Irregular Pre- Threshold

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Back ground (1/2)

- **Certification of landing systems request to assess ground profile under the approach path**

  CS AWO.A.ALS.107 Aerodrome conditions

  *[…] the effects of aerodrome conditions (e.g. elevation, ambient temperature, runway slope and **ground profile under the approach path**) are to be investigated […]*

- **Certification Guidance materials, provides one definition of ground profile under the approach to be considered**

  NOTE: The information on characteristics of aerodromes is contained in ICAO Annex 14. Examination of a number of airports used for automatic landing has shown that the following features may be encountered:

  […]

  b. hilltop runway — 12.5 % slope up to a point 60 m prior to the threshold; or

  c. sea-wall — 6 m (20 ft) step up to threshold elevation at a point 60 m prior to the threshold.

- **Airport Rules request precision approach terrain chart be published on facilities supporting Category II and III operations**

  ICAO Doc 9365 Manual of All-Weather Operations

  5.2 AERODROME FACILITIES

  Pre-threshold terrain

  5.2.5 Annex 4 requires that a precision approach terrain chart be published by States providing facilities for Category II and III operations, and Doc 8697 provides guidance on the production of suitable charts.

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Back ground (2/2)

- **Certification of landing systems request to assess ground profile under the approach path**
- **Certification Guidance materials, provides one definition of ground profile under the approach to be considered**
- **Airport Rules request precision approach terrain chart be published on facilities supporting Category II and III operations**
- **Slope variation in Radio altimeter operating area are allowed**

GM1 ADR-DSN.B.205 Radio altimeter operating area
[…] Where slope changes cannot be avoided, the rate of change between two consecutive slopes should not exceed 2 % per 30 m.

- **On runways with irregular pre-threshold operator needs to assess compatibility of aircraft with runway**

AMC3 SPA.LVO.110 ANS- and aerodrome-related requirements
SUITABLE AERODROMES – APPROACH OPERATIONS OTHER THAN EFVS OPERATIONS

*(f) Each aircraft type/equipment/runway combination should be verified by operations in CAT I or better conditions before authorising the use of autoland on any runway with **irregular pre-threshold terrain** or other foreseeable or known difficulties.*

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Issues identified

Unclear definition of irregular pre-threshold terrain

Precision approach terrain chart not recommended to published on CAT I runway, compatibility assessment of system with flare guidance cannot be achieved on CAT I runways

No guidance material on how to perform performance assessment on irregular pre-threshold terrain

HUDLS and EVS-L requires flare guidance, but no mention of irregular pre-threshold terrain to be considered in performance / operational assessment

Unclear definition of irregular pre-threshold terrain / Applicability to CAT 1 : Suggested improvements

- **Add Guidance material in GM1 ADR.OPS.A.005 Aerodrome data**

AERODROME PRE-THRESHOLD

For runways intended to be used for low visibility operation, pre-threshold terrain chart should be published as per ICAO Doc 9365 Manual of All-Weather Operations

If pre-threshold terrain presents significant variation, compatibility should be checked against limits used to certify aircraft systems providing flare guidance. If pre-threshold terrain is below or above the lower and upper limit defined in Figure 1 within the 400m prior the runway threshold, then the terrain should be classified as "irregular" as it may not be suitable with aircraft landing systems.

