Assignment 4

Solution Instructor: Trani

Problem 1

Before solving this problem, familiarize yourself with the FAA AC 150/5220-22B and review the course notes.

A reliever airport in California is evaluating the need for a runway arrestor system (EMAS). The airport has a 175-foot runway safety area at one runway end. The critical aircraft is a corporate jet similar in size to the Gulfstream III. The Gulfstream III is 1,500 lbs lighter than the Gulfstream G-350, shown in Figure 1. The airport has approach procedures with runway visibility minima of 1 nautical mile (RVR).

- Gulfstream III AAC = C
- Gulfstream III ADG = II
- RVR = 1 nm
- Gulfstream III OEW = 39,500 Lb
- Gulfstream III MTOW = 69,700 Lb

a) Find the RDC code for the runway design to accommodate the Gulfstream G-III. State all three parameters of RDC.

- The RDC is a three-component code relating AAC, ADG, and approach visibility minimums establishing the design characteristics for a particular runway.
  - RDC: AAC-ADG-RVR
  - RDC: C-II-5000

b) Find the size of the EMAS required to bring the runway end into compliance (i.e., legal RSA). State the recommended design exit speed used in your design.

- The minimum width of the EMAS must be the standard runway width for the applicable airplane design group per AC 150/5300-13. Therefore, EMAS width is 100 ft.
- Note: AC 150/5300-13B is available for download here:

  AC-150-5300-13B-Change1

Table G-11. Runway Design Standards Matrix, C/D/E-V

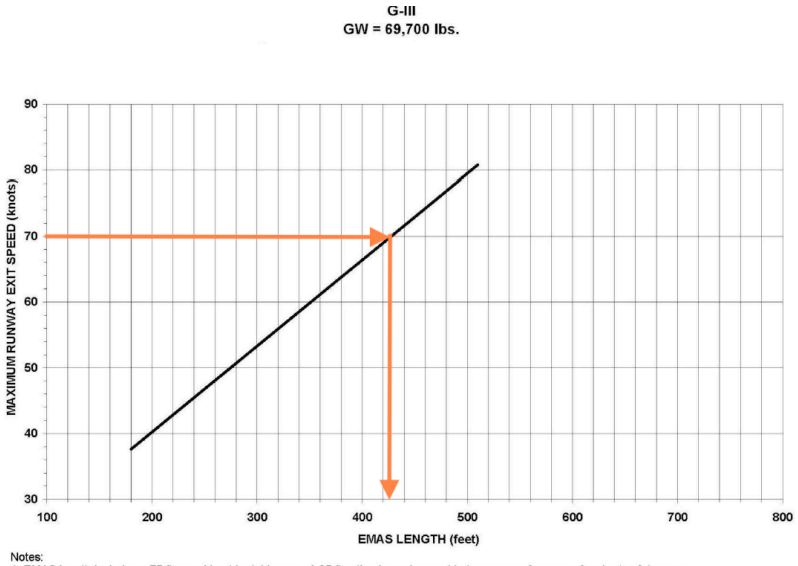
Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – V			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.7.1			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		35 ft	35 ft	35 ft	35 ft
Blast Pad Width		220 ft	220 ft	220 ft	220 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional		*Refer to paragraph* 3.11			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.9			
Holding Position [8]		250 ft	250 ft	250 ft	280 ft
Parallel taxiway/taxilane centerline [3, 5]	D	400-500 ft	400-500 ft	400-500 ft	400-500 ft
Aircraft parking area	G	*Refer to paragraph* 3			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note 1: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.
Note 2: See the Footnotes on the page after Table G-12.

- Based on FAA AC 150/5220-22B EMAS length must be at least 600 feet (or the length of the standard runway safety area, whichever is less) between the runway threshold and the far end of the EMAS bed.

- RSA length beyond the departure end for this aircraft is 1,000 ft.

- Therefore, the EMAS base length would be 600 feet at this desired airport in California.
- **The EMAS bed length would be 425 ft.**



Notes:
1. EMAS length includes a 75 ft paved lead-in rigid ramp. A 35 ft setback can be used to improve performance for short safety areas.
2. Standard design conditions include no reverse thrust and 0.25 braking friction coefficient.

