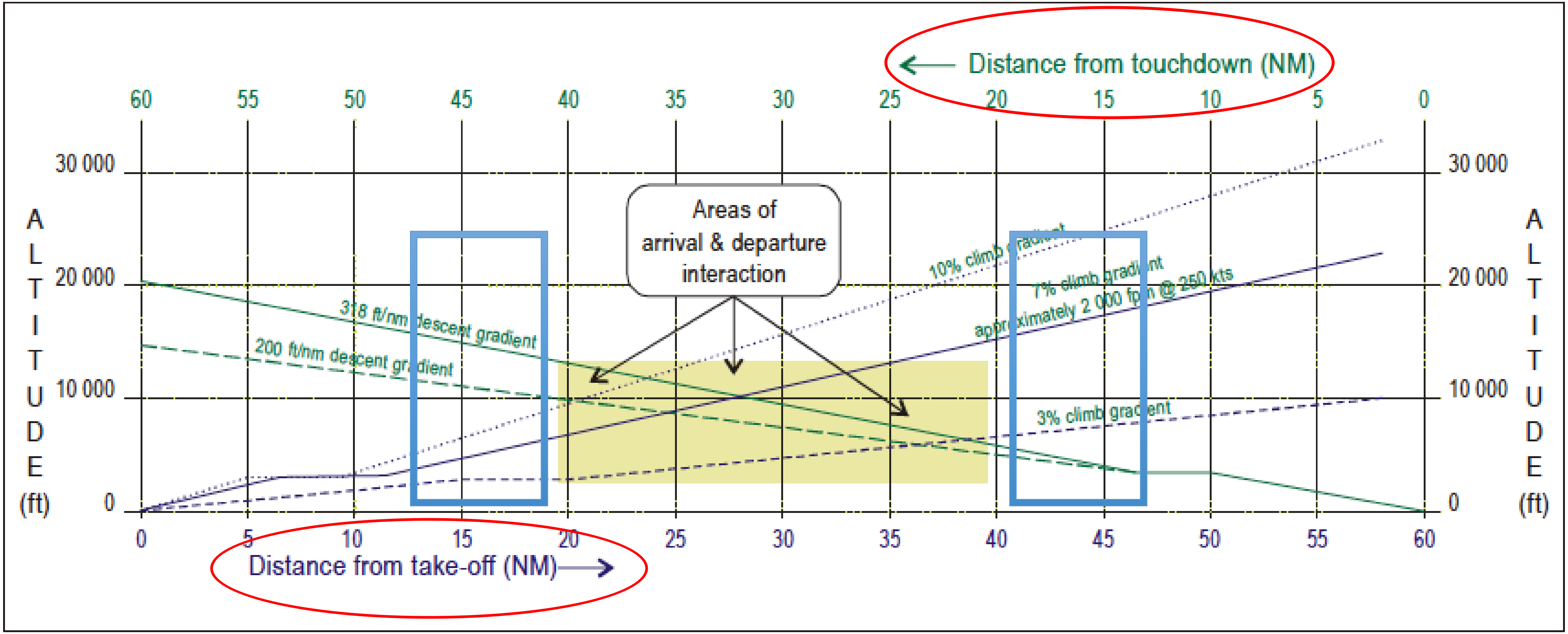
- The SID should be designed to allow the crossing of other inbound flows (STARs) where the crossing traffic flows will be **naturally segregated** by height when climbing or descending along their optimum profile.

  - ☞The performance of descending arrivals is quite uniform (250’ to 350’/NM), when compared to the performance of climbing departures (200’ to 1000’/NM)

Difference between CCO/CDO

Climb and Descent Profiles

- The vertical profile should be bounded by **minimum level requirements** (obstacles), **maximum level requirements** (for traffic separation purposes) or **level brackets** (minimum and maximum).
- In the following illustration, the interaction between descending arrivals and climbing departures is shown:
  - ☞It illustrates realistic climb and descent profiles.
  - ☞The shaded area shows where the climb and descent profiles are most likely to interact.
  - ☞For efficient design of flight paths that cross, it is better to cross early in the CCO or late in the CCO with the goal being to limit the potential interaction of SID/STAR flight trajectories.