***ZU_3** derived from 2% slope as per GM1 ADR-DSN.B.205 Radio altimeter operating area*

***ZU_1 ZL_1** derived from standard Radio altimeter precision (+/- 3ft)*

***ZL_2** derived from 6m see wall as per AMC AWO.A.ALS.107 §5.2.2.c*

***ZL_3** derived from -12.5% slope starting at 60m as per AMC AWO.A.ALS.107 §5.2.2.b*

***X_3** derived from conservative hypothesis on AIRBUS family highest flare height (70ft)*

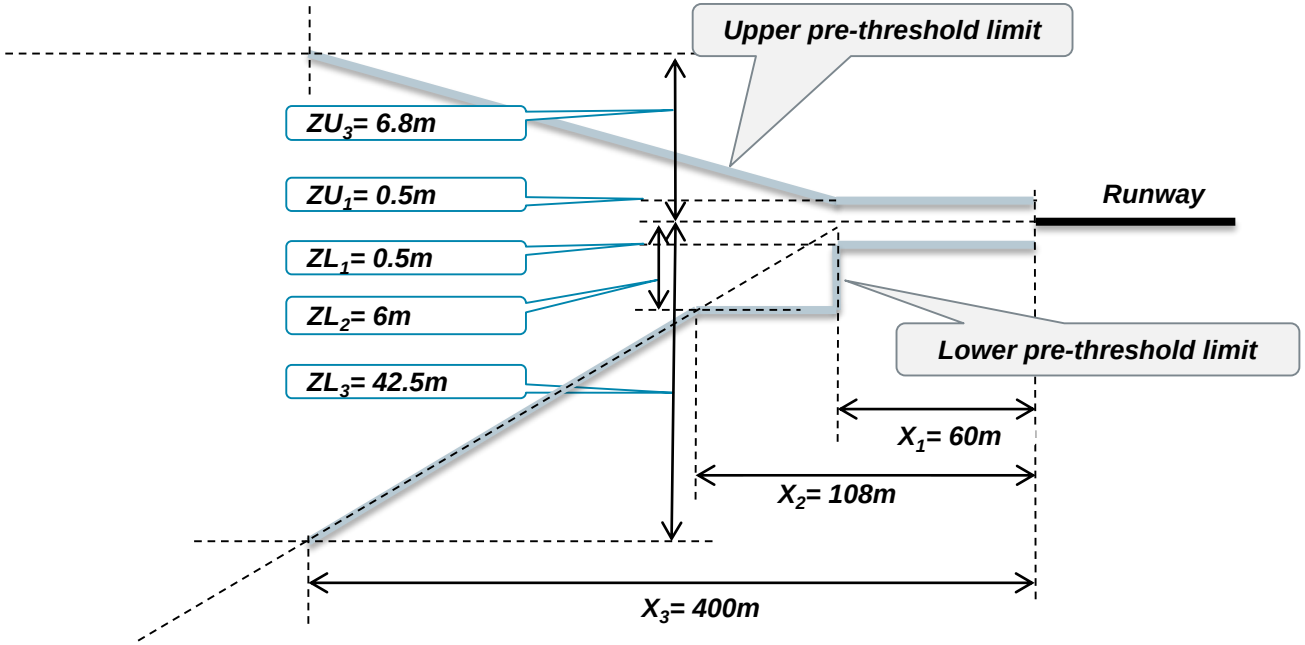

Figure 1 : Upper and lower limit of irregular pre-threshold terrain

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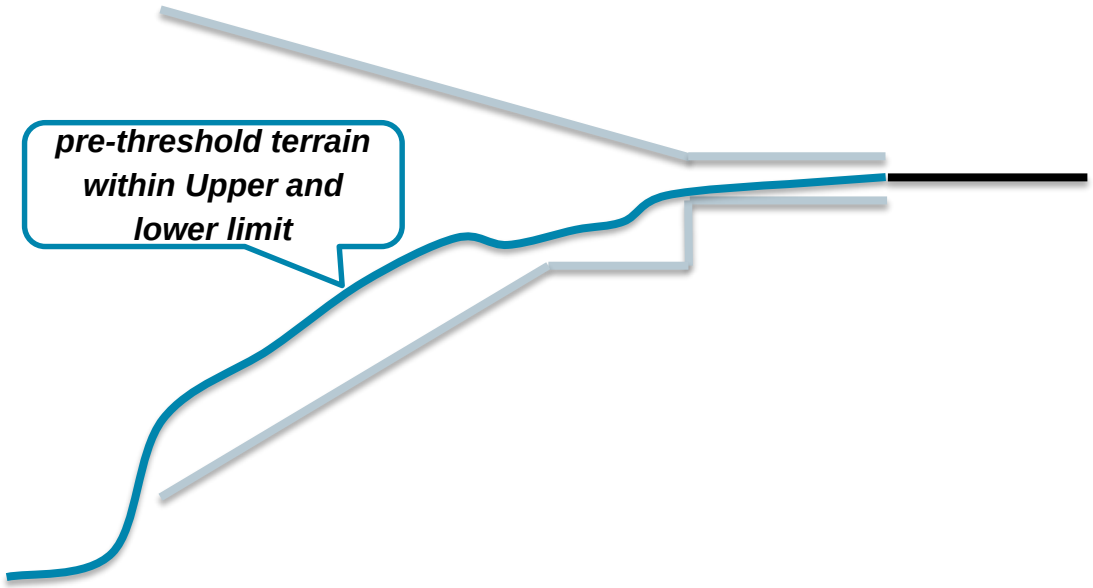
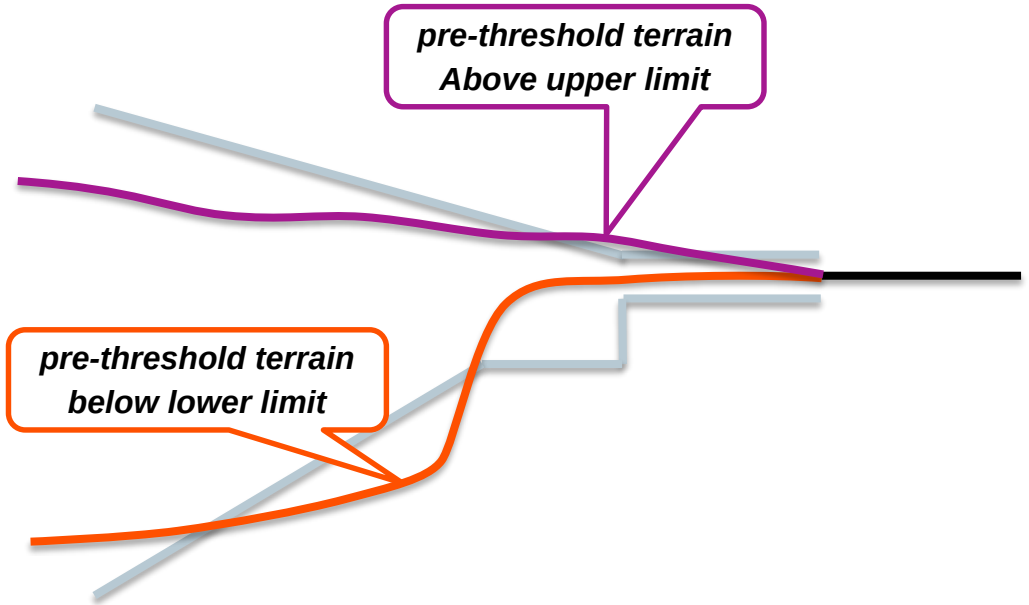
Example “regular” and “irregular” pre-threshold as per new defintion



