



International Civil Aviation Organization

CAR/SAM Regional Planning Implementation Group (GREPECAS)

Sixth Meeting of the GREPECAS Aerodromes and Ground Aids /
Aerodrome Operational Planning Subgroup (AGA/AOP/SG/6)

San Jose, Costa Rica, 23 to 27 June 2008

AGA/AOP/SG/6-WP/12

10/04/08

Agenda Item 5 Review of Task Forces Activities

5.1 Runway Strips & Runway End Safety Areas Task Force Report

**REPORT OF THE COORDINATION MEETING OF THE RUNWAY END SAFETY AREA
(RESA) AND RUNWAY STRIP TASK FORCE OF THE ICAO GREPECAS AGA/AOP
SUBGROUP**

(Presented by George I. Legarreta, Rapporteur, United States)

SUMMARY

Two safety deficiencies being addressed by AGA/AOP/SG are the standards and recommended practices (SARP) for runway end safety areas (RESA) and runway strips. In particular, AGA/AOP/SG formed the *Runway End Safety Area and Runway Strip Task Force* to address the question of how best to comply with existing SARPs and, possibly, any revised RESA SARPs that require greater lengths and widths.

On 30th July – 3rd August, 2007, the *RESA and Runway Strip Task Force* met at the ICAO Regional Office, Lima, Peru. The objectives of the meeting were:

- List of issues which ICAO [Montreal] needs to clarify the understanding of the SARPs relative to RESAs and runway strips;
- Solutions for runways that do not have sufficient land for constructing RESAs and must comply with the SARPs of ANNEX 14, Volume I, 4th edition;
- How engineered materials arresting systems (EMAS) for aircraft overruns can be used with different exit velocities [70 knots or less] or other types of materials that can produced deceleration of aircraft; and,
- How aircraft capabilities and pilot operations can assist airport authorities to better achieve RESA SARPs.

This WP paper provides the opinions and conclusions of the Task Force. Additionally, the report was presented at the meeting of the *Aerodrome Design Working Group (ADWG)* of the *Aerodromes Panel* held in Montreal, Canada, ICAO Headquarters on March 26-28, 2008.

References:

Annex 14, Volume I, 4th Edition

United States Federal Aviation Administration Advisory Circulars:

- AC 150/5300-13, *Airport Design*
- AC 150/5340-30C, *Design and Installation Details for Airport Visual Aids*
- AC 150/5220-20A, *Engineering Materials Arresting System (EMAS) for Aircraft Overruns*

The Advisory Circulars are available at
http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/

1. INTRODUCTION

1.1 Presently, some runways in the CAR/SAM regions do not comply with existing SARPs for RESAs and runway strips. Because RESA deficiencies are classified by ICAO Regional Offices as *Urgent*, in 2001 AGA/AOP/SG/1 established the *RESA and Runway Strip Task Force* to monitor the situations and report annually to AGA/AOP/SG of any improvements. The Task Force is also responsible for developing guidance documents and identifying potential solutions to eliminate such deficiencies.

1.2 On 30th July – 3rd August, 2007, the Task Force met at the ICAO SAM Regional Office, Lima, Peru to discuss RESA and runway strip compliance. The Task Force's final report, *Report of the Coordination Meeting of the Runway End Safety Area (RESA) and Runway Strip Task Force of the GREPECAS/AGA/AOP/Subgroup*, is hereby included which includes opinions, conclusions, and potential solutions to assist member states.

2. DISCUSSION

2.1 One observation identified that requires the immediate attention by ICAO Montreal is that the definition for RESA in the Spanish version of Annex 14, Volume I, is not in agreement with the English version. *The Task Force welcomes a timely correction to the Spanish version endorsing the English version.*

UPDATE:
ADWG informed the ICAO Secretary of the discrepancy. The Secretary agreed to notify the language department of the discrepancy and recommend that the English version be used for the Spanish version.

2.2 The Task Force report *endorses a special application of declared distance* to obtain RESAs which is not mentioned in ANNEX 14, Volume I.

UPDATE:
ADWG informed the ICAO Secretary of the benefits of this alternative to better comply with Annex 14, Vol. I RESA SARPs. The members of the ADWG additionally are in favor of this possible alternative. The next ADWG, October 2008, will formalize the concept to, hopefully, recommend the alternative to the *Aerodrome Panel* as an accepted practice.

2.3 The Task Force report *acknowledges that EMAS has proven itself effective in decelerating errant aircraft, but the system is costly.* To obtain some of the safety benefits but at lower costs, the Task Force concluded that errant aircraft entering an EMAS could use a lower entrance speed than the design speed of 70 knots used by the United States. Each member state respectively would determine its own design value for the entrance speed. Figure 5 of the report illustrates this conclusion.

2.4 The Task Force report informs airport authorities *how the performance variability among aircraft, principally during takeoff, and pilot practices* could assist their efforts to obtain RESAs with little or no operational impact to their customers. Figures 6, 7, and 8 of the report illustrate these conclusions.

2.5 The Task Force report acknowledges that the most severely land constraint runway ends may need to combine the above alternatives to obtain full or partial RESA SARPs.

