



**Guidance Material  
to JCAR Part 14  
(Aerodrome Design and Operations)**

**34 GM-01**

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## **FOREWORD**

The purpose of this guidance material is to provide guidance, which is supplementary to JCAR 14, and provide additional information to help implementation the standards and regulations specified in JCAR14 and ensure compliance with international and local regulations, it includes illustrations, explanations, and examples.

## **REFERENCE**

- Aerodrome Design and Operations — JCAR Part (14).
- ICAO Annex 14 (Aerodromes) - Volume I (Aerodrome Design and Operations).



**Capt. Haitham Misto**  
**Chief Commissioner /CEO**



## CHAPTER 1

### GENERAL

#### 1.1 Number, Sitting and Orientation of Runways.

Many factors should be taken into account in the determination of the sitting and orientation of runways. Without attempting to provide an exhaustive list of these factors nor an analysis of their effects, it appears useful to indicate those which most frequently require study. These factors may be classified under four headings:

- 1.1.1 **Type of operation.** Attention should be paid in particular to whether the aerodrome is to be used in all meteorological conditions or only in visual meteorological conditions, and whether it is intended for use by day and night, or only by day.
- 1.1.2 **Climatological conditions.** A study of the wind distribution should be made to determine the usability factor. In this regard, the following comments should be taken into account:
- (a) Wind statistics used for the calculation of the usability factor are normally available in ranges of speed and direction, and the accuracy of the results obtained depends, to a large extent, on the assumed distribution of observations within these ranges. In the absence of any sure information as to the true distribution, it is usual to assume a uniform distribution since, in relation to the most favorable runway orientations, this generally results in a slightly conservative for the usability factor.
  - (b) The maximum mean cross-wind components given in JCAR Part 14, Chapter 3, paragraph 3.1.3 refer to normal circumstances. There are some factors which may require that a reduction of those maximum values be taken into account at a particular aerodrome. These include:
    - (1) the wide variations which may exist, in handling characteristics and maximum permissible cross-wind components, among diverse types of airplanes (including future types) within each of the three groups given in JCAR Part 14, Chapter 3 paragraph 3.1.3;
    - (2) prevalence and nature of gusts;
    - (3) prevalence and nature of turbulence;
    - (4) the availability of a secondary runway;
    - (5) the width of runways;

- (6) the runway surface conditions — water, snow and ice on the runway materially reduce the allowable crosswind component; and
- (7) The strength of the wind associated with the limiting cross-wind component.

A study should also be made of the occurrence of poor visibility and/or low cloud base. Account should be taken of their frequency as well as the accompanying wind direction and speed.

**1.1.3 Topography of the aerodrome site**, its approaches, and surroundings, particularly:

- (a) compliance with the obstacle limitation surfaces;
- (b) Current and future land use. The orientation and layout should be selected so as to protect as far as possible the particularly sensitive areas such as residential, school and hospital zones from the discomfort caused by aircraft noise. Detailed information on this topic is provided in CARC Guidance Material Land Use and Environmental Control 34 GM-06, and in; ICAO Guidance on the Balanced Approach to Aircraft Noise Management (Doc 9829).
- (c) current and future runway lengths to be provided;
- (d) construction costs; and
- (e) possibility of installing suitable non-visual and visual aids for approach-to-land.

**1.1.4 Air traffic in the vicinity of the aerodrome**, particularly:

- (a) proximity of other aerodromes or ATS routes;
- (b) traffic density; and
- (c) Air traffic control and missed approach procedures.

**1.2 Number of runways in each direction.**

The number of runways to be provided in each direction depends on the number of aircraft movements to be catered to.



## CHAPTER 2

### Clearways and Stop ways

- 2.1 The decision to provide a stopway and/or a clearway as an alternative to an increased length of runway will depend on the physical characteristics of the area beyond the runway end, and on the operating performance requirements of the prospective airplanes. The runway, stopway and clearway lengths to be provided are determined by the airplane takeoff performance, but a check should also be made of the landing distance required by the airplanes using the runway to ensure that adequate runway length is provided for landing. The length of a clearway, however, cannot exceed half the length of take-off run available.
- 2.2 The airplane performance operating limitations require a length which is enough to ensure that the airplane can, after starting a take-off, either be brought safely to a stop or complete the take-off safely. For the purpose of discussion, it is supposed that the runway, stopway and clearway lengths provided at the aerodrome are only just adequate for the airplane requiring the longest take-off and accelerate-stop distances, taking into account its take-off mass, runway characteristics and ambient atmospheric conditions. Under these circumstances there is, for each take-off, a speed, called the decision speed; below this speed, the take-off must be abandoned if an engine fails, while above it the take-off must be completed. A very long take-off run and take-off distance would be required to complete a take-off when an engine fails before the decision speed is reached, because of the insufficient speed and the reduced power available. There would be no difficulty in stopping in the remaining accelerate-stop distance available provided action is taken immediately. In these circumstances the correct course of action would be to abandon the take-off.
- 2.3 On the other hand, if an engine fails after the decision speed is reached, the airplane will have sufficient speed and power available to complete the take-off safely in the remaining take-off distance available. However, because of the high speed, there would be difficulty in stopping the airplane in the remaining accelerate-stop distance available.
- 2.4 The decision speed is not a fixed speed for any airplane, but can be selected by the pilot within limits to suit the accelerate-stop and take-off distance available, airplane take-off mass, runway characteristics, and ambient atmospheric conditions at the aerodrome. Normally, a higher decision speed is selected as the accelerate-stop distance available increases.
- 2.5 A variety of combinations of accelerate-stop distances required and take-off distances required can be obtained to accommodate a particular airplane, taking into account the airplane take-off mass, runway characteristics, and ambient atmospheric conditions. Each combination requires its particular length of take-off run.

- 2.6 The most familiar case is where the decision speed is such that the take-off distance required is equal to the accelerate-stop distance required; this value is known as the balanced field length. Where stopway and clearway are not provided, these distances are both equal to the runway length. However, if landing distance is for the moment ignored, runway is not essential for the whole of the balanced field length, as the take-off run required is, of course, less than the balanced field length. The balanced field length can, therefore, be provided by a runway supplemented by an equal length of clearway and stopway, instead of wholly as a runway. If the runway is used for take-off in both directions, an equal length of clearway and stopway has to be provided at each runway end. The saving in runway length is, therefore, bought at the cost of a greater overall length.
- 2.7 In case economic considerations preclude the provision of stopway and, as a result, only runway and clearway are to be provided, the runway length (neglecting landing requirements) should be equal to the accelerate-stop distance required or the take-off run required, whichever is the greater. The take-off distance available will be the length of the runway plus the length of clearway.
- 2.8 The minimum runway length and the maximum stopway or clearway length to be provided may be determined as follows, from the data in the airplane flight manual for the airplane considered to be critical from the viewpoint of runway length requirements:
- (a) If a stopway is economically possible, the lengths to be provided are those for the balanced field length. The runway length is the take-off run required or the landing distance required, whichever is the greater. If the accelerate-stop distance required is greater than the runway length so determined, the excess may be provided as stopway, usually at each end of the runway. In addition, a clearway of the same length as the stopway must also be provided;
  - (b) If a stopway is not to be provided, the runway length is the landing distance required, or if it is greater, the accelerate-stop distance required, which corresponds to the lowest practical value of the decision speed. The excess of the take-off distance required over the runway length may be provided as clearway, usually at each end of the runway.
- 2.9 In addition to the above consideration, the concept of clearways in certain circumstances can be applied to a situation where the take-off distance required for all engines operating exceeds that required for the engine failure case.
- 2.10 The economy of a stopway can be entirely lost if, after each usage, it must be re-graded and compacted. Therefore, it should be designed to withstand at least a certain number of loadings of the airplane which the stopway is intended to serve without inducing structural damage to the airplane.



## CHAPTER 3

### Calculation of Declared Distances

- 3.1 The declared distances to be calculated for each runway direction comprise: the take-off run available (TORA), take-off distance available (TODA), accelerate-stop distance available (ASDA), and landing distance available (LDA).
- 3.2 Where a runway is not provided with a stopway or clearway and the threshold is located at the extremity of the runway, the four declared distances should normally be equal to the length of the runway, as shown in Figure A-1 (A).
- 3.3 Where a runway is provided with a clearway (CWY), then the TODA will include the length of clearway, as shown in Figure A-1 (B).
- 3.4 Where a runway is provided with a stopway (SWY), then the ASDA will include the length of stopway, as shown in Figure A-1 (C).
- 3.5 Where a runway has a displaced threshold, then the LDA will be reduced by the distance the threshold is displaced, as shown in Figure A-1 (D). A displaced threshold affects only the LDA for approaches made to that threshold; all declared distances for operations in the reciprocal direction are unaffected.
- 3.6 Figures A-1(B) through A-1(D) illustrate a runway provided with a clearway or a stopway or having a displaced threshold. Where more than one of these features exist, then more than one of the declared distances will be modified — but the modification will follow the same principle illustrated. An example showing a situation where all these features exist is shown in Figure A-1(E).
- 3.7 A suggested format for providing information on declared distances is given in Figure A-1 (F). If a runway direction cannot be used for take-off or landing, or both, because it is operationally forbidden, then this should be declared and the words “not usable” or the abbreviation “NU” entered.

## CHAPTER 4

### Slopes on a Runway

#### 4.1 Distance between slope changes

The following example illustrates how the distance between slope changes is to be determined (see Figure A-2):

D for a runway where the code number is 3 should be at least:

$$15\,000 (|x - y| + |y - z|) \text{ m}$$

$|x - y|$  being the absolute numerical value of  $x - y$

$|y - z|$  being the absolute numerical value of  $y - z$

Assuming  $x = + 0.01$

$$y = - 0.005$$

$$z = + 0.005$$

then  $|x - y| = 0.015$

$$|y - z| = 0.01$$

To comply with the specifications, D should be not less than:

$$15\,000 (0.015 + 0.01) \text{ m}$$

that is:  $15\,000 \times 0.025 = 375 \text{ m}$

#### 4.2 Consideration of longitudinal and transverse slopes

When a runway is planned that will combine the extreme values for the slopes and changes in slope permitted under JCAR Part 14, Chapter 3, 3.1.13 to 3.1.19, a study should be made to ensure that the resulting surface profile will not hamper the operation of airplanes.

### **4.3 Radio altimeter operating area**

In order to accommodate airplanes 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 runway. The area should be symmetrical about the extended center 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 airplanes are equipped with a radio altimeter for final height and flare guidance, and when the airplane 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.



## CHAPTER 5

### Runway Surface Evenness

- 5.1 In adopting tolerances for runway surface irregularities, the following standard of construction is achievable for short distances of 3 m and conforms to good engineering practice:

Except across the crown of a camber or across drainage channels, the finished surface of the wearing course is to be of such regularity that, when tested with a 3 m straightedge placed anywhere in any direction on the surface, there is no deviation greater than 3 mm between the bottom of the straight-edge and the surface of the pavement anywhere along the straight edge.

- 5.2 Caution should also be exercised when inserting runway lights or drainage grilles in runway surfaces to ensure that adequate smoothness of the surface is maintained.
- 5.3 The operation of aircraft and differential settlement of surface foundations will eventually lead to increases in surface irregularities. Small deviations in the above tolerances will not seriously hamper aircraft operations. In general, isolated irregularities of the order of 2.5 cm to 3 cm over a 45 m distance are acceptable, as shown in Figure A-3. Although maximum acceptable deviation varies with the type and speed of an aircraft, the limits of acceptable surface irregularities can be estimated to a reasonable extent. The following table describes acceptable tolerable and excessive limits.
- (a) if the surface irregularities exceed the heights defined by the acceptable limit curve but are less than the heights defined by the tolerable limit curve, at the specified minimum acceptable length, herein noted by the tolerable region, then maintenance action should be planned. The runway may remain in service. This region is the start of possible passenger and pilot discomfort;
  - (b) if the surface irregularities exceed the heights defined by the tolerable limit curve, but are less than the heights defined by the excessive limit curve, at the specified minimum acceptable length, herein noted by the excessive region, then maintenance corrective action is mandatory to restore the condition to the acceptable region. The runway may remain in service but be repaired within a reasonable period. This region could lead to the risk of possible aircraft structural damage due to a single event or fatigue failure over time; and
  - (c) if the surface irregularities exceed the heights defined by the excessive limit curve, at the specified minimum acceptable length, herein noted by the unacceptable region, then the area of the runway where the roughness has been identified warrants closure. Repairs must be made to restore the condition to within the acceptable limit region and the aircraft operators may be advised accordingly. This region runs the extreme risk of a structural failure and must be addressed immediately.