Example of pre-threshold terrain within Upper and lower limits



Example of pre-threshold terrain above upper limits or below lower limit

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No guidance material on how to perform performance assessment on irregular pre-threshold terrain: Suggested improvements

- **Add Guidance material inspired for AC 120 xLS Appendix 4. Irregular Terrain Assessment § 2**

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HUDLS and EVS-L requires flare guidance, but no mention of irregular pre-threshold terrain to be considered in performance / operational assessment: Suggested improvements (1/3)

- **Add « ground profile under the approach path » as factors to be considered for flare guidance (HUD and EFVS-L) in CS-AWO**
  - *CS AWO.A.HUD.107 Performance demonstration*
    *Add « the effects of aerodrome conditions (e.g. elevation, landing area slope and **ground profile under the approach path**) are to be investigated »*
  - *CS AWO.A.EFVS.109 EFVS performance (h) The lateral and longitudinal touchdown performance of an EFVS-L […]*
    *Add « the effects of aerodrome conditions (e.g. elevation, landing area slope and **ground profile under the approach path**) are to be investigated »*
  - *AMC AWO.A.EFVS.103 EFVS depiction*
    *Flare cue : add « When demonstrating performance of flare cue, effect of landing area slope and **ground profile under the approach path** should be considered »*

- **Add « irregular pre-threshold terrain » consideration in AMC5 SPA.LVO.110 ANS- and aerodrome-related requirements**

VERIFYING THE SUITABILITY OF RUNWAYS FOR EFVS OPERATIONS

*(f) if the system used to preform EFVS operation contains a flare prompt/guidance, each aircraft type/equipment/runway combination should be verified by operations in CAT I or better conditions before authorising the use of EFVS-L system, on any runway with **irregular pre-threshold terrain**, if landing area presents significant longitudinal runway slopes change, (refer to GM1 ADR.OPS.A.005 Aerodrome Data) or other foreseeable or known difficulties.*

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HUDLS and EVS-L requires flare guidance, but no mention of irregular pre-threshold terrain to be considered in performance / operational assessment: Suggested improvements (2/3)

- **Extend applicability of GM4 SPA.LVO.100 to HUDLS and EVS-L**

USE OF **LANDING SYSTEM TO TOUCHDOWN (AUTOLAND, HUDLS, HGS, EVS-L**)

It may be assumed that category II and category III runways will support ~~autoland~~ **landing** systems unless the State of the aerodrome has published information indicating otherwise **or pre-threshold terrain characteristics conform with the criteria of the landing system certification**. Where other runways are to be authorised **for the use of landing system** operations, the operator should consult the aircraft manufacturer to establish any requirements for satisfactory **landing system** performance and may conduct **landing system test** in CAT I or better conditions before authorising other use of **landing system**.

HUDLS and EVS-L requires flare guidance, but no mention of irregular pre-threshold terrain to be considered in performance / operational assessment: Suggested improvements (2/2)

- **Enlarge applicability of AMC3 SPA.LVO.110 ANS (c) (4), (d) (4), (e) and (f) to all flight guidance systems**

(c) For SA CAT I operations:

(4) the pre-threshold terrain should have been surveyed and assessed as suitable with regard to the usability of the radio altimeter or other device capable of providing equivalent performance and ~~autoland~~ ***landing systems (e.g. autoland, HUDLS/HGS with flare prompt/guidance);*** *and*

[…]

(d) For SA CAT II operations:

(4) the pre-threshold terrain should have been surveyed and assessed as suitable with regard to the usability of the radio altimeter or other device capable of providing equivalent performance and ~~autoland~~ ***landing systems (e.g. autoland, HUDLS/HGS with flare prompt/guidance);*** *and*

[…]

(e) The operator should verify the suitability of a runway before authorising the use of ~~autoland~~ ***landing systems (e.g. autoland, HUDLS/HGS with flare prompt/guidance);*** *on any runway other than a PA runway category II or a PA runway category III.*

(f) Each aircraft type/equipment/runway combination should be verified by operations in CAT I or better conditions before authorising the use of ~~autoland~~ ***landing system (e.i autoland, HUDLS, EFVS-L with flare prompt/guidance)****, on any runway with irregular pre-threshold terrain or other foreseeable or known difficulties*

Backup Slides

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Existing CS AWO.A.ALS.107

CS AWO.A.ALS.107 Aerodrome conditions

Expected Aerodrome conditions (e.g. elevation, ambient temperature, runway slope and **ground profile under the approach path**) shall be considered and appropriate limitations entered in the AFM. (AMC AWO.A.ALS.106, paragraph 5).

AMC AWO.A.ALS.106 Performance demonstration

1.3 In accordance with CS AWO.A.ALS.107, the effects of aerodrome conditions (e.g. elevation, ambient temperature, runway slope and **ground profile under the approach path**) are to be investigated and, if necessary, appropriate limitations derived for inclusion in the aeroplane flight manual AFM. Guidance is given in paragraph 5.

5.2 Ground profile

5.2.1 Where use is made of radio altimeter signals in the automatic landing system, any effects of **ground profile before the runway** or along the runway on the performance of the system should be examined.

5.2.2 The family of profiles to be investigated should take due account of the way in which the system uses the radio altimeter signals at different heights on the approach. Terrain and runway up slopes, down slopes and other terrain irregularities should be investigated.

NOTE: The information on characteristics of aerodromes is contained in ICAO Annex 14. Examination of a number of airports used for automatic landing has shown that the following features may be encountered:

a. sloping runway — slopes of 0.8 %;

b. hilltop runway — 12.5 % slope up to a point 60 m prior to the threshold; or

c. sea-wall — 6 m (20 ft) step up to threshold elevation at a point 60 m prior to the threshold.