2.6 *Regarding runway strips*, the Task Force requested ICAO Montreal to provide better, clearer guidance on the characteristics of the ground area of the runway strip beyond the graded portion of the strip. The items identified were as follows:

- (1) What conditions, materials, and types of construction may be in this zone, e.g., drainage channels, open wide channels, surface water, ground depressions, walls, fences, police guard houses, etc.
- (2) What transverse slope is to be applied in this ground area, i.e., from the edge of the graded strip to the edge of the 150-meter border.
- (3) With respect to the recommended transverse slope of the RUNWAY STRIP per paragraph 3.4.15, the transverse slope of any portion of a runway strip beyond that to be graded should not exceed an upward slope of 5% as measured in the direction away from the runway. However,
 - Applying the recommendation in paragraph 3.4.15, you can obtain a calculated height beyond the boarder of the runway strip which *may be higher* in elevation than the height of the runway centerline.
 - Concurrently per paragraph 3.4.15, the elevation of any point along the border [of the runway strip] will equal the elevation of the nearest point of the runway centerline or its extended centerline.
 - These observations require that the surface transition at the border simultaneously has a height equal to the height of the runway centerline [perpendicular to this point] and a height higher beyond the border per paragraph 3.4.15.
 - This situation should be clarified to resolve this discrepancy found in paragraph 3.4.15. That is, that the upward slope of 5% as measured in the direction away from the runway will be applicable up to the height of the closest runway centerline.

UPDATE: ADWG informed the ICAO Secretary of these issues. The Secretary will provide better guidance so that runway strip SARPs are applied more consistently throughout the ICAO regions.

ATTACHMENT

REPORT OF THE COORDINATION MEETING OF THE RUNWAY END SAFETY AREA (RESA) AND RUNWAY STRIP TASK FORCE OF THE GREPECAS AGA/AOP SUBGROUP

Lima, Peru, 30th July – 3rd August 2007
ICAO Regional Office

For your attention, permit us to present the report covering the most relevant aspects that were developed within the meeting relative to the operations of airports in your countries by the *Runway End Safety Area and Runway Strip Task Force* of the GREPECAS AGA/AOP Subgroup. The meeting was held at the ICAO Regional Office in Lima, Peru from the 30th July to the 3rd August, 2007.

- **Proposed issues treated by this meeting:**
 - List of issues which ICAO needs to clarify the understanding of the standards and recommended practices relative to RESAs and runway strips.
 - Solutions for runways that do not have sufficient land for constructing RESAs and must comply with the standards and recommended practices of ANNEX 14, Volume I, 4th edition.
 - How engineered materials arresting systems (EMAS) for aircraft overruns can be used with different exit velocities [70 knots or less] or other types of materials that can produce deceleration of aircraft.

- **Background:**

ICAO is currently proposing new provisions to increase the safety of aviation operations through the adaptation of the runway strips and the establishment of larger RESAs. However, keeping in mind that the majority of the airports in the CAR/SAM Regions were constructed before 1980, airports find themselves without the available land for the implementation and construction of these elements.

Similarly, there exist airports that provide services to important cities which were constructed in the middle of insurmountable natural obstacles thereby making implementation of new provisions difficult.

By the foregoing it is indispensable to study ANNEX 14 and to seek development of possible alternatives that would lead to compliance with the ICAO provisions while having the smallest effect on airport operations.

- **Development:**

The cited meeting was conducted on the premises of ICAO Lima Regional Office and attended by the following representatives: George Legarreta, rapporteur, civil engineer, AGA representative of United States; Colonel Alberto Palermo, AGA representative of Argentina; Aldemar Pinzon, civil engineer, AGA representative of Colombia, and Oscar Nieto, representative of Colombia. A few other AGA members were not able to attend.

During the discussions there emerged some technical considerations that require clarifications by ICAO in order to generate solutions for achieving compliance with the guidelines in the ANNEX 14 are following:

A. RUNWAY STRIP

It is essential to clarify certain aspects related to the form and structure of the runway strip.

Paragraph 3.4.3 of Annex 14 indicates that the width of the runway strip for precision approach runways for Code Numbers 3 and 4, shall be 150 meters on each side of the centerline of the runway and its extended centerline throughout the length of the runway strip. The same width is recommended for non-precision approach Code Numbers 3 and 4 runways. **Paragraph 3.4.8** states that the *graded portion* of the runway strip should be of 75 meters on each side of the centerline of the runway and its extended centerline throughout the length of the runway. However, there is no clear guidance on the characteristics of the ground area of the runway strip beyond this graded portion with respect to the following:

- (1) What transverse slope is to be applied in this ground area, i.e., from the edge of the graded strip to the edge of the 150-meter border.
- (2) What conditions, materials, and types of construction may be in this zone, e.g., drainage channels, open wide channels, surface water, ground depressions, walls, fences, police guard houses, etc.
- (3) With respect to the recommended transverse slope of the RUNWAY STRIP per paragraph 3.4.15, the transverse slope of any portion of a runway strip beyond that to be graded should not exceed an upward slope of 5% as measured in the direction away from the runway. However,
 - Applying the recommendation in paragraph 3.4.15, you can obtain a calculated height beyond the boarder of the runway strip which *may be higher* in elevation than the height of the runway centerline.
 - Concurrently per paragraph 3.4.15, the elevation of any point along the border [of the runway strip] will equal the elevation of the nearest point of the runway centerline or its extended centerline.
 - These observations require that the surface transition at the border simultaneously has a height equal to the height of the runway centerline [perpendicular to this point] and a height higher beyond the border per paragraph 3.4.15.
 - This situation should be clarified to resolve this discrepancy found in paragraph 3.4.15. That is, that the upward slope of 5% as measured in the direction away from the runway will be applicable up to the height of the closest runway centerline.

B. Runway End Safety Areas – RESA

Item 1. In the Spanish version of Annex 14, definition 1.1, RESA, defines the area off the runway ends for reducing the risk of damage to aircraft landing short or landing long. This definition addresses only the landing distance available [LDA] operation.

In the English version, the same definition 1.1 considers both aircraft operations of landing and takeoff. This definition addresses the LDA operation and the aborted takeoff operation [ASDA – accelerated-stop distance available operation].

Therefore it is suggested that the Spanish version be standardized with the English version for RESA with the following modification to the RESA definition:

“...an aircraft conducting a landing undershoot or landing overrun or an aborted takeoff.”