Possible vertical interaction between departing and arriving traffic

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LEVEL AND SPEED RESTRICTIONS

Level Restrictions

- So altitude restrictions **will be necessary**, but they **should not overly constrain** the CCO profile.
- Plan crossing points between STARs and SIDs in locations where both **arrivals** and **departures** are not competing for the same altitude.
- Keep in mind **aircraft performance** and **efficient engine thrust settings**.
  - ☞If it is necessary for ATC to assign an initial “level-off” to the departure aircraft, efforts should be made to assign an altitude no lower than 5,000’ AGL.

… and Noise

- In general, the **application of speed controls** is **undesirable**.
- Any published speed constraints need to be compatible with the minimum manoeuvring speed and optimum clean-up process of the aircraft.
- An additional consideration is that requiring **speed constraints** soon after the departure end of the runway **may delay flap retraction** and thus **increase noise production** in a noise sensitive part of the flight, as well as **increasing both fuel burn**.

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CCO AND NOISE ABATEMENT

NADP 1 & NADP 2

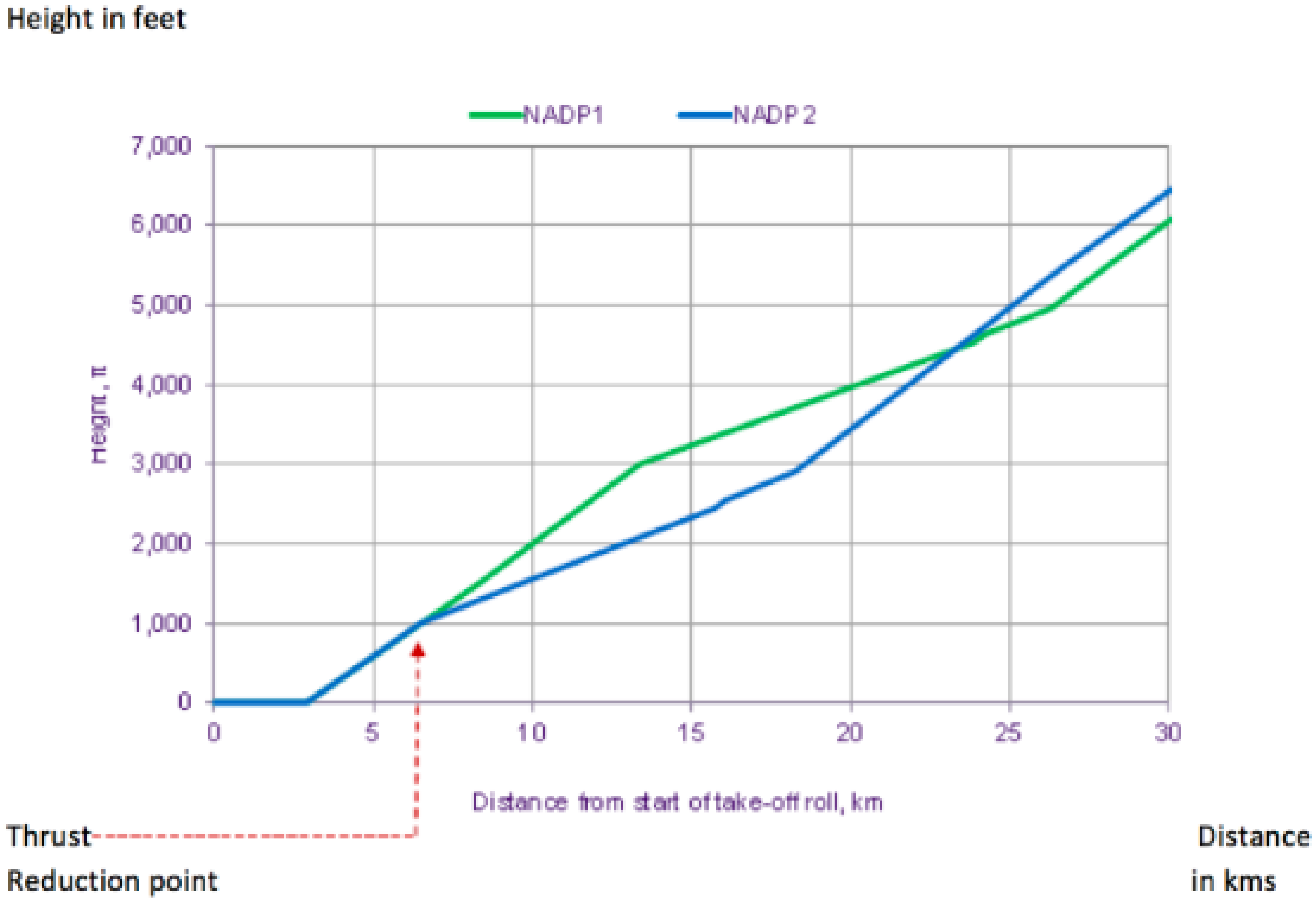
- Remember the second objective of SIDs?
  - ☞ Noise Abatement
- During the initial departure, the **thrust, speed and flap deployment** may produce significant noise;
- When planning SIDs over, or close to any noise sensitive areas, apply noise abatement procedures (NADP 1 and NADP 2) as per PANS-OPS (Doc 8168), Volume I, Part I, Section 7, Chapter 3, Appendix.