Existing **CS ADR-DSN.B.205 and GM1 ADR-DSN.B.205**

CS ADR-DSN.B.205 Radio altimeter operating area

(a) A radio altimeter operating area should be established in the pre-threshold area of a precision approach runway category II and III, and where practicable, in the pre-threshold area of a precision approach runway category I.

(b) Length of the area

A radio altimeter operating area should extend before the threshold for a distance of at least 300 m.

(c) Width of the area

A radio altimeter operating area should extend laterally, on each side of the extended centre line of the runway, to a distance of 60 m. The distance may be reduced to no less than 30 m if an safety assessment indicates that such reduction would not affect the safety of operations of aircraft.

GM1 ADR-DSN.B.205 Radio altimeter operating area

(a) In order to accommodate aeroplanes making auto-coupled approaches and automatic landings (irrespective of weather conditions), it is desirable that slope changes be avoided or kept to a minimum, on a rectangular area at least 300 m long before the threshold of a precision approach PA runway. The area should be symmetrical about the extended centre line, 120 m wide. The width may be reduced to no less than 60 m if a safety assessment indicates that such reduction would not affect the safety of operations of aircraft. The radio altimeter operating area is needed because for aeroplanes which are equipped with a radio altimeter for final height and flare guidance, when the aeroplane is above the terrain immediately prior to the threshold, the radio altimeter begins to provide information to the automatic pilot for auto-flare. Where slope changes cannot be avoided, the rate of change between two consecutive slopes should not exceed 2 % per 30 m. .

(b) With a radio altimeter operating area in the pre-threshold area of a precision approach runway, the margin to calculate the decision altitude (DA) should be smaller and the usability of the adjacent runway may be enhanced.

(c) For precision approach category I runways intended for SA CAT I approach operations, the establishment of a radio altimeter operating area may enhance the usability of the adjacent runway and maximise the benefits of reduced DH and RVR minima.

(d) Further Additional guidance on radio altimeter operating area is given in Manual of All-Weather Operations, (ICAO, Doc 9365, Section 5.2). Guidance on the use of radio altimeters is given in the ICAO, PANS-OPS, Volume II, Part II, Section 1.

Existing **SPA.LVO.110**

SPA.LVO.110 *General operating requirements* ANS- and aerodrome-related requirements

The operator shall ensure that only aerodromes and instrument procedures suitable for the intended operations are used for LVOs and operations with operational credits.

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Existing **AMC3 SPA.LVO.110**

AMC3 SPA.LVO.110 ANS- and aerodrome-related requirements

SUITABLE AERODROMES – APPROACH OPERATIONS OTHER THAN EFVS OPERATIONS

(a) For CAT II instrument approach operations, a PA runway category II or category III should be used.

(b) For CAT III instrument approach operations, a PA runway category III should be used.

(c) For SA CAT I operations:

(1) where an ILS/MLS is used, it should not be promulgated with any restrictions affecting its usability and should not be offset from the extended centreline;

(2) where an ILS is used, it should be at least the minimum ILS classification stated in the AFM and meet any of the required minimum performance parameters stated in the AFM;

(3) the glide path angle is 3.0o unless the operator has assessed that a steeper glide path, not exceeding 3.5o, provides an equivalent level of safety;

(4) the pre-threshold terrain should have been surveyed and assessed as suitable with regard to the usability of the radio altimeter or other device capable of providing equivalent performance and autoland systems; and

(5) runway markings, category I approach lights and the following runway lights: runway edge lights, threshold lights, and runway end lights should be available.

(d) For SA CAT II operations:

(1) where an ILS/MLS is used, it should not be promulgated with any restrictions affecting its usability and not be offset from the extended centreline;

(2) where an ILS is used, it should be certified to class II/D/3;

(3) the glide path angle is 3.0o unless the operator has assessed that a steeper glide path, not exceeding 3.5O, provides an equivalent level of safety;

(4) the pre-threshold terrain should have been surveyed and assessed as suitable with regard to the usability of the radio altimeter or other device capable of providing equivalent performance and autoland systems; and

(5) the following visual aids should be available:

(i) standard runway markings, category I approach lights and the following runway lights: runway edge lights, threshold lights and runway end lights; and

(ii) for operations with an RVR of less than 400 m, additionally TDZ and/or centreline lights.

(e) The operator should verify the suitability of a runway before authorising the use of autoland on any runway other than a PA runway category II or a PA runway category III.

(f) Each aircraft type/equipment/runway combination should be verified by operations in CAT I or better conditions before authorising the use of autoland on any **runway with irregular pre-threshold terrain** or other foreseeable or known difficulties.

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Existing **GM4 SPA.LVO.110**

GM4 SPA.LVO.110 ANS- and aerodrome-related requirements

USE OF AUTOLAND

It may be assumed that category II and category III runways will support autoland systems unless the State of the aerodrome has published information indicating otherwise. Where other runways are to be authorised for autoland operations, the operator should consult the aircraft manufacturer to establish any requirements for satisfactory autoland performance and may conduct autoland in CAT I or better conditions before authorising other use of autoland.

If an operator is not aware of current CAT II/III operations at a particular runway by some other operator and similar aircraft type, it is a good practice for the operator to have conducted at least one approach using the Category II or III system and procedures and preferably with LVPs in effect, to each runway intended for Category II/III operations in weather better than that requiring the use of Category II minima.