Item 2. Taking into account that the purpose of the RESA is mitigating landing LDA and takeoff ASDA emergencies, a *special application of declared distances* may obtain full-standard RESAs for runways. This potential safety benefit is realized because the four declared distances, LDA, TORA, TODA, and ASDA, are independent of each other.

This *special application of declared distances* is published by the United States Federal Aviation Administration in *Advisory Circular AC 150/5300-13, Airport Design*. The document is available at http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/. In general, an analysis is done for each direction of operation for a runway to manipulate the eight independent declared distances, four in each direction, to obtain the longest possible RESA off each runway end. In this special application two circumstances are considered:

(1) For landings, a RESA is located before the threshold for undershoots and located beyond the end of the runway for overruns. Therefore the landing operation (LDA) requires two RESAs.

In some cases the threshold is displaced. Displaced thresholds are handled in the same manner except that the RESA, which starts before the displaced threshold, uses the existing paved runway. This paved runway before the displaced threshold continues to be available for takeoff operations.

(2) For takeoffs, a RESA only exists at the end of the runway for the aborted emergencies (ASDA). Therefore the takeoff operation (ASDA) requires one RESA. In some cases the operational runway is slightly reduced (ASDA) but not the physical pavement (TORA). In practice only LDA and ASDA require RESAs.

Item 3. The vertical and horizontal runway lighting configurations that indicate each of the circumstances to the flight crews can be a bit complicated. Because of this, the USFAA applies the *same lighting configurations with or without declared distance* through *Advisory Circular 150/5340-30C, Design and Installation Details for Airport Visual Aids*. These designs can be taken into consideration as a guide for the implementation of each of the cases in the studies. Figures 1, 2, and 3 illustrate the continued use of the same lighting configurations and how the declared distances are declared for runways with sufficient land [Figures 1 and 2] and insufficient land [Figure 3] beyond the runway end. The document is available at:

http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/

(1) Figure 1 shows a runway, threshold, and stopway which has sufficient land beyond the runway end to obtain the standard U.S. runway safety area [RSA]. Please see the two different blue lines are shown one for ASDA that starts at the end of the stopway [SWY] and the other line that starts for LDA before the threshold. In this case the operation is from right to left.

(2) Figure 2 shows a runway, displaced threshold and stopway with sufficient land for standard U.S. RSAs. In this case most of the RSA for LDA is runway. The RSA for ASDA is beyond the stopway.

(3) Figure 3, insufficient land beyond the runway end to obtain standard U.S. RSA. In this case the lighting configurations remain the same but the ASDA and LDA in the direction from right to left are shorten. The shorten length is used to obtain the length for the U.S. RSA.

Item 4. In some cases, the runway is so confined that only a portion of the RESA is obtained. For such cases, the Task Force discussed alternative methods in conjunction with the special application of declared distances to obtain RESAs for both runway ends. That discussion follows.

C. How can EMAS (Engineering Materials Arresting Systems - Sistema de Detencion con Materiales de Ingenieria) be used with different exiting speeds (70 knots or less) or use other materials that impede entering aircraft.

Item 1. The task force discussed the benefits of EMAS (Engineering Materials Arresting System - Sistema de Detencion con Materiales de Ingenieria) installations used by airports in the United States, which considered a coefficient of runway surface friction at 0.25, aircraft exit speed from the runway at 70 knots, and aircraft braking without reverse thrust. Please see figure 4 for typical installation. These design conditions are consistent with USFAA *Advisory Circular 150/5220-20A, Engineering Materials Arresting System (EMAS) for Aircraft Overruns*. [The document is available at:

http://www.faa.gov/airports/airtraffic/airports/resources/advisory_circulars/

Item 2. The perception of the group on this system is that it has proven its efficiency in situations of aircraft overrun emergencies that occurred at airports in the United States, where there has been some EMAS implemented with lower than the design 70 knot runway exit speed because of lack of land. In other words, shorter EMAS were installed due to insufficient terrain.

It was also observed that each Member State is free to choose the design entry speed for aircraft into the EMAS and thereby reducing the costs of the EMAS construction. Figure 5 shows the length of an EMAS for the DC-10 at a 70 knot runway exit speed as 158 meters [520-feet]. In comparison a 60-knot runway exit speed reduces the EMAS for the DC-10 down to 122 meters [400 feet]. The 10-knot reduction reduces the EMAS length for this design aircraft by 23 percent.

Item 3. Moreover, the working group discussed that there is at present a dependency on a single supplier of one type of EMAS, who has patented the product and whose installation costs are high. However, options exist to reduce the final cost by modifying the condition of entry speed into the EMAS as was shown in Figure 5.

In conclusion each Member State is free to acquire EMAS for its airports in complementing the areas for RESAs or to develop studies of materials that permit compliance with the objects of RESA.

Item 4.

CONCLUDING REMARKS

- **MATERIALS FOR RESA:** Member States may use all kinds of proven material deemed useful for the deceleration of the aircraft, as well as define the parameters that must comply with the design aircraft for this surface material (velocity, mass, braking system, etc.). All proposed material must bear the transport of rescue and firefighting vehicles RFF.