The EMAS system design condition stops the "critical aircraft" upon exiting the runway at 70 knots.

c) State the standard RSA, ROFA, and RPZ dimensions for the Gulfstream G-III.

Table G-8. Runway Design Standards Matrix, C/D/E-II

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – II			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs 3.3 and 3.7.1*			
Runway Width	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		120 ft	120 ft	120 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width [13]	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional		*Refer to paragraph 3.11*			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 3.9*			
Holding Position		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	300 ft	300 ft	300 ft	400 ft
Aircraft parking area	G	*Refer to paragraph 3*			
Helicopter touchdown pad		*Refer to AC 150/5390-2*			

Note 1: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.
Note 2: See the Footnotes on the page after Table G-12.

- RSA:
- Length beyond departure end = 1000 ft
- Length prior to threshold = 600 ft
- Width = 500 ft

- ROFA:
- Length beyond departure end = 1000 ft
- Length prior to threshold = 600 ft
- Width = 800 ft

- RPZ:
- Length = 1700 ft
- Inner width = 500 ft
- Outer width = 1010 ft

d) Read the FAA definition of airports (https://www.faa.gov/airports/planning_capacity/categories) and state the purpose of reliever airports.

- Reliever airports are nonprimary airports designated by the Secretary of Transportation to relieve congestion at a commercial service airport and to provide more general aviation access to the overall community (Source: https://www.faa.gov/airports/planning_capacity/categories)

e) Estimate the runway length needed at the airport using SARLAT 2 if the airport is located 1,860 feet above sea level and the design temperature is 28 degrees Fahrenheit above ISA conditions. In your analysis, use the Gulfstream 350 aircraft (similar in performance to the G-III) with 70% useful load.

- ISA conditions temperature at 1,860 ft above the sea level is:

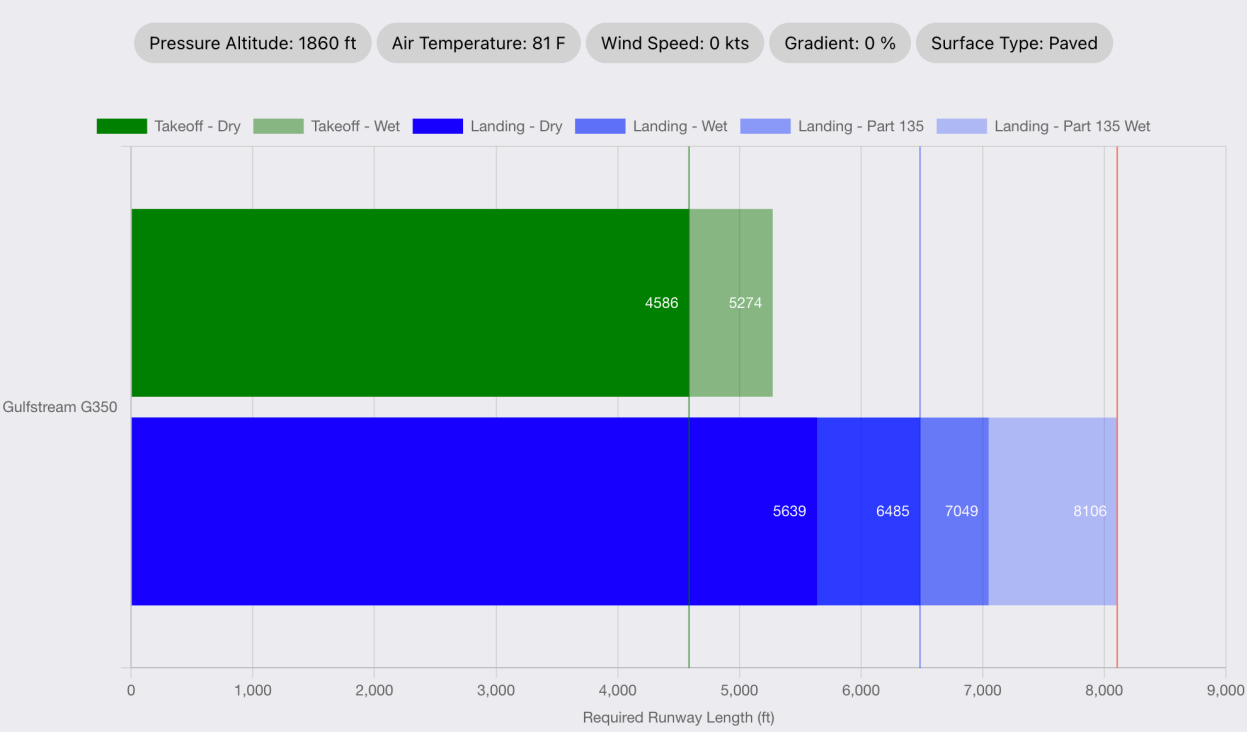
$$\text{ISA Temperature at airport site} = 15^{\circ}C - \left(\frac{2^{\circ}C}{1000 \text{ feet}} \times 1860 \text{ feet}\right) = 15^{\circ}C - 3.72^{\circ}C = 11.28^{\circ}C$$