Surface Irregularity	Length of Irregularity (m)								
	3	6	9	12	15	20	30	45	60
Acceptable surface irregularity height (cm)	2.9	3.8	4.5	5	5.4	5.9	6.5	8.5	10
Tolerable Surface Irregularity Height (cm)	3.9	5.5	6.8	7.8	8.6	9.6	11	13.6	16
Excessive surface irregularity height (cm)	5.8	7.6	9.1	10	10.8	11.9	13.9	17	20

*Note that "Surface Irregularity" is defined herein to mean isolated surface elevation deviations that do not lie along a uniform slope through any given section of a runway. For the purposes of this concern, a "section of a runway" is defined herein to mean a segment of a runway throughout which a continuing general uphill, downhill or flat slope is prevalent. The length of this section is generally between 30 and 60 metres, and can be greater, depending on the longitudinal profile and the condition of the pavement.*

The maximum tolerable step type bump, such as that which could exist between adjacent slabs, is simply the bump height corresponding to zero bump length at the upper end of the tolerable region of the roughness criteria of Figure A-3. The bump height at this location is 1.75 cm.

5.4 The following figure illustrates a comparison of the surface roughness criteria with those developed by the United States Federal Aviation Administration.

*Note: Further guidance regarding temporary slopes for overlay works on operational runways can be found in CARC Guidance Material Pavements 34 GM-09.*

5.5 Deformation of the runway with time may also increase the possibility of the formation of water pools. Pools as shallow as approximately 3 mm in depth, particularly if they are located where they are likely to be encountered at high speed by landing airplanes, can induce aquaplaning, which can then be sustained on a wet runway by a much shallower depth of water. Improved guidance regarding the significant length and depth of pools relative to aquaplaning is the subject of further research. It is, of course, especially necessary to prevent pools from forming whenever there is a possibility that they might become frozen.

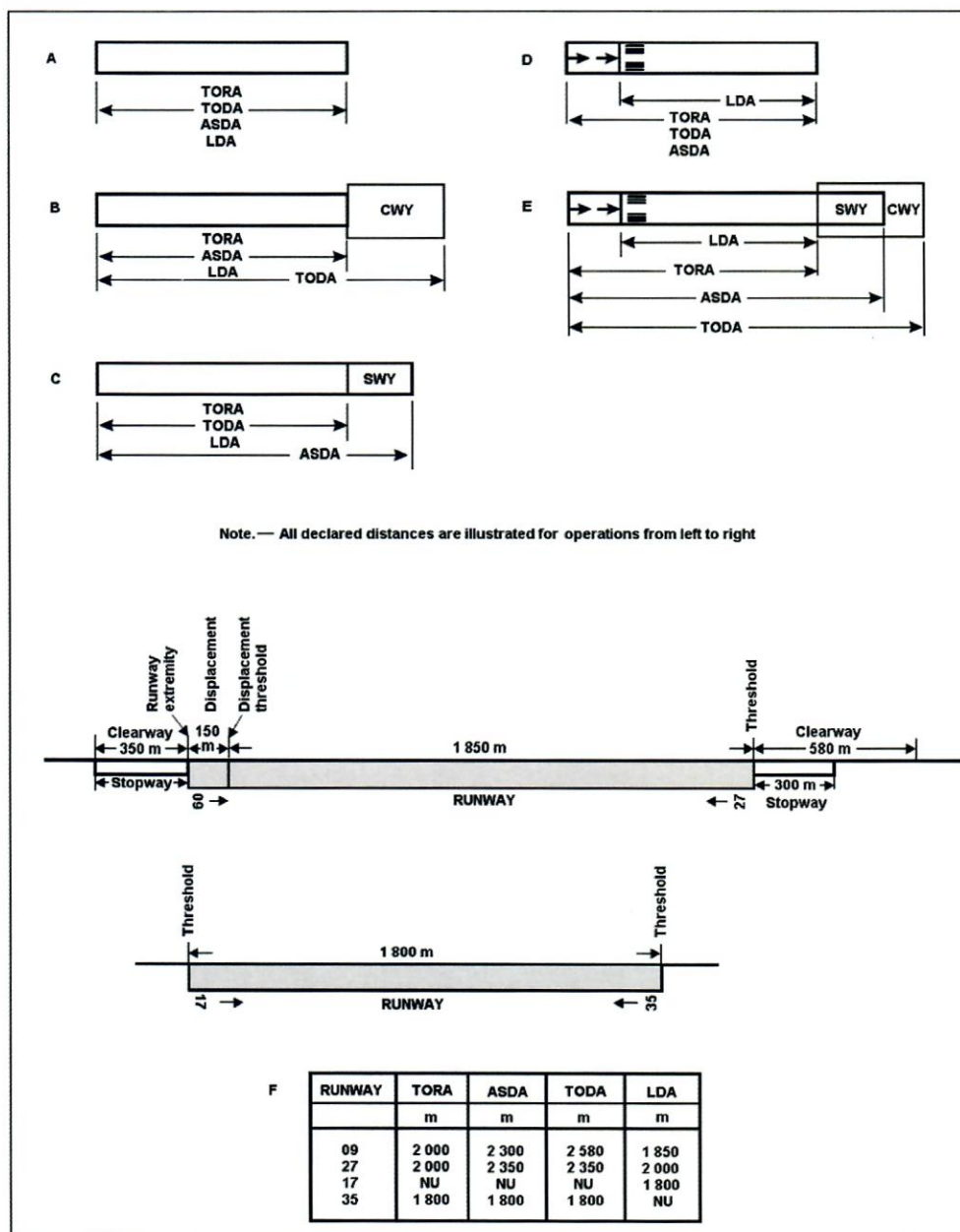


Figure A-1. Illustration of declared distances

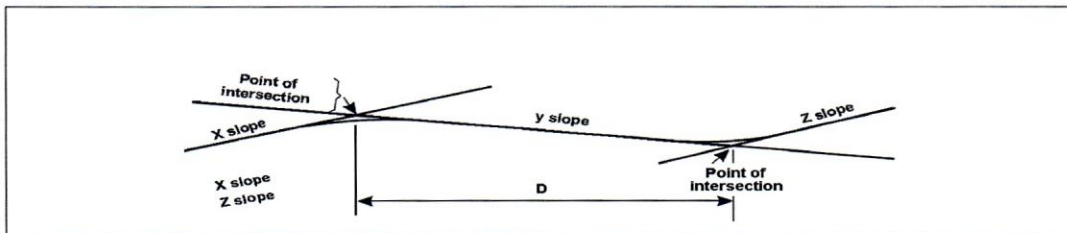
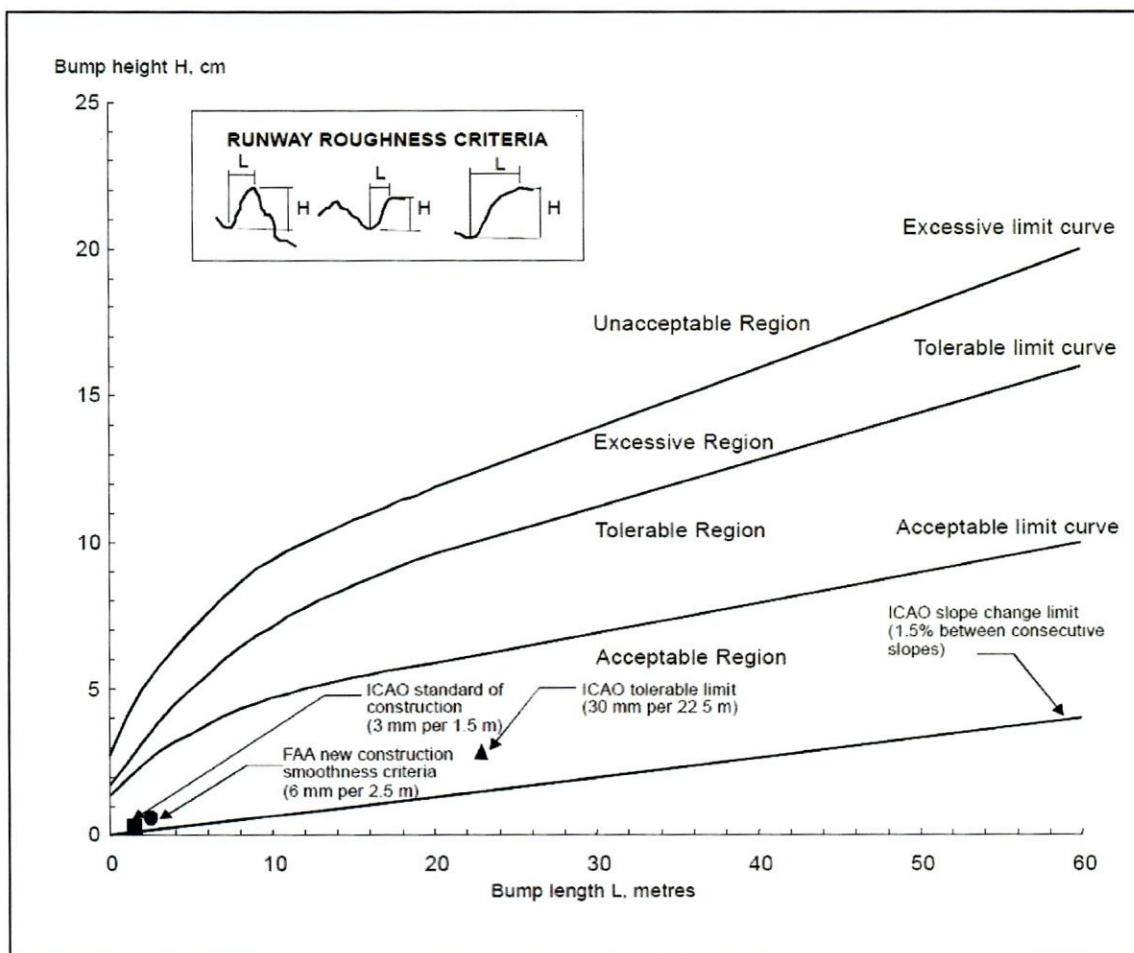


Figure A-2. Profile on centre line of runway



*Note: These criteria address single event roughness, not long wavelength harmonic effects nor the effect of repetitive surface undulations.*

Figure A-3. Comparison of Roughness Criteria



## CHAPTER 6

### Runway Condition Report for Reporting Runway Surface Condition

- 6.1 On a global level, movement areas are exposed to a multitude of climatic conditions and consequently a significant difference in the condition to be reported. The runway condition report (RCR) describes a basic methodology applicable for all these climatic variations and is structured in such a way that States can adjust them to the climatic conditions applicable for that State or region.
- 6.2 The concept of the RCR is premised on:
- a) an agreed set of criteria used in a consistent manner for runway surface condition assessment, aeroplane (performance) certification and operational performance calculation;
  - b) a unique runway condition code (RWYCC) linking the agreed set of criteria with the aircraft landing and takeoff performance table, and related to the braking action experienced and eventually reported by flight crews;
  - c) reporting of contaminant type and depth that is relevant to take-off performance;
  - d) a standardized common terminology and phraseology for the description of runway surface conditions that can be used by aerodrome operator inspection personnel, air traffic controllers, aircraft operators and flight crew; and
  - e) globally-harmonized procedures for the establishment of the RWYCC with a built-in flexibility to allow for local variations to match the specific weather, infrastructure and other particular conditions.
- 6.3 These harmonized procedures are reflected in a runway condition assessment matrix (RCAM) which correlates the RWYCC, the agreed set of criteria and the aircraft braking action which the flight crew should expect for each value of the RWYCC.
- 6.4 Procedures which relate to the use of the RCAM are provided in the PANS-Aerodromes 34 GM-15
- 6.5 It is recognized that information provided by the aerodrome's personnel assessing and reporting runway surface condition is crucial to the effectiveness of the runway condition report. A misreported runway condition alone should not lead to an accident or incident. Operational margins should cover for a reasonable error in the assessment, including unreported changes in the runway condition. But a misreported runway condition can mean that the margins are no longer available to



cover for other operational variance (such as unexpected tailwind, high and fast approach above threshold or long flare).