- **OPERATION OF AIRCRAFT:** Airport operators need to be aware that “*aircraft options*” made available to air carriers can be used to obtain RESAs without reducing runway length. That is, the airport operator should ask their customers: What (1) operational and (2) equipment options certified by the airframe manufacturers help to obtain standard RESAs? The most common options are engine performance ratings and brake release procedures for takeoff and flap settings for landing. The safety benefit via a change in engine types and operations normally result in shorter runways. This reduction in runway length can then be used for RESAs. The following examples illustrate this safety benefit.
 - **Example 1:** Consider the Boeing 737-400, MTOW = 68,040 KG (150,000 pounds) under the following conditions: Runway length = 3,000 meters (9,850 feet), airport elevation above mean sea level (MSL) = 150 meters (500 ft), “*Hot Day*” operation approximately 30 degrees C (86 Degree F).
 - **Figure 6** shows the horizontal Red Line at 3,000-meter runway length intersecting with the 150-meter MSL with the vertical line showing an operational takeoff weight of approximately 66,500 KG (146,300 pounds).
 - **Result:** A takeoff weight restriction of 1,540 KG (3,700 pounds) exists for this procedure.
 - In comparison **Figure 7**, same aircraft but a different engine and operation (see yellow highlight), shows that the horizontal Red Line never intersects the 150-meter (500-foot) MSL but instead intersects the MTOW line.
 - **Result:** The aircraft is not operational weight restricted. In fact, this takeoff operation uses approximately 2,800 meters (9,200 feet), a savings of 200 meters (660 feet) for the RESA.
 - Graphs are available at:
http://www.boeing.com/commercial/airports/plan_manuals.html
 - Airbus: http://www.content.airbusworld.com/SITES/Technical_Data/index.html
 - Other manufacturers have similar web sites.
 - **Example 2:** Consider **Figure 8** same design aircraft but for a different airport at sea level. This airport operator wants to comply not only with the standard 90 meter RESA but with the recommended 240-meter RESA. Additionally, airport does not want to restrict the customer’s operation. Therefore the MTOW is used.
 - **Figure 8** shows that the vertical Red Line = MTOW intersecting the SEA LEVEL airport elevation generates a horizontal Red Line that assigns a runway length of 2,670 meters. This is a savings of 330 meters [3,000m – 2,670m = 330m]. This length is more than necessary for the 60m runway strip + the recommended 240 m RESA = total of 300 m.
 - **Result:** With the special application of declared distance, both runway ends can obtain the recommended 240-meter RESA.

Cordially,

George Legarreta, Civil Engineer, Office of Airport Safety and Standards, United States
Commodore Jose Alberto Palermo, Chief, Department of Aerodrome, Argentina
Aldemar Pinzon, Civil Engineer, Aeronautical Specialist, Colombia

Figure 1

AC 150/5340-30B
Appendix 1

August 1, 2006

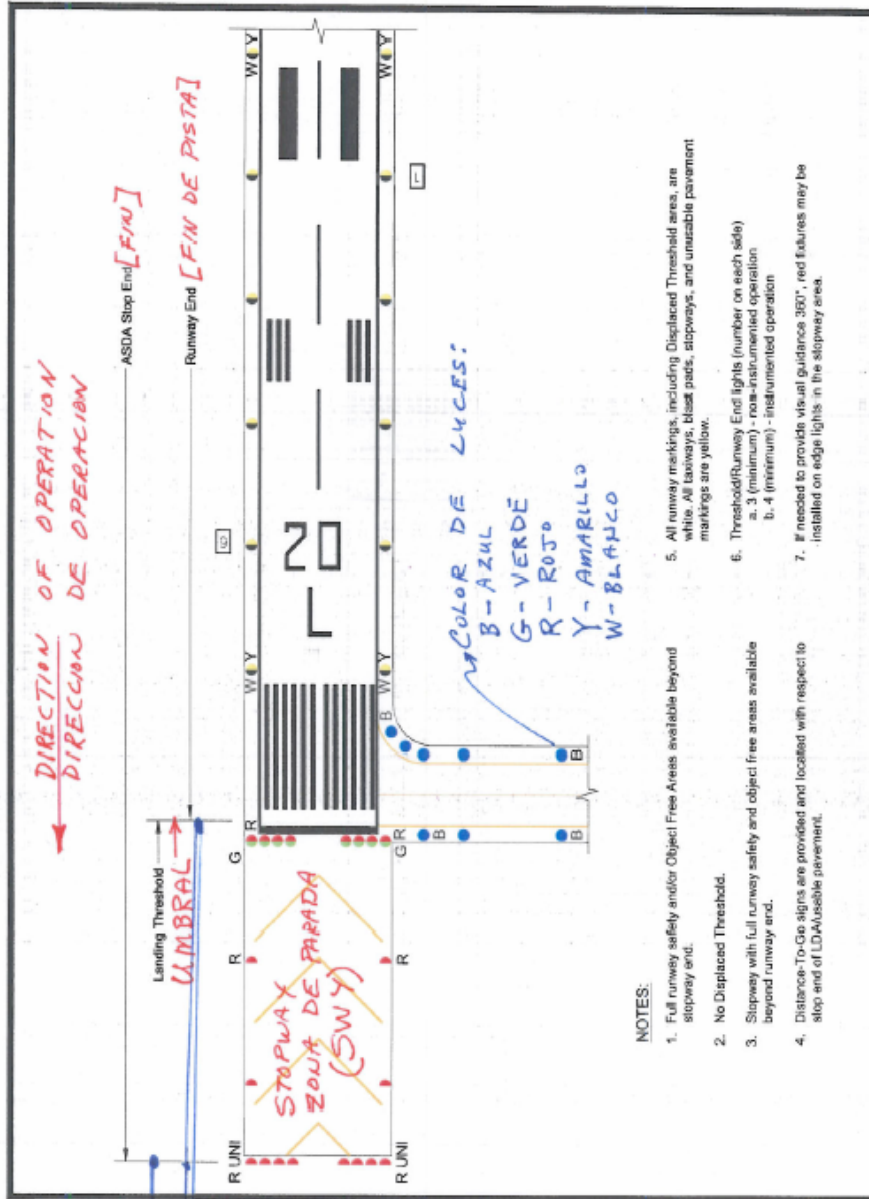


Figure 11. Lighting for Runway with Stopway.