ICAO Doc 9365 Manual of All-Weather Operations

3.2 AERODROME FACILITIES AND REQUIREMENTS

3.2.6 The topography of the terrain under the approach path can be important in all-weather operations because it can affect radio altimeter operation. Radio altimeters are useful for any operation and are typically required for autoland, HUD guidance to landing, and for Category II and Category III operations. The ground under the last part of the final approach should be regular and preferably level. This is important to ensure correct radio altimeter operation for pilot use, as well as for the terrain awareness and warning system and automatic landing system operation. **At runways with significant irregularity of the terrain under the approach path**, it may be necessary for an operator to conduct aeroplane model-specific assessments of the effect of the irregular terrain on approach and landing operations. Isolated buildings or projections that do not materially disturb radio altimeter indications are usually acceptable (see also 5.2.5).

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ICAO Doc 9365 Manual of All-Weather Operations

5.2 AERODROME FACILITIES

Pre-threshold terrain

5.2.5 Annex 4 requires that a precision approach terrain chart be published by States providing facilities for Category II and III operations, and Doc 8697 provides guidance on the production of suitable charts. The operation of some automatic landing systems is dependent on the radio altimeters. The flare profile, rate of descent at touchdown, and the distance of the touchdown point from the runway threshold can be affected by the profile of the terrain immediately prior to the threshold. The terrain which is most critical lies in an area 60 m either side of the runway centre line extending into the approach area to a distance of at least 300 m before the threshold. The guidance material in Annex 14, Volume I, makes reference to the **maximum slopes of pre-threshold terrain which are normally acceptable** when planning a new runway on which operations are to include coupled approaches and automatic landing. However, radio altimeter inputs may also be required when the aeroplane is on final approach as much as 8 km (5 NM) from touchdown. At aerodromes where the terrain beneath the approach flight path is not level, abnormal autopilot behaviour may result as follows

a) where the terrain under the approach is markedly lower than the threshold, the radio altimeter input for a particular stage of the approach may be signalled later than required;

b) where the terrain under the approach is markedly higher than the threshold, the radio altimeter input for a particular stage of the approach may be signalled sooner than required; and

c) where the terrain consists of a series of ridges and valleys, an input of incorrect altitude information to the automatic flight control systems may take place. This may result in unacceptable autopilot and flight-path behaviour

ICAO Doc 9365 Manual of All-Weather Operations

5.2.6 Where the characteristics of the terrain are considered marginal for a particular aeroplane type, a demonstration should be made to determine that the performance or function of the automatic flight control system is not adversely affected. **The demonstration may take the form of flight trials or a suitable analysis**. Any additions or alterations to existing structures or terrain in the pre-threshold area should be considered for their effect on published information. In the event that an alteration has a significant effect on radio altimeters, the amended data relating to the terrain profile should be rapidly disseminated.

5.2.7 In accordance with Annex 4, Chapter 6, the precision approach terrain chart depicts a profile of the terrain to a distance of 900 m (3 000 ft) from the threshold along the extended centre line of the runway. Therefore determination of DA/H by means of the radio altimeter should consider the approach terrain out to 900 m from the threshold.

ICAO Annex 14 Volume 1 Aerodrome Design and Operation

3.8 Radio altimeter operating area

General

3.8.1 **Recommendation.—** *A radio altimeter operating area should be established in the pre-threshold area of a precision approach runway.*

Length of the area

3.8.2 **Recommendation.—** *A radio altimeter operating area should extend before the threshold for a distance of at least 300 m.*

Width of the area

3.8.3 **Recommendation.—** *A radio altimeter operating area should extend laterally, on each side of the extended centre line of the runway, to a distance of 60 m, except that, when special circumstances so warrant, the distance may be reduced to no less than 30 m if an aeronautical study indicates that such reduction would not affect the safety of operations of aircraft.*

Longitudinal slope changes

3.8.4 **Recommendation.—** *On a radio altimeter operating area, slope changes should be avoided or kept to a minimum. Where slope changes cannot be avoided, the slope changes should be as gradual as practicable and abrupt changes or sudden reversals of slopes avoided.* ***The rate of change between two consecutive slopes should not exceed 2 per cent per 30 m.***

Note.— Guidance on radio altimeter operating area is given in Attachment A, Section 4.3, and in the Manual of All-Weather Operations, *(Doc 9365), Section 5.2. Guidance on the use of radio altimeter is given in the PANS-OPS, Volume II, Part II, Section 1.*