NADP 1 & NADP 2

- **NADP 1** is used where there are noise sensitive areas **close** to the airport;
- **NADP 2** is used to alleviate noise in an area **further away**, more than 14 NM from the start of roll on the airport runway.
- In both NADPs, aircraft to climb to 800' and then reduce thrust :
  - ☞**NADP 1**: Keep flaps lowered in take-off mode and **continue climbing as fast as possible to 3,000'**. Then retract flaps, increase thrust and go on your way
  - ☞NADP 2: Withdraw flaps at that point and continue at a decreased rate of climb until 3,000'. Then increase climb and thrust and go on your way

NADP 1 & NADP 2

The profiles look like this



NADP 1 & NADP 2

- Applying a NADPs may result in a speed profile that has an **effect on the turn radius:**
  a. For **NADP 1**, where the initial take-off will be based on a constant speed until the acceleration altitude 3,000' AGL, the **initial speed remains low** and therefore the **turn radius is smaller**.
  b. For **NADP 2**, the initial **speed will increase rapidly** and therefore may have an effect on the nominal flight path. This may result in a **larger turn radius**.
- To **reduce noise**, speeds **should not be restricted** to lower than **230 Kt** due to significant increase in **drag and fuel burn.**

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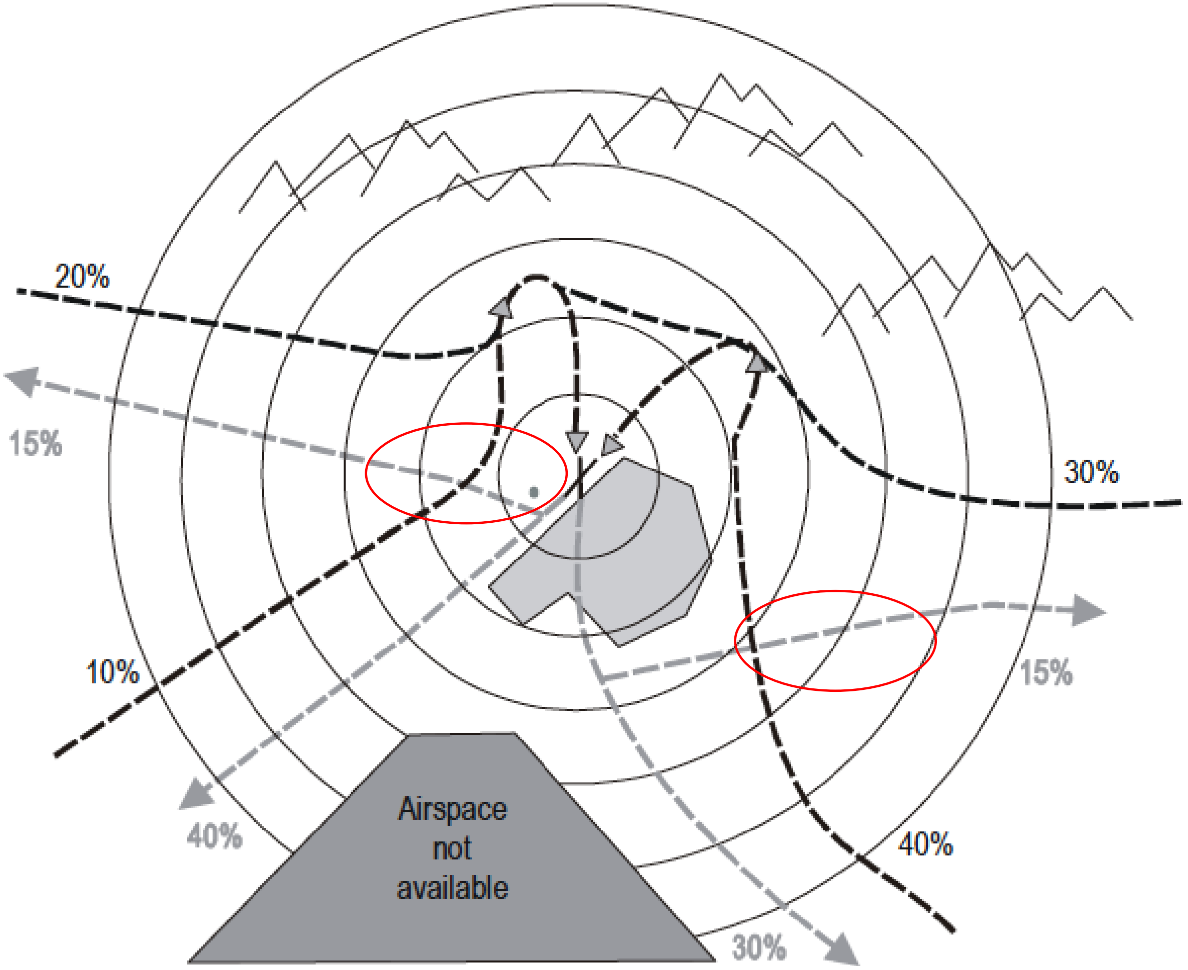
TRADE-OFF BETWEEN CCO AND CDO

Trade off between CCO and CDO

- A level segment for an aircraft in descent would normally burn less fuel than for the same duration of level segment for an equivalent aircraft in climb.
- Therefore give departures a priority during the planning process!
- The next example shows where a STAR could have a level window