START OF U.S. RSA FOR ASDA
START OF U.S. RSA FOR LDA

LYCES PARA PISTA CON ZONA DE PARADA (SWY)

SUFFICIENT LAND
SUFICIENTE TERENO

Figure 2

August 1, 2006

AC 150/5340-30B
Appendix 1

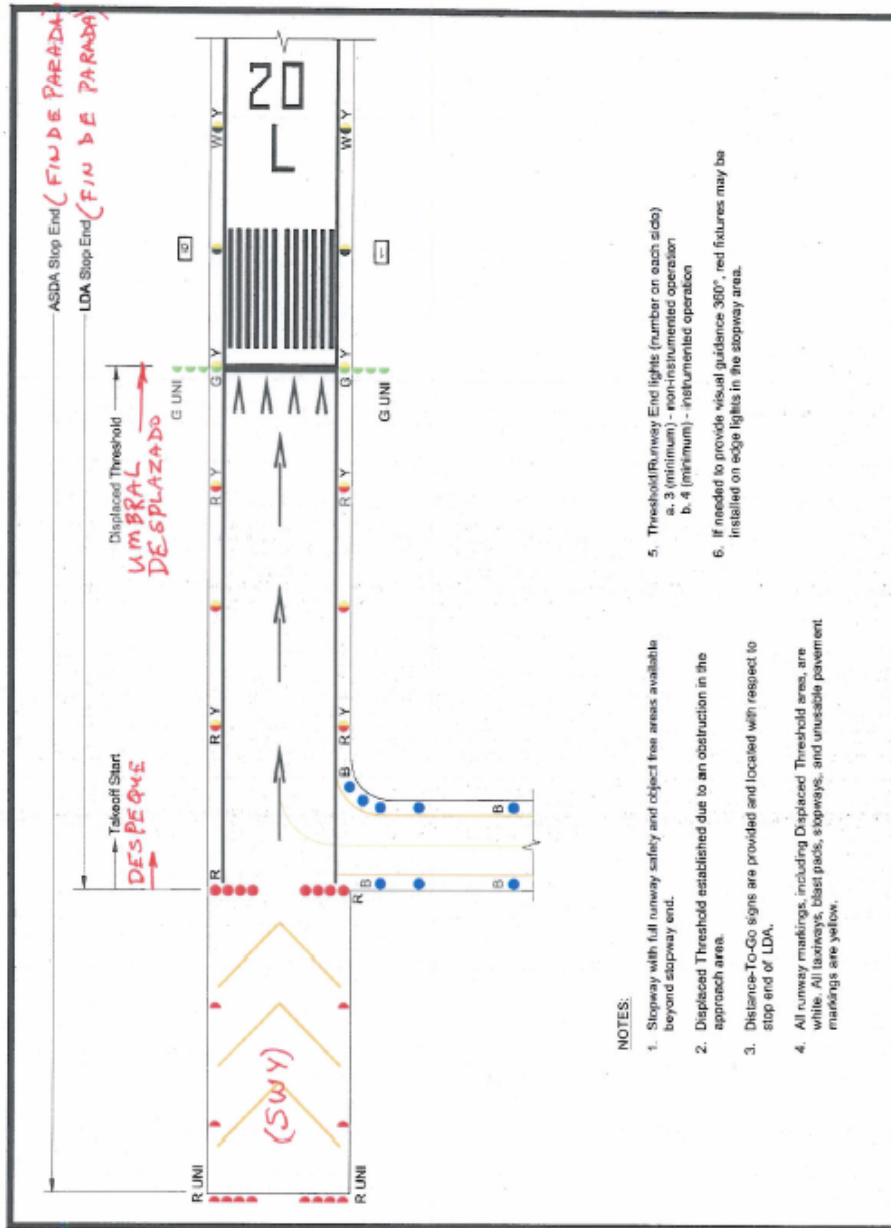


Figure 12. Lighting for Runway with Displaced Threshold & Stopway.

LUCES PARA PISTA CON UMBRAL DESPLAZADA Y CON ZONA DE PARADA.