- 6.6 This is further amplified by the need for providing the assessed information in the proper format for dissemination, which requires insight into the limitations set by the syntax for dissemination. This in turn restricts the wording of plain text remarks that can be provided.
- 6.7 It is important to follow standard procedures when providing assessed information on the runway surface conditions to ensure that safety is not compromised when aeroplanes use wet or contaminated runways. Personnel should be trained in the relevant fields of competence and their competence verified in a manner required by the State to ensure confidence in their assessments.
- 6.8 The training syllabus may include initial and periodic recurrent training in the following areas:
- (a) aerodrome familiarization, including aerodrome markings, signs and lighting;
  - (b) aerodrome procedures as described in the aerodrome manual;
  - (c) aerodrome emergency plan;
  - (d) Notice to Airmen (NOTAM) initiation procedures;
  - (e) completion of/initiation procedures for RCR;
  - (f) aerodrome driving rules;
  - (g) air traffic control procedures on the movement area;
  - (h) radiotelephone operating procedures;
  - (i) phraseology used in aerodrome control, including the ICAO spelling alphabet;
  - (j) aerodrome inspection procedures and techniques;
  - (k) type of runway contaminants and reporting;
  - (l) assessment and reporting of runway surface friction characteristics;
  - (m) use of runway friction measurement device;
  - (n) calibration and maintenance of runway friction measurement device;
  - (o) awareness of uncertainties related to l) and m); and
  - (p) low visibility procedures.

## CHAPTER 7

### Drainage Characteristics of the Movement Area and Adjacent Areas

#### 7.1 General

7.1.1 Rapid drainage of surface water is a primary safety consideration in the design, construction and maintenance of movement area and adjacent areas. The objective is to minimize water depth on the surface by draining water off the runway in the shortest path possible and particularly out of the area of the wheel path. There are two distinct drainage processes taking place:

- (a) natural drainage of the surface water from the top of the pavement surface until it reaches the final recipient such as rivers or other water bodies; and
- (b) dynamic drainage of the surface water trapped under a moving tire until it reaches outside the tire-to-ground contact area.

7.1.2 Both processes can be controlled through:

- (a) design;
- (b) construction; and
- (c) maintenance.

of the pavements in order to prevent accumulation of water on the pavement surface.

#### 7.2 Design of pavement

7.2.1 Surface drainage is a basic requirement and serves to minimize water depth on the surface. The objective is to drain water off the runway in the shortest path. Adequate surface drainage is provided primarily by an appropriately sloped surface (in both the longitudinal and transverse directions). The resulting combined longitudinal and transverse slope is the path for the drainage runoff. This path can be shortened by adding transverse grooves.

7.2.2 Dynamic drainage is achieved through built-in texture in the pavement surface. The rolling tire builds up water pressure and squeezes the water out the escape channels provided by the texture. The dynamic drainage of the tire-to-ground contact area may be improved by adding transverse grooves provided that they are subject to rigorous maintenance.



### 7.3 Construction of pavement

- 7.3.1 Through construction, the drainage characteristics of the surface are built into the pavement. These surface characteristics are:
- (a) Slopes;
  - (b) Texture
    - (i) Microtexture;
    - (ii) Macrottexture;
- 7.3.2 Slopes for the various parts of the movement area and adjacent parts are described in JCAR Part 14, Chapter 3 and figures are given as per cent. Further guidance is given in CARC Guidance Material Runways 34 GM-11.
- 7.3.3 Texture in the literature is described as microtexture or macro-texture. These terms are understood differently in various parts of the aviation industry.
- 7.3.4 Micro-texture is the texture of the individual stones and is hardly detectable by the eye. Micro-texture is considered a primary component in skid resistance at slow speeds. On a wet surface at higher speeds a water film may prevent direct contact between the surface asperities and the tire due to insufficient drainage from the tire-to-ground contact area.
- 7.3.5 Microtexture is a built-in quality of the pavement surface. By specifying crushed material that will withstand polishing microtexture, drainage of thin waterfilms are ensured for a longer period of time. Resistance against polishing is expressed in terms of the Polished Stone Values (PSV) which is in principle a value obtained from a friction measurement in accordance with international standards. These standards define the PSV minima that will enable a material with a good micro-texture to be selected.
- 7.3.6 A major problem with microtexture is that it can change within short time periods without being easily detected. A typical example of this is the accumulation of rubber deposits in the touchdown area which will largely mask micro-texture without necessarily reducing macrottexture.
- 7.3.7 Macrottexture is the texture among the individual stones. This scale of texture may be judged approximately by the eye. Macrottexture is primarily created by the size of aggregate used or by surface treatment of the pavement and is the major factor influencing drainage capacity at high speeds. Materials shall be selected so as to achieve good macrottexture.

- 7.3.8 The primary purpose of grooving a runway surface is to enhance surface drainage. Natural drainage can be slowed down by surface texture, but grooving can speed up the drainage by providing a shorter drainage path and increasing the drainage rate.
- 7.3.9 For measurement of macro-texture, simple methods such as the “sand and grease patch” methods described in the Pavement Surface Conditions Guidance Material were developed. These methods were used for the early research on which current airworthiness requirements are based, which refer to a classification categorizing macrotexture from A to E. This classification was developed, using sand or grease patch measuring techniques, and issued in 1971 by the Engineering Sciences Data Unit (ESDU).

Runway classification based on texture information from ESDU 71026:

Classification	Texture depths (mm)
A	0.10 – 0.14
B	0.15 – 0.24
C	0.25 – 0.50
D	0.51 – 1.00
E	1.01 – 2.54

- 7.3.10 Using this classification, the threshold value between microtexture and macrotexture is 0.1 mm mean texture depth (MTD). Related to this scale the normal wet runway aircraft performance is based upon texture giving drainage and friction qualities midway between classification B and C (0.25 mm). Improved drainage through better texture might qualify for a better aircraft performance class. However, such credit must be in accordance with aeroplane manufacturers documentation and agreed by the State. Presently credit is given to grooved or porous friction course runways following design, construction and maintenance criteria acceptable to the State. The harmonized certification standards of some States refer to texture giving drainage and friction qualities midway between classification D and E (1.0 mm).
- 7.3.11 For construction, design and maintenance, States use various international standards. Currently ISO 13473-1: Characterization of pavement texture by use of surface profiles -- Part 1: Determination of Mean Profile Depth links the volumetric measuring technique with non-contact profile measuring techniques giving comparable texture values. These standards describe the threshold value between microtexture and macrotexture as 0.5 mm. The volumetric method has a validity range from 0.25 to 5 mm MTD. The profilometry method has a validity range from 0 to 5 mm mean profile depth (MPD). The values of MPD and MTD differ due to the finite size of the glass spheres used in the volumetric technique and because the MPD is derived from a two-dimensional profile rather than a three-dimensional surface.



Therefore, a transformation equation must be established for the measuring equipment used to relate MPD to MTD.

#### **7.4 Maintenance of drainage characteristics of pavement**

- 7.4.1 Macrotexture does not change within a short timespan but accumulation of rubber can fill up the texture and as such reduce the drainage capacity, which can result in impaired safety. Furthermore, the runway structure may change over time and give unevenness which results in ponding after rainfall. Guidance on rubber removal and unevenness can be found in CARC Guidance Material Pavement Surface Condition. Guidance on methods for improving surface texture can be found in CARC Guidance Material Pavements 34 GM-09.
- 7.4.2 When groovings are used, the condition of the grooves should be regularly inspected to ensure that no deterioration has occurred and that the grooves are in good condition. Guidance on maintenance of pavements is available in CARC Guidance Material Pavement Surface Condition and CARC Aerodrome Maintenance Services 34 GM-02.
- 7.4.3 The pavement may be shot blasted in order to enhance the pavement macrotexture.
- 7.4.4 The texture depth along the length of the runway should average at least 0.625 mm for good skid-resistant properties.

## CHAPTER 8

### Strips

#### 8.1 Shoulder

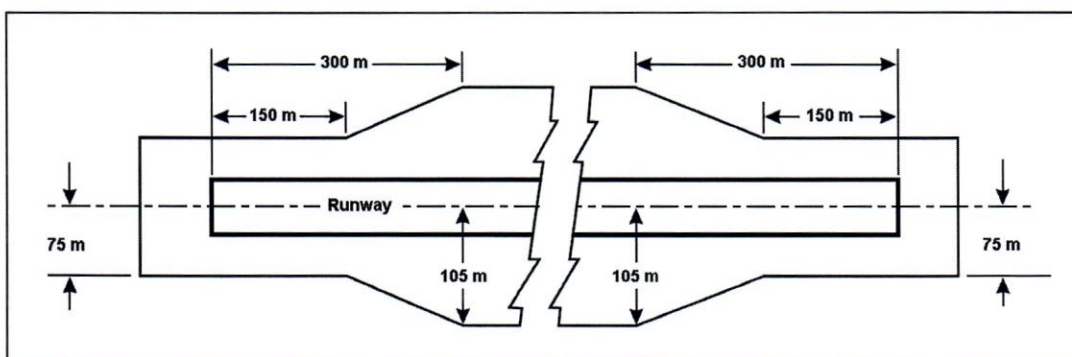
- 8.1.1 The shoulder of a runway or stopway should be prepared or constructed so as to minimize any hazard to an airplane running off the runway or stopway. Some guidance is given in the following paragraphs on certain special problems which may arise, and on the further question of measures to avoid the ingestion of loose stones or other objects by turbine engines.
- 8.1.2 In some cases, the bearing strength of the natural ground in the strip may be sufficient, without special preparation, to meet the requirements for shoulders. Where special preparation is necessary, the method used will depend on local soil conditions and the mass of the airplanes the runway is intended to serve. Soil tests will help in determining the best method of improvement (e.g. drainage, stabilization, surfacing, light paving).
- 8.1.3 Attention should also be paid when designing shoulders to prevent the ingestion of stones or other objects by turbine engines. Similar considerations apply here to those which are discussed for the margins of taxiways in the Aerodrome Design Manual, Part 2, both as to the special measures which may be necessary and as to the distance over which such special measures, if required, should be taken.
- 8.1.4 Where shoulders have been treated specially, either to provide the required bearing strength or to prevent the presence of stones or debris, difficulties may arise because of a lack of visual contrast between the runway surface and that of the adjacent strip. This difficulty can be overcome either by providing a good visual contrast in the surfacing of the runway or strip, or by providing a runway side stripe marking.

#### 8.2 Objects on strips:

Within the general area of the strip adjacent to the runway, measures should be taken to prevent an airplane's wheel, when sinking into the ground, from striking a hard vertical face. Special problems may arise for runway light fittings or other objects mounted in the strip or at the intersection with a taxiway or another runway. In the case of construction, such as runways or taxiways, where the surface must also be flush with the strip surface, a vertical face can be eliminated by chamfering from the top of the construction to not less than 30 cm below the strip surface level. Other objects, the functions of which do not require them to be at surface level, should be buried to a depth of not less than 30 cm.

### 8.3 Grading of a strip for precision approach runways

JCAR Part 14, Chapter 3, paragraph 3.4.8 recommends that the portion of a strip of an instrument runway within at least 75 m from the center line should be graded where the code number is 3 or 4. For a precision approach runway, it may be desirable to adopt a greater width where the code number is 3 or 4. Figure A-4 shows the shape and dimensions of a wider strip that may be considered for such a runway. This strip has been designed using information on aircraft running off runways. The portion to be graded extends to a distance of 105 m from the center line, except that the distance is gradually reduced to 75 m from the center line at both ends of the strip, for a length of 150 m from the runway end.