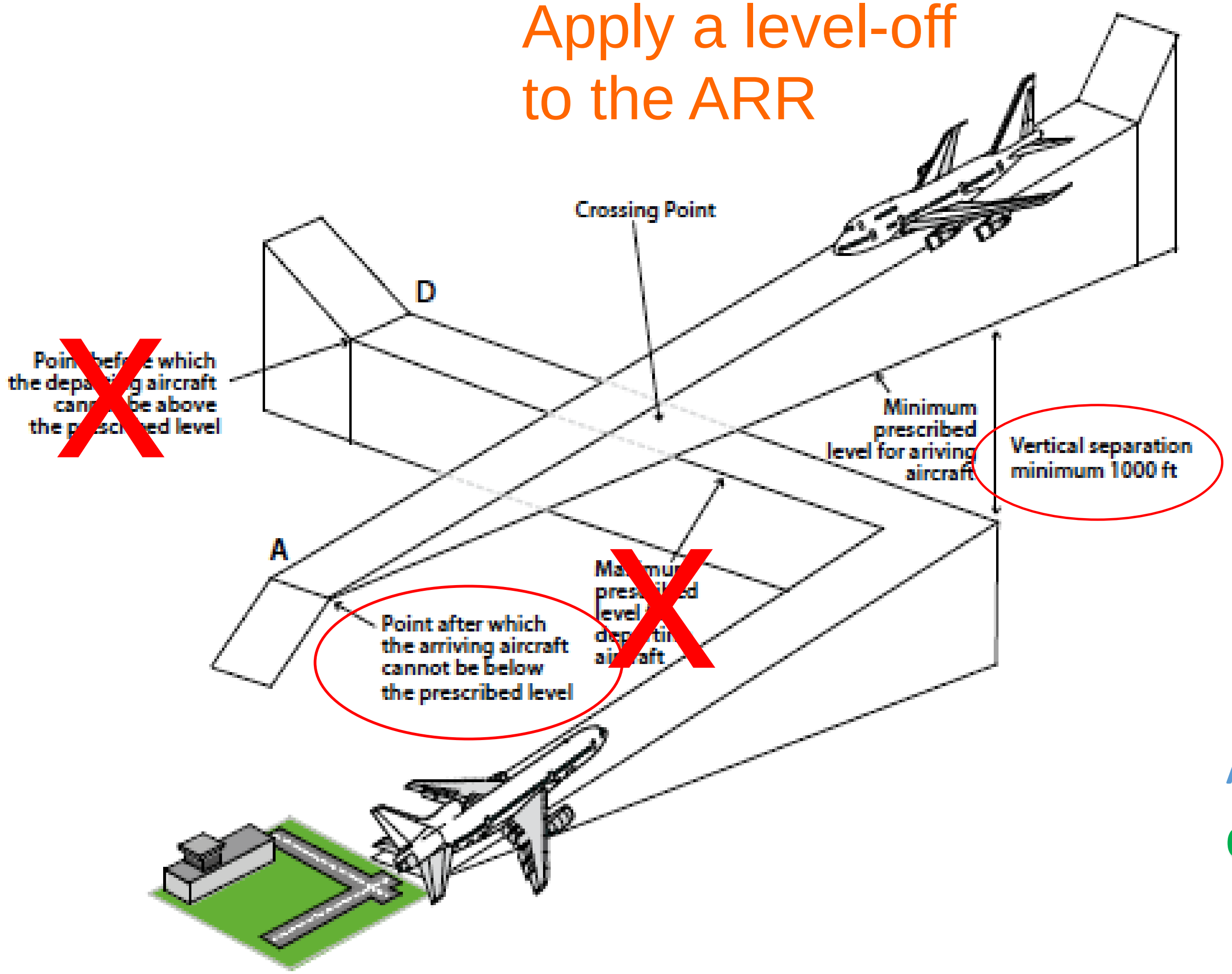
Trade-off between CCO/CDO



Therefore give **departures a priority**

Trade-off between CCO/CDO

Apply a level-off
to the ARR



DEP needs to keep
Climbing!

An example where a
departure is given a priority

Trade off between CCO and CDO

- The balance will depend on **local characteristics**, the aircraft performance of local users, the **significance of noise** in the areas affected, etc.
- Level flight segments, where there are **also speed constraints**, result in **much more severe** **operational constraints** than where level flight segments occur where <u>there is no speed constraint</u>.
- Avoid level flight segments where speed constraints exist.

Publication and Charting Issues

- ❑ Unless specifically required **as a part of the instrument procedure design**, meaning regarding obstacles, there is no need to provide **specific level windows** or **speed restrictions** for CCO on charts.
- ❑ This means that if you do not see any level windows, or speed restrictions, it is because this is **not a hard requirement**.
- ❑ However, I would recommend that any level restrictions **should be clearly depicted on the charts:**
  - ☞ Less so with speed, unless required to negotiate a turn from downwind to final for example.
- ❑ Level restrictions should be expressed using altitude windows (with minimum and maximum altitudes), or by “at or above” or “at or below” constraints.
- ❑ May be recommended to state on the chart which SID is CCO.