SUFFICIENT LAND

Figure 4. Typical EMAS Installation Section

AC 150/5220-22A
Appendix 1

9/30/2005

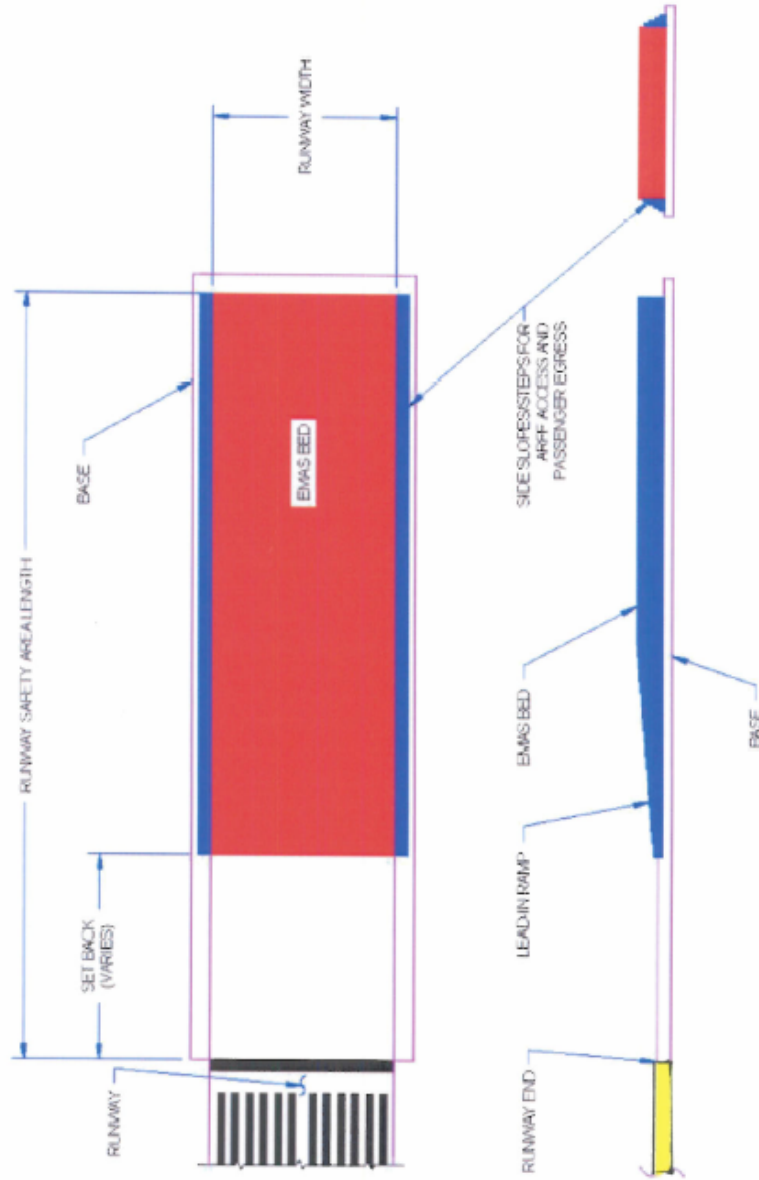


FIGURE A1-2. EMAS TYPICAL SECTION.