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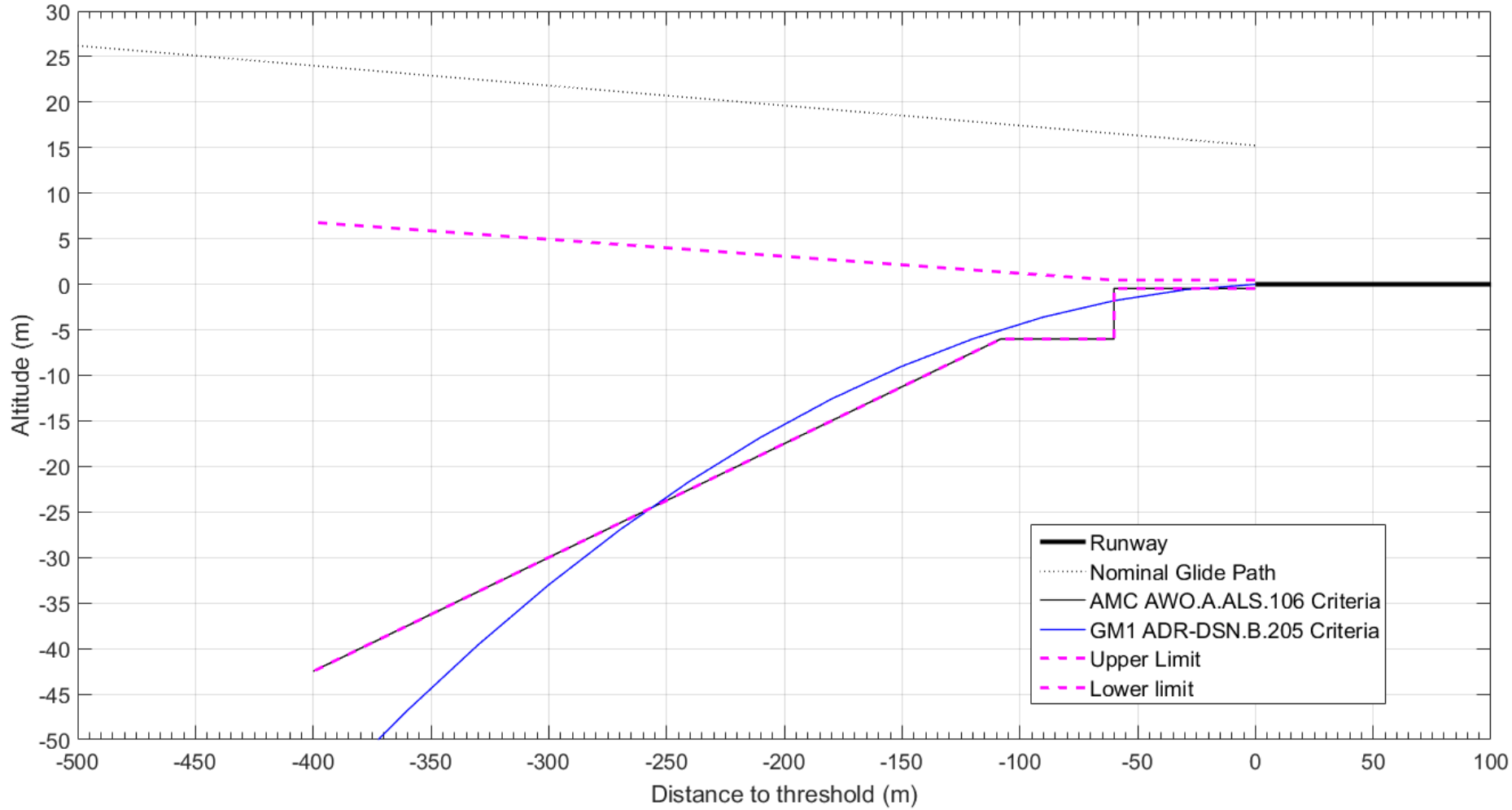
ICAO Annex 14 Volume 1 Aerodrome Design and Operation Attachement A

4.3 Radio altimeter operating area

In order to accommodate aeroplanes making auto-coupled approaches and automatic landings (irrespective of weatherconditions) it is desirable that slope changes be avoided or kept to a minimum, on a rectangular area at least 300 m long before the threshold of a precision approach runway. The area should be symmetrical about the extended centre line, 120 m wide. When special circumstances so warrant, the width may be reduced to no less than 60 m if an aeronautical study indicates that such reduction would not affect the safety of operations of aircraft. This is desirable because these aeroplanes are equipped with a radio altimeter for final height and flare guidance, and when the aeroplane is above the terrain immediately prior to the threshold, the radio altimeter will begin to provide information to the automatic pilot for auto-flare.

Where slope changes cannot be avoided, the rate of change between two consecutive slopes should not exceed 2 per cent per 30 m.