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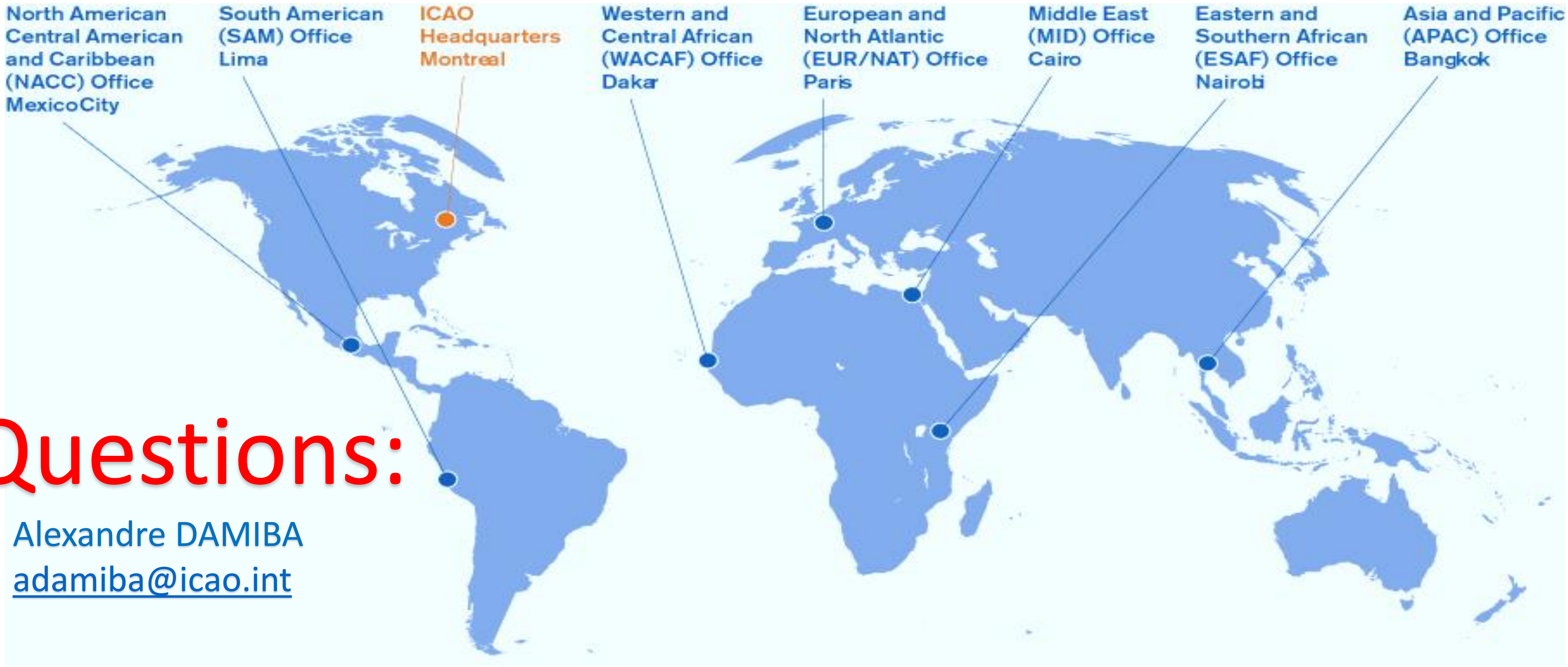
SUMMARY

Summary

- SIDs… CCO
- Objectives and Benefits
- Factors affecting SID planning
- CCO design examples – Basic and Enhanced
- Climb rates rates – 200 – 1000'/NM
- Main differences between CDOs and CCOs
- Level restrictions
- Noise Abatement – NAPD 1 and NAPD 2

Comprehension Check

1. Name some factors that affect the design of a SID.
   - **Traffic flows**, **terrain**, **restricted airspace**, **aircraft performance**, and **noise abatement,**
2. What does the planning process of STARs and SIDs require?
   - **Modification of STARs and many compromises.**
3. What are the two objectives of SIDs?
4. Name the two examples of CCO procedure design?
5. Describe the main difference between CDOs / STARs and CCOs / SIDs?
6. What are a typical descent performance of arrivals, compared to a typical climb performance of departures in feet per NM?
7. Describe the difference in speed and turn radius of NADP 1 and NADP 2.
8. Where a trade-off between CCO and CDO is unavoidable, which should be given a priority?



Questions:

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