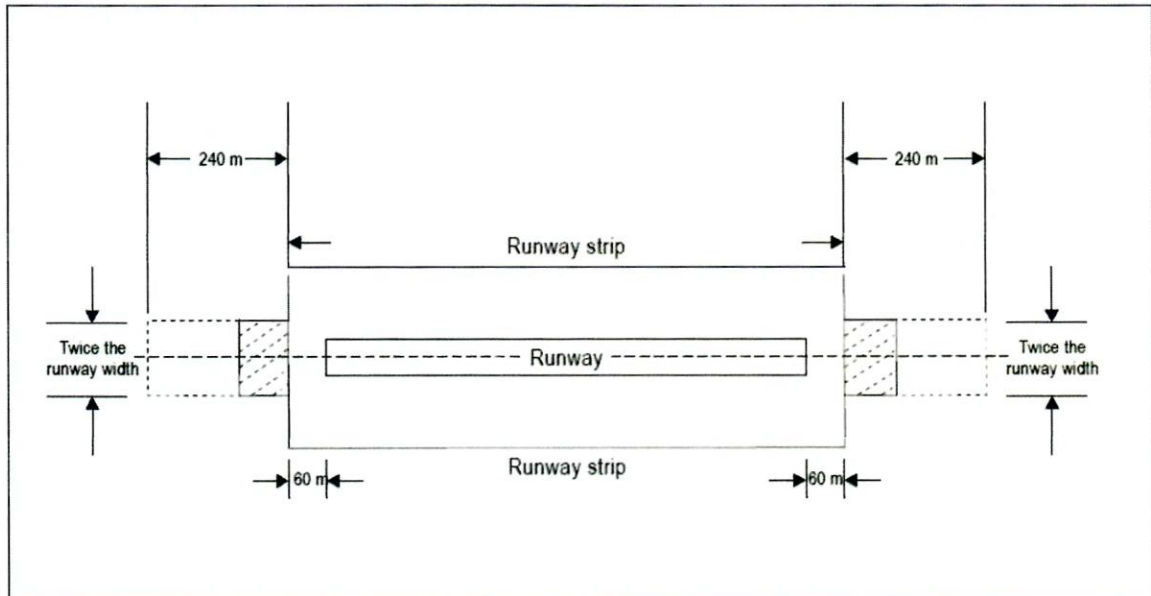
**Figure A-4.** Graded portion of a strip including a precision approach runway where the code number is 3 or 4



## **CHAPTER 9**

### **Runway End Safety Areas**

- 9.1 Where a runway end safety area is provided in accordance with JCAR Part 14, Chapter 3, consideration should be given to providing an area long enough to contain overruns and undershoots resulting from a reasonably probable combination of adverse operational factors. On a precision approach runway, the ILS localizer is normally the first upstanding obstacle, and the runway end safety area should extend up to this facility. In other circumstances the first upstanding obstacle may be a road, a railroad or other constructed or natural feature. The provision of a runway end safety area should Take such obstacles into consideration.
- 9.2 Where provision of a runway end safety area would be particularly prohibitive to implement, consideration would have to be given to reducing some of the declared distances of the runway for the provision of a runway end safety area and installation of an arresting system.
- 9.3 Research programmes, as well as evaluation of actual aircraft overruns into arresting systems, have demonstrated that the performance of some arresting systems can be predictable and effective in arresting aircraft overruns.
- 9.4 Demonstrated performance of an arresting system can be achieved by a validated design method, which can predict the performance of the system. The design and performance should be based on the type of aircraft anticipated to use the associated runway that imposes the greatest demand upon the arresting system.
- 9.5 The design of an arresting system must consider multiple aircraft parameters, including but not limited to, allowable aircraft gear loads, gear configuration, tire contact pressure, aircraft center of gravity and aircraft speed. Accommodating undershoots must also be addressed. Additionally, the design must allow the safe operation of fully loaded rescue and fire fighting vehicles, including their ingress and egress.
- 9.6 The information relating to the provision of a runway end safety area and the presence of an arresting system should be published in the AIP.
- 9.7 Additional information is contained in CARC Guidance Material Runways 34 GM-11.



**Figure A-5.** Runway end safety area for a runway where the code number is 3 or 4.

## CHAPTER 10

### Location of Threshold

#### 10.1 General

- 10.1.1 The threshold is normally located at the extremity of a runway, if there are no obstacles penetrating above the approach surface. In some cases, however, due to local conditions it may be desirable to displace the threshold permanently (see below). When studying the location of a threshold, consideration should also be given to the height of the ILS reference datum and/or MLS approach reference datum and the determination of the obstacle clearance limits. (Specifications concerning the height of the ILS reference datum and MLS approach reference datum are given in JCAR Part 171)
- 10.1.2 In determining that no obstacle penetrate above the approach surface, account should be taken of mobile objects (vehicles on roads, trains, etc.) at least within that portion of the approach area within 1 200 m longitudinally from the threshold and of an overall width of not less than 150 m.

#### 10.2 Displaced threshold

- 10.2.1 If an object extends above the approach surface and the object cannot be removed, consideration should be given to displacing the threshold permanently.
- 10.2.2 To meet the obstacle limitation objectives of JCAR Part 14, Chapter 4, the threshold should ideally be displaced down the runway for the distance necessary to provide that the approach surface is cleared of obstacles.
- 10.2.3 However, displacement of the threshold from the runway extremity will inevitably cause reduction of the landing distance available, and this may be of greater operational significance than penetration of the approach surface by marked and lighted obstacles. A decision to displace the threshold, and the extent of such displacement, should therefore have regard to an optimum balance between the considerations of clear approach surfaces and adequate landing distance. In deciding this question, account will need to be taken of the types of airplanes which the runway is intended to serve, the limiting visibility and cloud base conditions under which the runway will be used, the position of the obstacles in relation to the threshold and extended center line and, in the case of a precision approach runway, the significance of the obstacles to the determination of the obstacle clearance limit.
- 10.2.4 Notwithstanding the consideration of landing distance available, the selected position for the threshold should not be such that the obstacle-free surface to the threshold is steeper than 3.3 per cent where the code number is 4 or steeper than 5 per cent where the code number is 3.





- 10.2.5 In the event of a threshold being located according to the criteria for obstacle-free surfaces in the preceding paragraph, the obstacle marking requirements of JCAR Part 14, Chapter 6 should continue to be met in relation to the displaced threshold.
- 10.2.6 Depending on the length of the displacement, the RVR at the threshold could differ from that at the beginning of the runway for take-offs. The use of red runway edge lights with photometric intensities lower than the nominal value of 10 000 cd for white lights increases that phenomenon. The impact of a displaced threshold on take-off minima should be assessed by the appropriate authority.
- 10.2.7 Provisions regarding marking and lighting of displaced thresholds and some operational standards can be found in JCAR Part 14, Chapter 5 paragraphs 5.2.4.9 and 5.2.4.10, 5.3.5.6, 5.3.8.1, 5.3.9.7, 5.3.10.3 and 5.3.10.7, and 5.3.12.6 of this Appendix.



## CHAPTER 11

### Approach Lighting Systems

#### 11.1 Types and characteristics

- 11.1.1 The specifications in this volume provide for the basic characteristics for simple and precision approach lighting systems. For certain aspects of these systems, some latitude is permitted, for example, in the spacing between center line lights and crossbars. The approach lighting patterns that have been generally adopted are shown in Figures A-7 and A-8. A diagram of the inner 300 m of the precision approach category II and III lighting system is shown in Figure 5-14.
- 11.1.2 The approach lighting configuration is to be provided irrespective of the location of the threshold, i.e. whether the threshold is at the extremity of the runway or displaced from the runway extremity. In both cases, the approach lighting system should extend up to the threshold. However, in the case of a displaced threshold, inset lights are used from the runway extremity up to the threshold to obtain the specified configuration. These inset lights are designed to satisfy the structural requirements specified in JCAR Part 14, Chapter 5, paragraph 5.3.1.9, and the photometric requirements specified in Appendix 2, Figure A2-1 or A2-2.
- 11.1.3 Flight path envelopes to be used in designing the lighting are shown in Figure A-6.

#### 11.2 Installation tolerances

##### Horizontal

- 11.2.1 The dimensional tolerances are shown in Figure A-8.
- 11.2.2 The center line of an approach lighting system should be as coincident as possible with the extended center line of the runway with a maximum tolerance of  $\pm 15'$ .
- 11.2.3 The longitudinal spacing of the center line lights should be such that one light (or group of lights) is located in the center of each crossbar, and the intervening center line lights are spaced as evenly as practicable between two crossbars or a crossbar and a threshold.
- 11.2.4 The crossbars and barrettes should be at right angles to the center line of the approach lighting system with a tolerance of  $\pm 30'$ , if the pattern in Figure A-8 (A) is adopted or  $\pm 2^\circ$ , if Figure A-8 (B) is adopted.

- 11.2.5 When a crossbar has to be displaced from its standard position, any adjacent crossbar should, where possible, be displaced by appropriate amounts in order to reduce the differences in the crossbar spacing.
- 11.2.6 When a crossbar in the system shown in Figure A-8 (A) is displaced from its standard position, its overall length should be adjusted so that it remains one-twentieth of the actual distance of the crossbar from the point of origin. It is not necessary, however, to adjust the standard 2.7 m spacing between the crossbar lights, but the crossbars should be kept symmetrical about the center line of the approach lighting.

### Vertical

- 11.2.7 The ideal arrangement is to mount all the approach lights in the horizontal plane passing through the threshold (see Figure A-9), and this should be the general aim as far as local conditions permit. However, buildings, trees, etc., should not obscure the lights from the view of a pilot who is assumed to be  $1^\circ$  below the electronic glide path in the vicinity of the outer marker.
- 11.2.8 Within a stopway or clearway, and within 150 m of the end of a runway, the lights should be mounted as near to the ground as local conditions permit in order to minimize risk of damage to airplanes in the event of an overrun or undershoot. Beyond the stopway and clearway, it is not so necessary for the lights to be mounted close to the ground and therefore undulations in the ground contours can be compensated for by mounting the lights on poles of appropriate height.
- 11.2.9 It is desirable that the lights be mounted so that, as far as possible, no object within a distance of 60 m on each side of the center line protrudes through the plane of the approach lighting system. Where a tall object exists within 60 m of the center line and within 1 350 m from the threshold for a precision approach lighting system, or 900 m for a simple approach lighting system, it may be advisable to install the lights so that the plane of the outer half of the pattern clears the top of the object.
- 11.2.10 In order to avoid giving a misleading impression of the plane of the ground, the lights should not be mounted below a gradient of 1 in 66 downwards from the threshold to a point 300 m out, and below a gradient of 1 in 40 beyond the 300 m point. For a precision approach category II and III lighting system, more stringent criteria may be necessary, e.g. negative slopes not permitted within 450 m of the threshold.
- 11.2.11 Center line. The gradients of the center line in any section (including a stopway or clearway) should be as small as practicable, and the changes in gradients should be as few and small as can be arranged and should not exceed 1 in 60. Experience has shown that as one proceeds



outwards from the runway, rising gradients in any section of up to 1 in 66, and falling gradients of down to 1 in 40, are acceptable.

- 11.2.12 Crossbars. The crossbar lights should be so arranged as to lie on a straight line passing through the associated centre line lights, and wherever possible this line should be horizontal. It is permissible, however, to mount the lights on a transverse gradient not more than 1 in 80, if this enables crossbar lights within a stopway or clearway to be mounted nearer to the ground on sites where there is a cross-fall.