Existing criterias / New criteria



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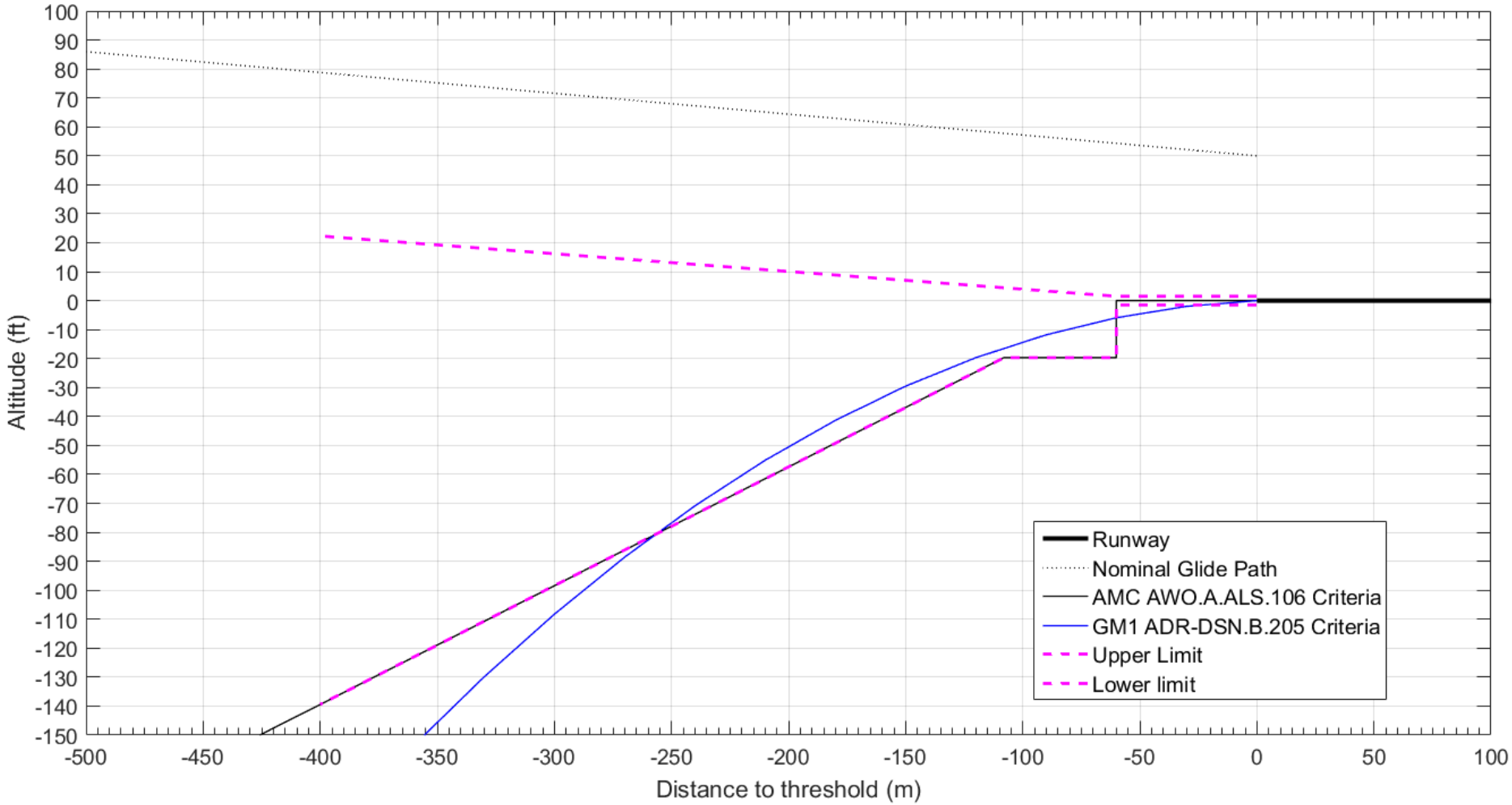
Existing criterias / New criteria



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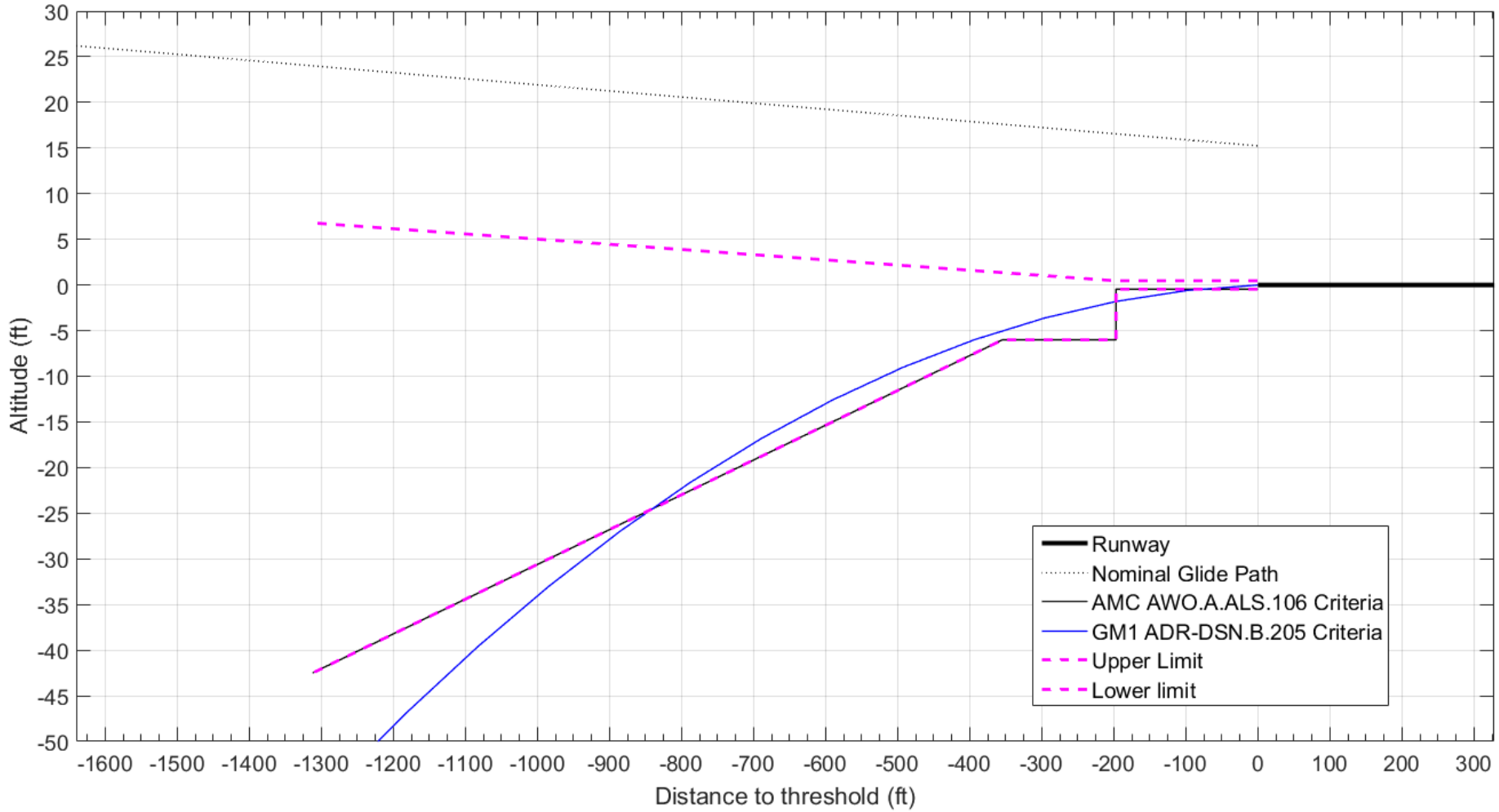
Existing criterias / New criteria