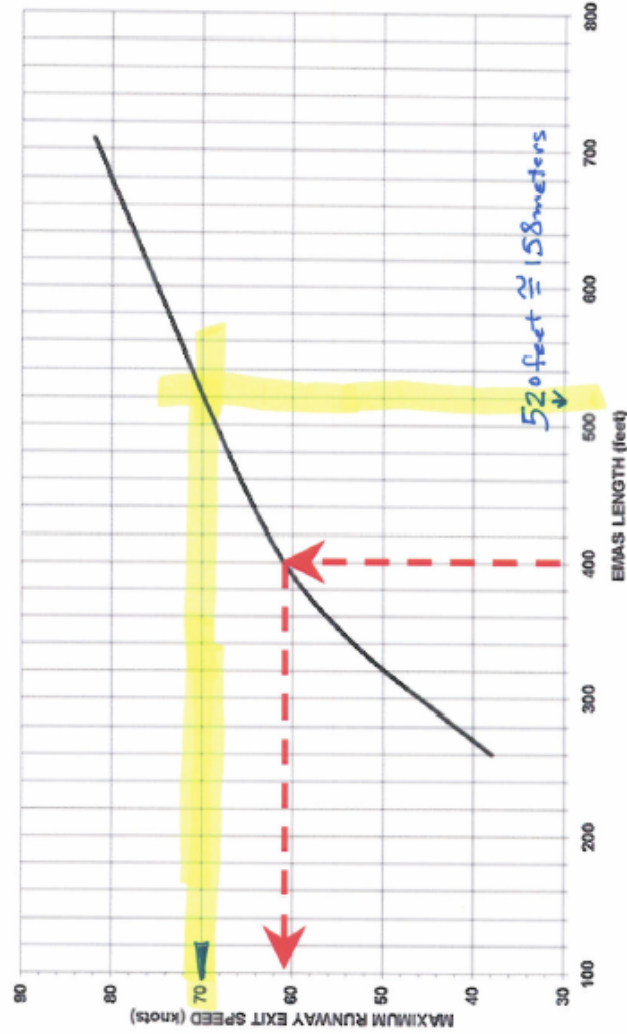
Figure 5. Length of EMAS for DC-10

AC 150/5220-22A
Appendix 2

9/30/2005

PLANNING PURPOSES ONLY
NOT TO BE USED FOR DESIGN - SEE PARAGRAPH 6

DC-10
GW = 455,000 lbs.
NO REVERSE THRUST & POOR BRAKING



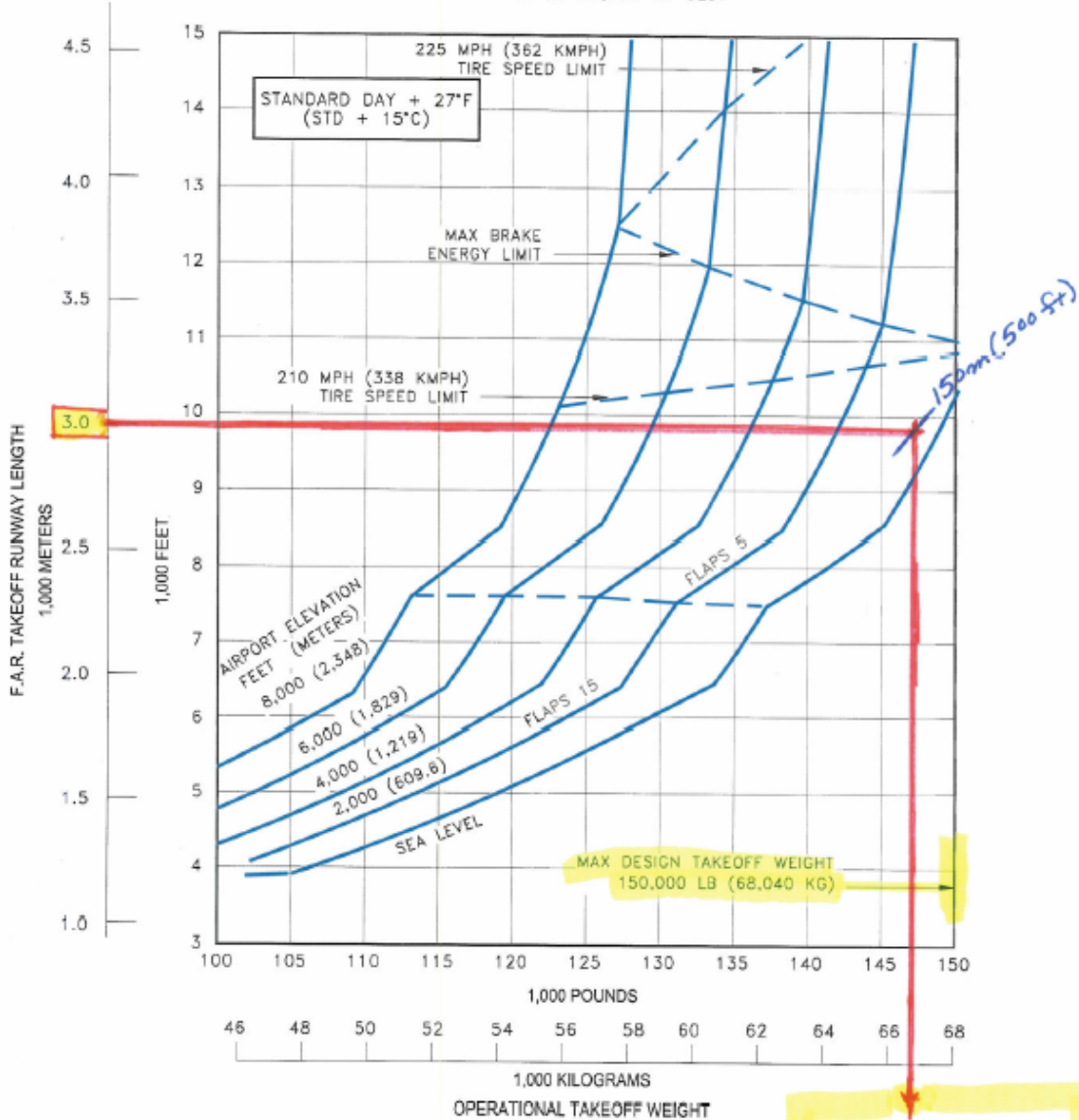
- Notes:
1. Arrestor includes a 75 ft paved lead-in rigid ramp. A 35 ft setback can be used to improve performance for short safety areas.
 2. Poor braking simulated using 0.25 braking friction coefficient.

FIGURE A2-2.

Figure 6.

NOTES:

- * NO ENGINE AIRBLEED FOR AIR CONDITIONING
- * ZERO WIND, ZERO RUNWAY GRADIENT
- * CONSULT USING AIRLINE FOR SPECIFIC OPERATING PROCEDURE PRIOR TO FACILITY DESIGN
- * CFM 56-3B2 ENGINES RATED AT 22,000 LB SLST



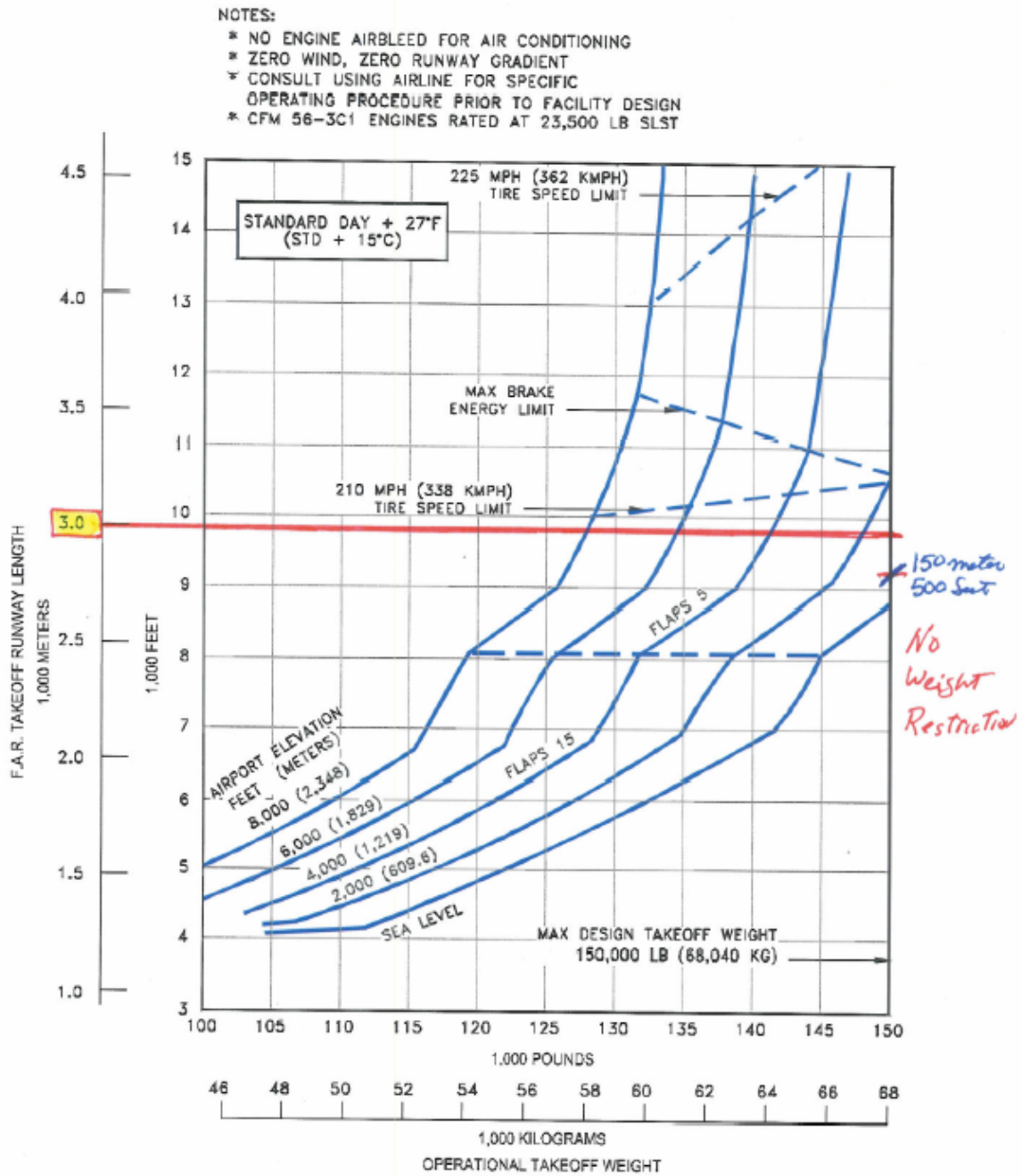
3.3.16 F.A.R. TAKEOFF RUNWAY LENGTH REQUIREMENTS