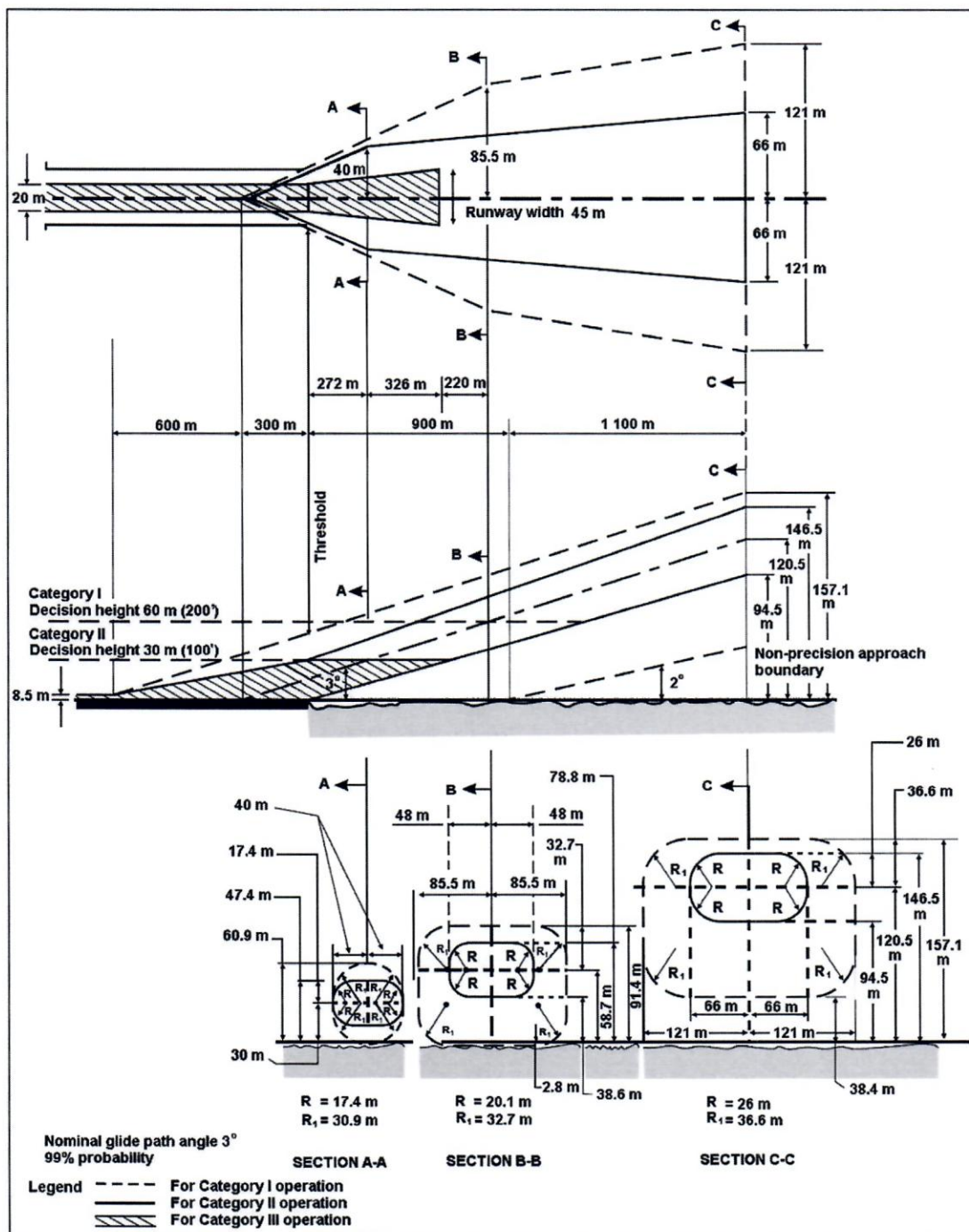
### **11.3 Clearance of obstacles**

- 11.3.1 An area, hereinafter referred to as the light plane, has been established for obstacle clearance purposes, and all lights of the system are in this plane. This plane is rectangular in shape and symmetrically located about the approach lighting system's center line. It starts at the threshold and extends 60 m beyond the approach end of the system, and is 120 m wide.
- 11.3.2 No objects are permitted to exist within the boundaries of the light plane which are higher than the light plane except as designated herein. All roads and highways are considered as obstacles extending 4.8 m above the crown of the road, except aerodrome service roads where all vehicular traffic is under control of the aerodrome authorities and coordinated with the aerodrome traffic control tower. Railroads, regardless of the amount of traffic, are considered as obstacles extending 5.4 m above the top of the rails.
- 11.3.3 It is recognized that some components of electronic landing aids systems, such as reflectors, antennas, monitors, etc., must be installed above the light plane. Every effort should be made to relocate such components outside the boundaries of the light plane. In the case of reflectors and monitors, this can be done in many instances.
- 11.3.4 Where an ILS localizer is installed within the light plane boundaries, it is recognized that the localizer, or screen if used, must extend above the light plane. In such cases the height of these structures should be held to a minimum and they should be located as far from the threshold as possible. In general, the rule regarding permissible heights is 15 cm for each 30 m the structure is located from the threshold. As an example, if the localizer is located 300 m from the threshold, the screen will be permitted to extend above the plane of the approach lighting system by  $10 \times 15 = 150$  cm maximum, but preferably should be kept as low as possible consistent with proper operation of the ILS.
- 11.3.5 In locating an MLS azimuth antenna, the guidance contained in Annex 10, Volume I, Attachment G should be followed. This material, which also provides guidance on collocating an MLS azimuth antenna with an ILS localizer antenna, suggests that the MLS azimuth antenna may be sited within the light plane boundaries where it is not possible or practical to locate it beyond the outer end of the approach lighting for the opposite direction of approach.

If the MLS azimuth antenna is located on the extended center line of the runway, it should be as far as possible from the closest light position to the MLS azimuth antenna in the direction of the runway end. Furthermore, the MLS azimuth antenna phase center should be at least 0.3 m above the light center of the light position closest to the MLS azimuth antenna in the direction of the runway end. (This could be relaxed to 0.15 m if the site is otherwise free of significant multipath problems.) Compliance with this requirement, which is intended to ensure that the MLS signal quality is not affected by the approach lighting system, could result in the partial obstruction of the lighting system by the MLS azimuth antenna. To ensure that the resulting obstruction does not degrade visual guidance beyond an acceptable level, the MLS azimuth antenna should not be located closer to the runway end than 300 m and the preferred location is 25 m beyond the 300 m crossbar (this would place the antenna 5 m behind the light position 330 m from the runway end). Where an MLS azimuth antenna is so located, a central part of the 300 m crossbar of the approach lighting system would alone be partially obstructed. Nevertheless, it is important to ensure that the unobstructed lights of the crossbar remain serviceable all the time.

- 11.3.6 Objects existing within the boundaries of the light plane, requiring the light plane to be raised in order to meet the criteria contained herein, should be removed, lowered or relocated where this can be accomplished more economically than raising the light plane.
- 11.3.7 In some instances, objects may exist which cannot be removed, lowered or relocated economically. These objects may be located so close to the threshold that they cannot be cleared by the 2 per cent slope. Where such conditions exist and no alternative is possible, the 2 per cent slope may be exceeded or a “stair step” resorted to in order to keep the approach lights above the objects. Such “step” or increased gradients should be resorted to only when it is impracticable to follow standard slope criteria, and they should be held to the absolute minimum. Under this criterion no negative slope is permitted in the outermost portion of the system.