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Radio Altimeter standard accuracy

STD-ED30-016

The accuracy of height information shall be measured under standard conditions for each height output. The errors must not be in excess of those set forth in Table 1, hereafter.

Every parasitic effect which might affect the accuracy, such a doppler shift, step error of height lag, shall be included in the accuracy assessment.

The measurement conditions need not be applied simultaneously but may be combined by analytical methods.

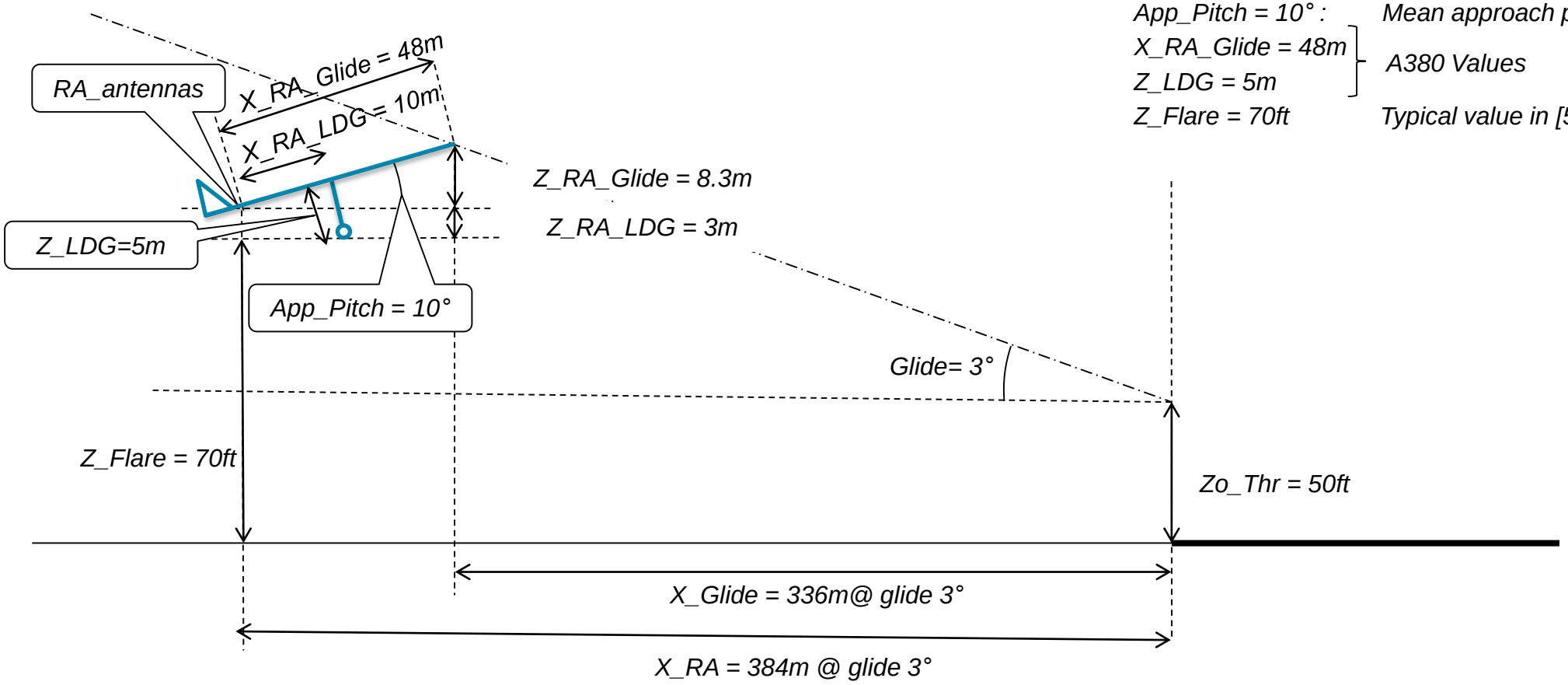
TABLE 1

ACCURACY REQUIREMENTS		
Height range	Accuracy of height information displayed to the crew (1)	Accuracy of electrical height data output
3 to 100 feet (1 to 30m)	± 5 feet (1.5m)	± 3 feet (0.9m)
100 to 500 feet (30m to 150m)	± 5% of true height	± 3% of true height
500 feet (150m) to the maximum of the scale (1)	± 7% of true height	± 5% of true height

Maximum distance to Threshold

Conservatives assumptions :

Zo_Thr = 50ft :	*Can vary from 55 to 50ft*
Glide slope = 2.5:	*Can vary from 2.5° to 3.5°*
App_Pitch = 10° :	*Mean approach pitch 2 to 4°*
X_RA_Glide = 48m	*A380 Values*
Z_LDG = 5m	
Z_Flare = 70ft	*Typical value in [50ft-60ft] range*



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