STANDARD DAY +27°F (STD + 15°C)
 MODEL 737-400 (CFM56-3B-2 ENGINES AT 22,000 LB SLST)

D6-58325-6

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Figure 7



3.3.18 F.A.R. TAKEOFF RUNWAY LENGTH REQUIREMENTS

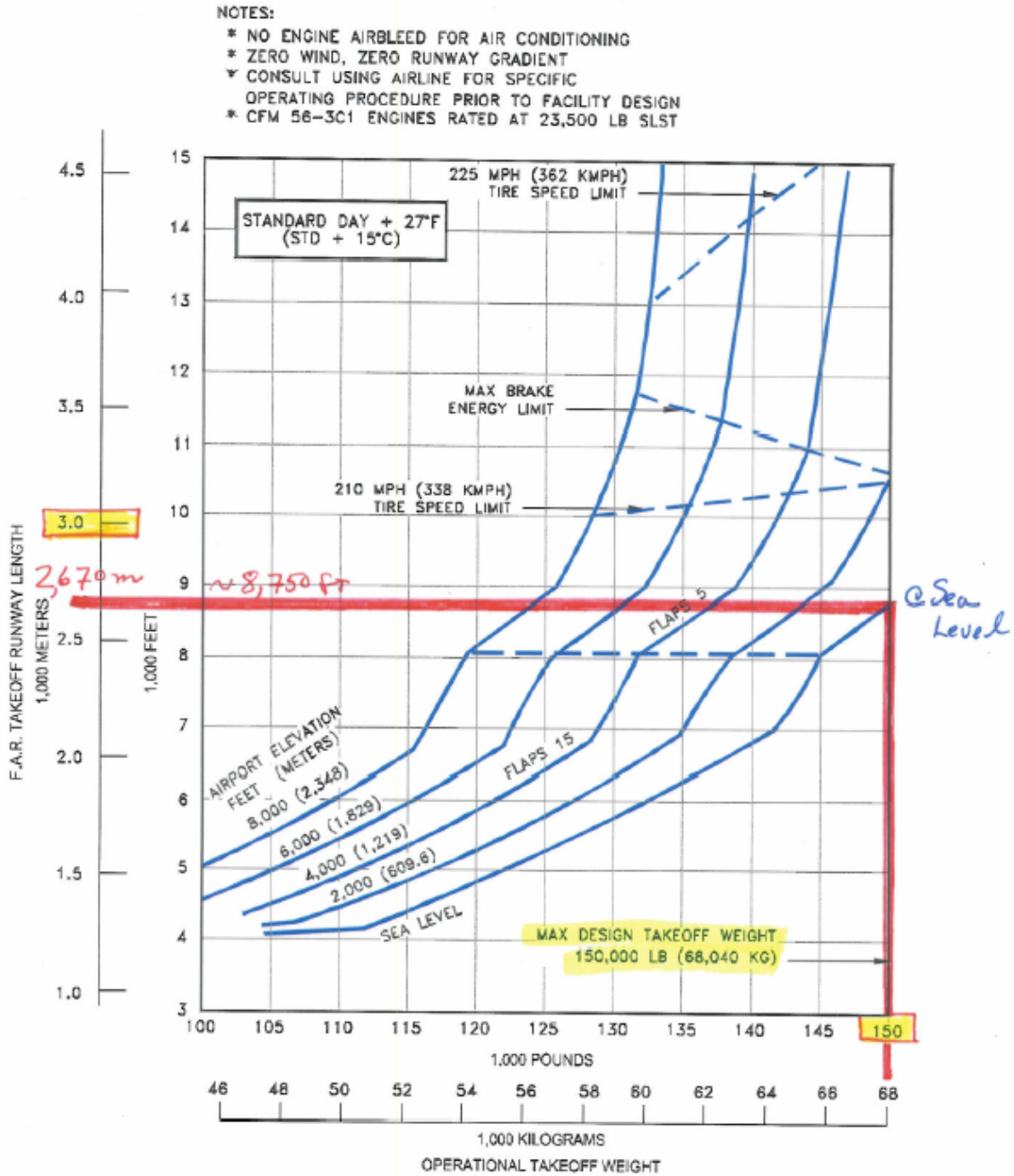
STANDARD DAY +27°F (STD + 15°C)

MODEL 737-400 (CFM56-3C1 ENGINES AT 23,500 LB SLST)

D6-58325-6

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Figure 8.



3.3.18 F.A.R. TAKEOFF RUNWAY LENGTH REQUIREMENTS
STANDARD DAY +27°F (STD + 15°C)
MODEL 737-400 (CFM56-3C1 ENGINES AT 23,500 LB SLST)
D6-58325-6

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