**Figure A-6.** Flight path envelopes to be used for lighting design for category I, II and III operations



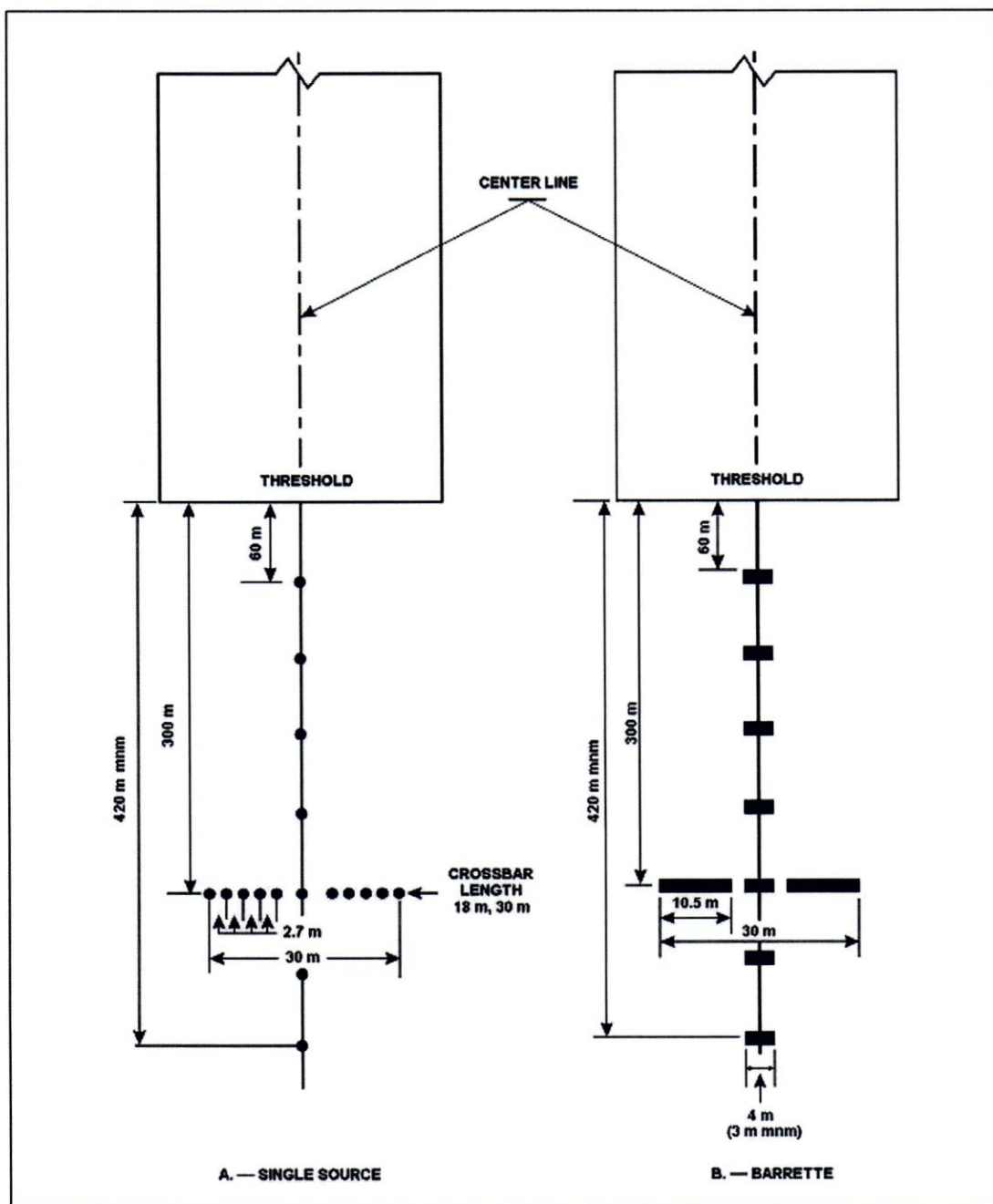


Figure A-7. Simple approach lighting systems



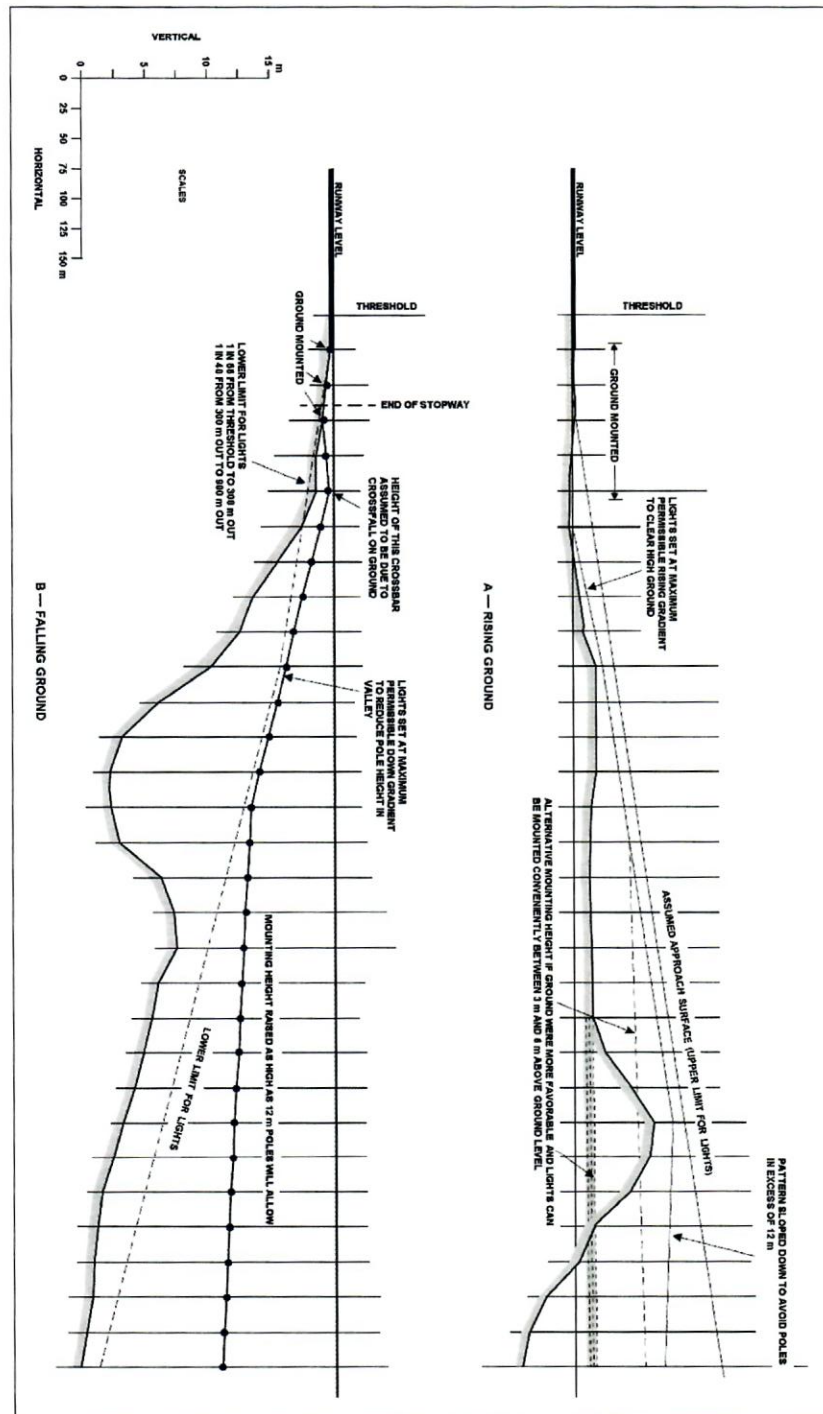


Figure A-9. Vertical installation tolerance



#### 11.4 Consideration of the effects of reduced lengths

- 11.4.1 The need for an adequate approach lighting system to support precision approaches where the pilot is required to acquire visual references prior to landing, cannot be stressed too strongly. The safety and regularity of such operations is dependent on this visual acquisition. The height above runway threshold at which the pilot decides there are sufficient visual cues to continue the precision approach and land will vary, depending on the type of approach being conducted and other factors such as meteorological conditions, ground and airborne equipment, etc. The required length of approach lighting system which will support all the variations of such approaches is 900 m, and this shall always be provided whenever possible.
- 11.4.2 However, there are some runway locations where it is impossible to provide the 900 m length of approach lighting system to support precision approaches.
- 11.4.3 In such cases, every effort should be made to provide as much approach lighting system as possible. The appropriate authority may impose restrictions on operations to runways equipped with reduced lengths of lighting. There are many factors which determine at what height the pilot must have decided to continue the approach to land or execute a missed approach. It must be understood that the pilot does not make an instantaneous judgment upon reaching a specified height. The actual decision to continue the approach and landing sequence is an accumulative process which is only concluded at the specified height. Unless lights are available prior to reaching the decision point, the visual assessment process is impaired and the likelihood of missed approaches will increase substantially. There are many operational considerations which must be taken into account by the appropriate authorities in deciding if any restrictions are necessary to any precision approach and these are detailed in Annex 6.

## CHAPTER 12

### Priority of Installation of Visual Approach Slope Indicator Systems

- 12.1 It has been found impracticable to develop guidance material that will permit a completely objective analysis to be made of which runway on an aerodrome should receive first priority for the installation of a visual approach slope indicator system. However, factors that must be considered when making such a decision are:
- (a) frequency of use;
  - (b) seriousness of the hazard;
  - (c) presence of other visual and non-visual aids;
  - (d) type of airplanes using the runway; and
  - (e) frequency and type of adverse weather conditions under which the runway will be used.
- 12.2 With respect to the seriousness of the hazard, the order given in the application specifications for a visual approach slope indicator system, 5.3.5.1 b) to e) of JCAR Part 14, Chapter 5 may be used as a general guide. These may be summarized as:
- (a) inadequate visual guidance because of:
    - (1) approaches over water or featureless terrain, or absence of sufficient extraneous light in the approach area by night;
    - (2) deceptive surrounding terrain;
  - (b) serious hazard in approach;
  - (c) serious hazard if airplanes undershoot or overrun; and
  - (d) unusual turbulence.
- 12.3 The presence of other visual or non-visual aids is a very important factor. Runways equipped with ILS or MLS would generally receive the lowest priority for a visual approach slope indicator system installation. It must be remembered, though, that visual approach slope indicator systems are visual approach aids in their own right and can supplement electronic aids. When serious hazards exist and/or a substantial number of airplanes not equipped for ILS or MLS use a runway, priority might be given to installing a visual approach slope indicator on this runway.
- 12.4 Priority should be given to runways used by turbojet airplanes.

## **CHAPTER 13**

### **Lighting of Unserviceable Areas**

Where a temporarily unserviceable area exists, it may be marked with fixed-red lights. These lights should mark the most potentially dangerous extremities of the area. A minimum of four such lights should be used, except where the area is triangular in shape where a minimum of three lights may be employed. The number of lights should be increased when the area is large or of unusual configuration. At least one light should be installed for each 7.5 m of peripheral distance of the area. If the lights are directional, they should be orientated so that as far as possible their beams are aligned in the direction from which aircraft or vehicles will approach. Where aircraft or vehicles will normally approach from several directions, consideration should be given to adding extra lights or using omnidirectional lights to show the area from these directions. Unserviceable area lights should be frangible. Their height should be sufficiently low to preserve clearance for propellers and for engine pods of jet aircraft.



## CHAPTER 14

### Rapid Exit Taxiway Indicator Lights

- 14.1 Rapid exit taxiway indicator lights (RETILs) comprise a set of yellow unidirectional lights installed in the runway adjacent to the center line. The lights are positioned in a 3-2-1 sequence at 100 m intervals prior to the point of tangency of the rapid exit taxiway center line. They are intended to give an indication to pilots of the location of the next available rapid exit taxiway.
- 14.2 In low visibility conditions, RETILs provide useful situational awareness cues while allowing the pilot to concentrate on keeping the aircraft on the runway center line.
- 14.3 Following a landing, runway occupancy time has a significant effect on achievable runway capacity. RETILs allow pilots to maintain a good roll-out speed until it is necessary to decelerate to an appropriate speed for the turn into a rapid exit turn-off. A roll-out speed of 60 knots until the first RETIL (three-light barrette) is reached is seen as the optimum.

## CHAPTER 15

### Intensity Control of Approach and Runway Lights

- 15.1 The conspicuity of a light depends on the impression received of contrast between the light and its background. If a light is to be useful to a pilot by day when on approach, it must have an intensity of at least 2 000 or 3 000 cd, and in the case of approach lights an intensity of the order of 20 000 cd is desirable. In conditions of very bright daylight fog it may not be possible to provide lights of sufficient intensity to be effective. On the other hand, in clear weather on a dark night, an intensity of the order of 100 cd for approach lights and 50 cd for the runway edge lights may be found suitable. Even then, owing to the closer range at which they are viewed, pilots have sometimes complained that the runway edge lights seemed unduly bright.
- 15.2 In fog the amount of light scattered is high. At night this scattered light increases the brightness of the fog over the approach area and runway to the extent that little increase in the visual range of the lights can be obtained by increasing their intensity beyond 2 000 or 3 000 cd. In an endeavor to increase the range at which lights would first be sighted at night, their intensity must not be raised to an extent that a pilot might find excessively dazzling at diminished range.
- 15.3 From the foregoing will be evident the importance of adjusting the intensity of the lights of an aerodrome lighting system according to the prevailing conditions, so as to obtain the best results without excessive dazzle that would disconcert the pilot. The appropriate intensity setting on any particular occasion will depend both on the conditions of background brightness and the visibility. Detailed guidance material on selecting intensity setting for different conditions is given in the Aerodrome Design Manual, Part 4.



## **CHAPTER 16**

### **Signal Area**

A signal area need be provided only when it is intended to use visual ground signals to communicate with aircraft in flight. Such signals may be needed when the aerodrome does not have an aerodrome control tower or an aerodrome flight information service unit, or when the aerodrome is used by airplanes not equipped with radio. Visual ground signals may also be useful in the case of failure of two-way radio communication with aircraft. It should be recognized, however, that the type of information which may be conveyed by visual ground signals should normally be available in AIPs or NOTAM. The potential need for visual ground signals should therefore be evaluated before deciding to provide a signal area.





## CHAPTER 17

### Rescue and Fire Fighting Services

#### 17.1 Administration

- 17.1.1 The rescue and firefighting service at an aerodrome should be under the administrative control of the aerodrome management, which should also be responsible for ensuring that the service provided is organized, equipped, staffed, trained and operated in such a manner as to fulfill its proper functions.
- 17.1.2 In drawing up the detailed plan for the conduct of search and rescue operations in accordance with 4.2.1 of Annex 12, the aerodrome management should coordinate its plans with the relevant rescue coordination centers to ensure that the respective limits of their responsibilities for an aircraft accident within the vicinity of an aerodrome are clearly delineated.
- 17.1.3 Coordination between the rescue and firefighting service at an aerodrome and public protective agencies, such as local fire brigade, police force, coast guard and hospitals, should be achieved by prior agreement for assistance in dealing with an aircraft accident.
- 17.1.4 A grid map of the aerodrome and its immediate vicinity should be provided for the use of the aerodrome services concerned. Information concerning topography, access roads and location of water supplies should be indicated. This map should be conspicuously posted in the control tower and fire station, and available on the rescue and fire fighting vehicles and such other supporting vehicles required to respond to an aircraft accident or incident. Copies should also be distributed to public protective agencies as desirable.
- 17.1.5 Coordinated instructions should be drawn up detailing the responsibilities of all concerned and the action to be taken in dealing with emergencies. The appropriate authority should ensure that such instructions are promulgated and observed.

#### 17.2 Training

The training curriculum should include initial and recurrent instruction in at least the following areas:

- a) airport familiarization;
- b) aircraft familiarization;
- c) rescue and fire-fighting personnel safety;
- d) emergency communications systems on the aerodrome, including aircraft fire related alarms;

- e) use of the fire hoses, nozzles, turrets and other appliances required for compliance with JCAR Part 14, Chapter 9, paragraph 9.2;
- f) application of the types of extinguishing agents required for compliance with JCAR Part 14, Chapter 9, paragraph 9.2;
- g) emergency aircraft evacuation assistance;
- h) fire-fighting operations;
- i) adaptation and use of structural rescue and fire-fighting equipment for aircraft rescue and fire-fighting;
- j) dangerous goods;
- k) familiarization with fire fighters' duties under the aerodrome emergency plan; and
- l) protective clothing and respiratory protection.

### **17.3 Level of protection**

- 17.3.1 Level of protection to be provided In accordance with JCAR Part 14, Chapter 9, paragraph 9.2 aerodromes should be categorized for rescue and fire-fighting purposes and the level of protection provided should be appropriate to the aerodrome category.
- 17.3.2 However, JCAR Part 14, Chapter 9 paragraph 9.2, permits a lower level of protection to be provided for a limited period where the number of movements of the aeroplanes in the highest category normally using the aerodrome is less than 700 in the busiest consecutive three months. It is important to note that the concession included in JCAR Part 14, Chapter 9, paragraph 9.2 is applicable only where there is a wide range of difference between the dimensions of the aeroplanes included in reaching 700 movements.

### **17.4 Rescue equipment for difficult environments**

- 17.4.1 Suitable rescue equipment and services should be available at an aerodrome where the area to be covered by the service includes water, swampy areas or other difficult environment that cannot be fully served by conventional wheeled vehicles. This is particularly important where a significant portion of approach/departure operations takes place over these areas.



- 17.4.2 The rescue equipment should be carried on boats or other vehicles such as helicopters and amphibious or air cushion vehicles, capable of operating in the area concerned. The vehicles should be so located that they can be brought into action quickly to respond to the areas covered by the service.
- 17.4.3 At an aerodrome bordering the water, the boats or other vehicles should preferably be located on the aerodrome, and convenient launching or docking sites provided. If these vehicles are located off the aerodrome, they should preferably be under the control of the aerodrome rescue and fire-fighting service or, if this is not practicable, under the control of another competent public or private organization working in close coordination with the aerodrome rescue and fire-fighting service (such as police, military services, harbor patrol or coast guard).
- 17.4.4 Boats or other vehicles should have as high a speed as practicable so as to reach an accident site in minimum time. To reduce the possibility of injury during rescue operations, water jet-driven boats are preferred to water propeller driven boats unless the propellers of the latter boats are ducted. Should the water areas to be covered by the service be frozen for a significant period of the year, the equipment should be selected accordingly. Vehicles used in this service should be equipped with life rafts and life preservers related to the requirements of the larger aircraft normally using the aerodrome, with two-way radio communication, and with floodlights for night operations. If aircraft operations during periods of low visibility are expected, it may be necessary to provide guidance for the responding emergency vehicles.
- 17.4.5 The personnel designated to operate the equipment should be adequately trained and drilled for rescue services in the appropriate environment.

## **17.5 Facilities**

- 17.5.1 The provision of special telephone, two-way radio communication and general alarm systems for the rescue and fire-fighting service is desirable to ensure the dependable transmission of essential emergency and routine information. Consistent with the individual requirements of each aerodrome, these facilities serve the following purposes:
- (a) direct communication between the activating authority and the aerodrome fire station in order to ensure the prompt alerting and dispatch of rescue and fire fighting vehicles and personnel in the event of an aircraft accident or incident;
  - (b) direct communication between the rescue and firefighting service and the flight crew of an aircraft in emergency;
  - (c) emergency signals to ensure the immediate summoning of designated personnel not on standby duty;
  - (d) as necessary, summoning essential related services on or off the aerodrome; and





- (e) maintaining communication by means of two-way radio with the rescue and fire fighting vehicles in attendance at an aircraft accident or incident.

17.5.2 The availability of ambulance and medical facilities for the removal and after-care of casualties arising from an aircraft accident should receive the careful consideration of the appropriate authority and should form part of the overall emergency plan established to deal with such emergencies.

## CHAPTER 18

### Operators of Vehicles

- 18.1 The authorities responsible for the operation of vehicles on the movement area should ensure that the operators are properly qualified. This may include, as appropriate to the driver's function, knowledge of:
- (a) the geography of the aerodrome;
  - (b) aerodrome signs, markings and lights;
  - (c) radiotelephone operating procedures;
  - (d) terms and phrases used in aerodrome control including the ICAO spelling alphabet;
  - (e) rules of air traffic services as they relate to ground operations;
  - (f) airport rules and procedures; and
  - (g) specialist functions as required, for example, in rescue and firefighting.
- 18.2 The operator should be able to demonstrate competency, as appropriate, in:
- (a) the operation or use of vehicle transmit/receive equipment;
  - (b) understanding and complying with air traffic control and local procedures;
  - (c) vehicle navigation on the aerodrome; and
  - (d) special skills required for the particular function.
- In addition, as required for any specialist function, the operator should be the holder of a State driver's license, a State radio operator's license or other licenses.
- 18.3 The above should be applied as is appropriate to the function to be performed by the operator and it is not necessary that all operators be trained to the same level, for example, operators whose functions are restricted to the apron.
- 18.4 If special procedures apply for operations in low visibility conditions, it is desirable to verify an operator's knowledge of the procedures through periodic checks.

## CHAPTER 19

### ACR-PCR Method of Reporting Pavement Strength

(Applicable as of 28 November 2024)

#### 19.1 Overload operations

19.1.1 Overloading of pavements can result either from loads too large, or from a substantially increased application rate, or both. Loads larger than the defined (design or evaluation) load shorten the design life, whilst smaller loads extend it. With the exception of massive overloading, pavements in their structural behavior are not subject to a particular limiting load above which they suddenly or catastrophically fail. Behavior is such that a pavement can sustain a definable load for an expected number of repetitions during its design life. As a result, occasional minor over-loading is acceptable, when expedient, with only limited loss in pavement life expectancy and relatively small acceleration of pavement deterioration. For those operations in which magnitude of overload and/or the frequency of use do not justify a detailed analysis, the following criteria are suggested:

- (a) for flexible and rigid pavements, occasional movements by aircraft with ACR not exceeding 10 per cent above the reported PCR should not adversely affect the pavement;
- (b) the annual number of overload movements should not exceed approximately 5 per cent of the total annual movements, excluding light aircraft.

19.1.2 Such overload movements should not normally be permitted on pavements exhibiting signs of distress or failure. Furthermore, overloading should be avoided during any periods of thaw following frost penetration, or when the strength of the pavement or its subgrade could be weakened by water. Where overload operations are conducted, the appropriate authority should review the relevant pavement condition regularly, and should also review the criteria for overload operations periodically since excessive repetition of overloads can cause severe shortening of pavement life or require major rehabilitation of pavement.

#### 19.2 ACRs for several aircraft types.

For convenience, a dedicated software is available on the ICAO website, for computing any aircraft ACRs at any mass on rigid and flexible pavements for the four standard subgrade strength categories detailed in JCAR Part 14, Chapter 2, 2.6.6 b).



## CHAPTER 20

### Autonomous Runway Incursion Warning System (ARIWS)

*Note (1): These autonomous systems are generally quite complex in design and operation and, as such deserve careful consideration by all levels of the industry, from the regulating authority to the end user. This guidance is offered to provide a clearer description of the system(s) and offer some suggested actions required in order to properly implement these system(s) at an aerodrome in any State.*

*Note (2): CARC Runway Incursions prevention program presents different approaches for the prevention of runway incursion.*

#### 20.1 General description

- 20.1.1 The operation of an ARIWS is based upon a surveillance system which monitors the actual situation on a runway and automatically returns this information to warning lights at the runway (take-off) thresholds and entrances. When an aircraft is departing from a runway (rolling) or arriving at a runway (short final), red warning lights at the entrances will illuminate, indicating that it is unsafe to enter or cross the runway. When an aircraft is aligned on the runway for take-off and another aircraft or vehicle enters or crosses the runway, red warning lights will illuminate at the threshold area, indicating that it is unsafe to start the take-off roll.
- 20.1.2 In general, an ARIWS consists of an independent surveillance system (primary radar, multilateration, specialized cameras, dedicated radar, etc.) and a warning system in the form of extra airfield lighting systems connected through a processor which generates alerts independent from ATC directly to the flight crews and vehicle operators.
- 20.1.3 An ARIWS does not require circuit interleaving, secondary power supply or operational connection to other visual aid systems.
- 20.1.4 In practice, not every entrance or threshold needs to be equipped with warning lights. Each aerodrome will have to assess its needs individually depending on the characteristics of the aerodrome. There are several systems developed offering the same or similar functionality.

#### 20.2 Flight crew actions

- 20.2.1 It is of critical importance that flight crews understand the warning being transmitted by the ARIWS system. Warnings are provided in near real-time, directly to the flight crew because there is no time for “relay” types of communications. In other words, a conflict warning generated to ATS which must then interpret the warning, evaluate the situation and communicate to the aircraft in question, would result in several seconds being taken up where each second is critical in the ability to stop the aircraft safely, and prevent a potential collision.

Pilots are presented with a globally consistent signal which means “STOP IMMEDIATELY” and must be taught to react accordingly. Likewise, pilots receiving an ATS clearance to take-off or cross a runway, and seeing the red light array, must STOP and advise ATS that they aborted/stopped because of the red lights. Again, the criticality of the timeline involved is so tight that there is no room for misinterpretation of the signal. It is of utmost importance that the visual signal be consistent around the world.

- 20.2.2 It must also be stressed that the extinguishing of the red lights does not, in itself, indicate a clearance to proceed. That clearance is still required from air traffic control. The absence of red warning lights only means that potential conflicts have not been detected.
- 20.2.3 In the event that a system becomes unserviceable, one of two things will occur. If the system fails in the extinguished condition, then no procedural changes need to be accomplished. The only thing that will happen is the loss of the automatic, independent warning system. Both ATS operations and flight crew procedures (in response to ATS clearances) will remain unchanged.
- 20.2.4 Procedures should be developed to address the circumstance where the system fails in the illuminated condition. It will be up to the ATS and/or aerodrome operator to establish those procedures depending on their own circumstances. It must be remembered that flight crews are instructed to “STOP” at all red lights. If the affected portion of the system, or the entire system is shut off, the situation is reverted to the extinguished scenario described in 20.2.3 above.

### 20.3 Aerodromes

- 20.3.1 An ARIWS does not have to be provided at all aerodromes. An aerodrome considering the installation of such a system may wish to assess its needs individually, depending on traffic levels, aerodrome geometry, ground taxi patterns, etc. Local user groups such as the Local Runway Safety Team (LRST) can be of assistance in this process. Also, not every runway or taxiway needs to be equipped with the lighting array(s) and not every installation requires a comprehensive ground surveillance system to feed information to the conflict detection computer.
- 20.3.2 Although there may be local specific requirements, some basic system requirements are applicable to all ARIWS:
  - (a) the control system and energy power supply of the system must be independent from any other system in use at the aerodrome, especially the other parts of the lighting system;
  - (b) the system must operate independently from ATS communications;
  - (c) the system must provide a globally accepted visual signal that is consistent and instantly understood by crews; and



- (d) local procedures should be developed in the case of malfunction or failure of a portion of, or the entire system.

## **20.4 Air traffic services**

20.4.1 The ARIWS is designed to be complementary to normal ATS functions, providing warnings to flight crews and vehicle operators when some conflict has been unintentionally created or missed during normal aerodrome operations. The ARIWS will provide a direct warning when, for example, ground control or tower (local) control has provided a clearance to hold short of a runway but the flight crew or vehicle operator has “missed” the hold short portion of their clearance and tower has issued a take-off or landing clearance to that same runway, and the non-read back by the flight crew or vehicle operator was missed by air traffic control.

20.4.2 In the case where a clearance has been issued and a crew reports a non-compliance due to “red lights”, or aborting because of “red lights”, then it is imperative that the controller assess the situation and provide additional instructions as necessary. It may well be that the system has generated a false warning or that the potential incursion no longer exists; however, it may also be a valid warning. In any case, additional instructions and/or a new clearance need to be provided. In a case where the system has failed, then procedures will need to be put into place as described in 20.2.3 and 20.2.4 above. In no case should the illumination of the ARIWS be dismissed without confirmation that, in fact, there is no conflict. It is worth noting that there have been numerous incidents avoided at aerodromes with such systems installed. It is also worth noting that there have been false warnings as well, usually as a result of the calibration of the warning software, but in any case, a confirmation of the potential conflict existence or non-existence must be done.

20.4.3 While many installations may have a visual or audio warning available to ATS personnel, it is in no way intended that ATS personnel be required to actively monitor the system. Such warnings may assist ATS personnel in quickly assessing the conflict in the event of a warning and help them to provide appropriate further instructions, but the ARIWS should not play an active part in the normal functioning of any ATS facility.

20.4.4 Each aerodrome where the system is installed will develop procedures depending upon their unique situation. Again, it must be stressed that under no circumstances should pilots or operators be instructed to “cross the red lights”. As indicated previously, the use of local runway safety teams can greatly assist in this development process.

## **20.5 Promulgation of information**

20.5.1 Information on the characteristics and status of an ARIWS at an aerodrome are promulgated in the AIP section AD 2.9 in PANS – AIM and its status updated as necessary through NOTAM or ATIS in compliance with JCAR Part 14, Chapter 2 of this Part section 2.9.1.





- 20.5.2 Aircraft operators are to ensure that flight crews documentation include procedures regarding ARIWS and appropriate guidance information, in compliance with Annex 6, Part I.
- 20.5.3 Aerodromes may provide additional sources of guidance on operations and procedures for their personnel, aircraft operators, ATS and third parties personnel who may have to deal with an ARIWS.



## CHAPTER 21

### Taxiway Design Guidance for Minimizing the Potential for Runway Incursions

- 21.1 Good aerodrome design practices can reduce the potential for runway incursions while maintaining operating efficiency and capacity. The following taxiway design guidance may be considered to be part of a runway incursion prevention programme as a means to ensure that runway incursion aspects are addressed during the design phase for new runways and taxiways. Within this focused guidance, the prime considerations are to limit the number of aircraft or vehicles entering or crossing a runway, provide pilots with enhanced unobstructed views of the entire runway, and correct taxiways identified as hot spots as far as possible.
- 21.2 The centre line of an entrance taxiway should be perpendicular to the runway centre line, where possible. This design principle provides pilots with an unobstructed view of the entire runway, in both directions, to confirm that the runway and approach are clear of conflicting traffic before proceeding towards the runway. Where the taxiway angle is such that a clear unobstructed view, in both directions, is not possible, consideration should be given to providing a perpendicular portion of the taxiway immediately adjacent to the runway to allow for a full visual scan by the pilots prior to entering or crossing a runway.
- 21.3 For taxiways intersecting with runways, avoid designing taxiways wider than recommended in part. This design principle offers improved recognition of the location of the runway holding position and the accompanying sign, marking, and lighting visual cues.
- 21.4 Existing taxiways wider than recommended in this part, can be rectified by painting taxi side stripe markings to the recommended width. As far as practicable, it is preferable to redesign such locations properly rather than to repaint such locations.
- 21.5 Multi-taxiway entrances to a runway should be parallel to each other and should be distinctly separated by an unpaved area. This design principle allows each runway holding location an earthen area for the proper placement of accompanying sign, marking, and lighting visual cues at each runway holding position. Moreover, the design principle eliminates the needless costs of building unusable pavement and as well as the costs for painting taxiway edge markings to indicate such unusable pavement. In general, excess paved areas at runway holding positions reduce the effectiveness of sign, marking, and lighting visual cues.
- 21.6 Build taxiways that cross a runway as a single straight taxiway. Avoid dividing the taxiway into two after crossing the runway. This design principle avoids constructing “Y-shaped” taxiways known to present risk of runway incursions.
- 21.7 If possible, avoid building taxiways that enter at the mid-runway location. This design principle helps to reduce the collision risks at the most hazardous locations (high energy location) because



normally departing aircraft have too much energy to stop, but not enough speed to take-off, before colliding with another errant aircraft or vehicle.

- 21.8 Provide clear separation of pavement between a rapid exit taxiway and other non-rapid taxiways entering or crossing a runway. This design principle avoids two taxiways from overlapping each other to create an excessive paved area that would confuse pilots entering a runway.
- 21.9 Avoid the placement of different pavement materials (asphalt and cement concrete) at or near the vicinity of the runway holding position, as far as practicable. This design principle avoids creating visual confusion as to the actual location of the runway holding position.
- 21.10 Many aerodromes have more than one runway, notably paired parallel runways (two runways on one side of the terminal), which creates a difficult problem in that either on arrival or departure an aircraft is required to cross a runway. Under such a configuration, the safety objective here is to avoid or at least keep to a minimum the number of runway crossings. This safety objective may be achieved by constructing a “perimeter taxiway”. A perimeter taxiway is a taxi route that goes around the end of a runway, enabling arrival aircraft (when landings are on outer runway of a pair) to get to the terminal or departure aircraft (when departures are on outer runway of a pair) to get to the runway without either crossing a runway, or conflicting with a departing or approaching aircraft.
- 21.11 A perimeter taxiway would be designed according to the following criteria:
- (a) Sufficient space is required between the landing threshold and the taxiway center line where it crosses under the approach path, to enable the critical taxiing aircraft to pass under the approach without penetrating any approach surface.
  - (b) The jet blast impact of aircraft taking off should be considered in consultation with aircraft manufacturers; the extent of take-off thrust should be evaluated when determining the location of a perimeter taxiway.
  - (c) The requirement for a runway end safety area, as well as possible interference with landing systems and other navigation aids should also be taken into account. For example, in the case of an Instrument Landing System, the perimeter taxiway should be located behind the localizer antenna, not between the localizer antenna and the runway, due to the potential for severe Instrument Landing System disturbance, noting that this is harder to achieve as the distance between the localizer and the runway increases.
  - (d) Human factors issues should also be taken into account. Appropriate measures should be put in place to assist pilots to distinguish between aircraft that are crossing the runway and those that are safely on a perimeter taxiway.



## CHAPTER 22

### Aerodrome Mapping Data

#### 22.1 Introduction

JCAR Part 14, Chapter 2, 2.1.2 and 2.1.3, contain provisions related to the provision of aerodrome mapping data. The aerodrome mapping data features are collected and made available to the aeronautical information services for aerodromes designated by States with consideration of the intended applications. These applications are closely tied to an identified need and operational use where the application of the data would provide a safety benefit or could be used as mitigation to a safety concern

#### 22.2 Applications

22.2.1 Aerodrome mapping data includes aerodrome geographic information that support applications which improve the user's situational awareness or supplement surface navigation, thereby increasing safety margins and operational efficiency. With appropriate data element accuracy, these data sets support collaborative decision making, common situational awareness, and aerodrome guidance applications. The data sets are intended to be used in the following air navigation applications:

- (a) on-board positioning and route awareness including moving maps with own aircraft position, surface guidance and navigation.
- (b) traffic awareness including surveillance and runway incursion detection and alerting (such as respectively in A-SMGCS levels 1 and 2);
- (c) ground positioning and route awareness including situational displays with aircraft and vehicles position and taxi route, surface guidance and navigation (such as A-SMGCS levels 3 and 4);
- (d) facilitation of aerodrome-related aeronautical information, including NOTAMs;
- (e) resource and aerodrome facility management; and
- (f) aeronautical chart production.

22.2.2 The data may also be used in other applications such as training / flight simulators and onboard or ground enhanced vision systems (EVS), synthetic vision systems (SVS) and combined vision systems (CVS).

**22.3 Determination of aerodromes to be considered for collection of aerodrome mapping data features**

22.3.1 In order to determine which aerodromes may make use of applications requiring the collection of aerodrome mapping data features, the following aerodrome characteristics may be considered:

- safety risks at the aerodrome
- visibility conditions
- aerodrome layout; and
- traffic density.

*Note: Further guidance on aerodrome mapping data can be found in CARC Guidance Material Aerodrome Operational Services 34GM-03.*

## CHAPTER 23

### Runway Distance Remaining Signs (RDRSs)

- 23.1 Runway distance remaining signs (RDRSs) do not have to be provided at all aerodromes. An aerodrome considering the installation of such signs may wish to assess their need individually, depending on factors such as runway length, aerodrome elevation, aerodrome geometry, traffic levels, lack of runway end safety area, lack of runway friction and climate.
- 23.2 RDRSs are placed along the full length of the runway at longitudinal spacing of 300 m ( $\pm 30$  m), parallel and equidistant from the runway centre line as in Configurations A, B or C, illustrated in Figure A-10. RDRSs are arranged by any of three different configurations as shown in Figure A-10.
- 23.3 In Configuration A, the RDRSs consist of double-faced signs and are located on both sides of the runway. Where the runway length is not an exact multiple of 300 m, the signs are placed at locations where the runway total length is divided equally.
- 23.4 In Configuration B, the RDRSs consist of double-faced signs and are located on both sides of the runway. Where the runway length is not an exact multiple of 300 m, one-half of the excess distance is added to the distance of each sign from each runway extremity. To illustrate the case where the distance between the end of the runway and the sign is the maximum, for a runway length of 1 950 m, the excess distance is 150 m and the location of the last sign on each runway end is 300 m plus one-half of 150 m, or 375 m. This configuration allows a maximum of 375 m at the end of the runway, but the other signs are exactly 300 m apart. The signs may be omitted on one side of the runway because of clearance conflict or by design.
- Note. For Configurations A and B, the signs may be omitted on one side of the runway because of clearance conflict or by design.*
- 23.5 In Configuration C, the RDRSs consist of single-faced signs and are located on one side of each runway, viewed in the direction of take-off or landing. The advantage of Configuration C is that the runway distance remaining is more accurately reflected for a runway length that is not an exact multiple of 300m.
- 23.6 An RDRS may be omitted if the sign cannot be placed within the tolerance of  $\pm 30$  m.



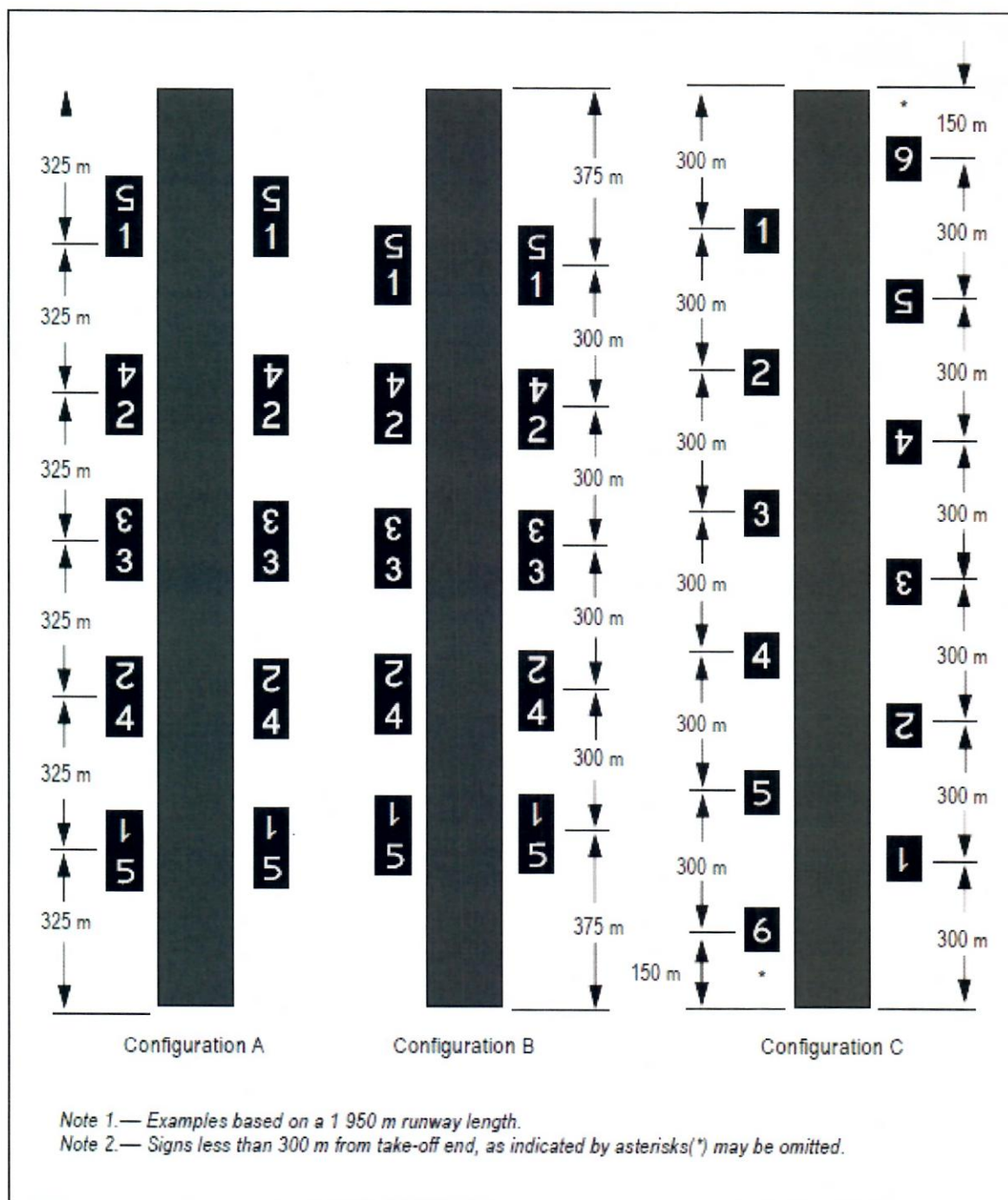


Figure A-10. Runway distance remaining sign configurations

### **Applicable JCARs and Other Publications**

#### **1. Applicable JCARs**

- JCAR Part 139 Aerodrome Operations and Certification
- JCAR Part 157 Notice of Construction, Alteration, Activation, and Deactivation of Airports
- JCAR Part 150 Airport Noise Compatibility Planning
- JCAR PART 77 Objects Affecting Navigable Airspace
- JCAR PART 301 Aviation Environmental Regulations
- JCAR PART 140 Ground Handling Services

#### **2. Other Publications**

- Visual Aids for Navigation
- Runways Design
- Aerodrome Electrical Systems
- Land Use and Environmental Control
- Wildlife Control and Reduction
- Removal of Disabled Aircraft
- Control of Obstacles
- Aerodrome Operational Service
- Aerodrome Maintenance Service
- Safety Management System
- Airfield Pavement Surface Evaluation and Rating Manuals
- Aerodrome Certification Procedures
- Runway Incursions prevention program
- Pavement Operations
- Operational Safety on Airports During Construction
- Airport Safety Self-Inspection
- Airport Ground Vehicle Operations/CARC Guide
- National Bird Strike Information System (IBIS)
- Overview of Safety Management System (Information Paper)
- IATA Safety Audit of Ground Operations (ISAGO)
- Rubber Removal Technique Information Paper
- Airport Emergency Planning
- Apron Management Services
- Critical Data Related to Safety Occurrences Reported at Aerodromes for the Monitoring of Safety
- Pavement Surface Conditions



- Rescue and Firefighting Personnel and Training (Arabic Ver.)
- Rescue and Firefighting Personnel and Training (English Ver.)
- Rescue Operations in Difficult Environments
- Surface Movement Guidance and Control System