11.28 Celsius ~ 52.3 Fahrenheit

Design temperature = 52.3 + 28 = 80.3 ~ 81 Fahrenheit

- Assume zero wind and no runway gradient.

- **Runway length required for takeoff (dry) = 4586 ~ 4600 ft**
- **Runway length required for landing (wet) = 6485 ~ 6500 ft**
- **Therefore the required runway length would be 6500 ft.**



Problem 2

Use Google Earth and review the EMAS systems installed on runway thresholds 5 and 23 at Charleston, West Virginia (CRW). The critical aircraft operating at CRW is similar in size to the Boeing 757 (see Figure 2).

a) Measure the runway 5 and 23 thresholds EMAS systems carefully. State the dimensions of each arrestor bed.

- Runway 23 EMAS is 328 ft long and 170 ft wide. (you may also confirm this dimension on the Airnave website: https://www.airnav.com/airport/KCRW

b) If the critical aircraft is the Boeing 757 (gross weight is 255,000 lbs.), estimate the EMAS design speed based on the arrestor bed dimension estimated in part (a).

- **EMAS design speed = 54 knots**

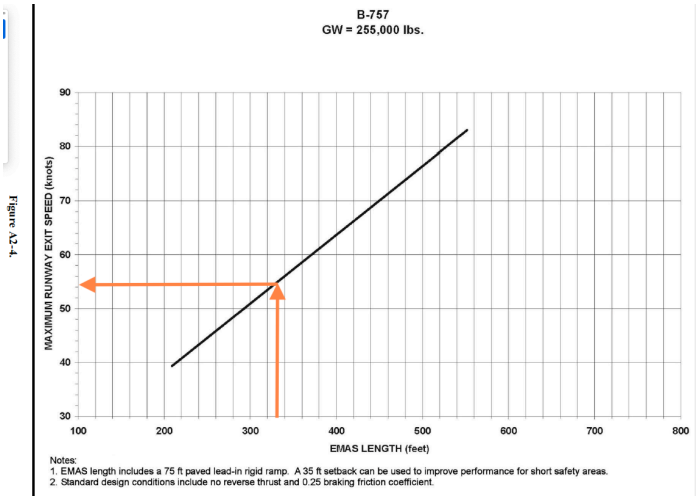


Figure A2-4.

c) Explain the reason for the EMAS systems installed on runways 5 and runway 23. Use Google Earth to view the elevation profiles past each runway threshold. Comment on what you see in those profiles.

- Comment: The EMAS is installed at the end of runway 23 to stop an aircraft that overruns during takeoff. This is crucial due to the steep drop in elevation beyond the runway's end

Figure 2. Boeing 757-200 Landing on Runway 26R at Atlanta Hartsfield International Airport (A.A. Trani).

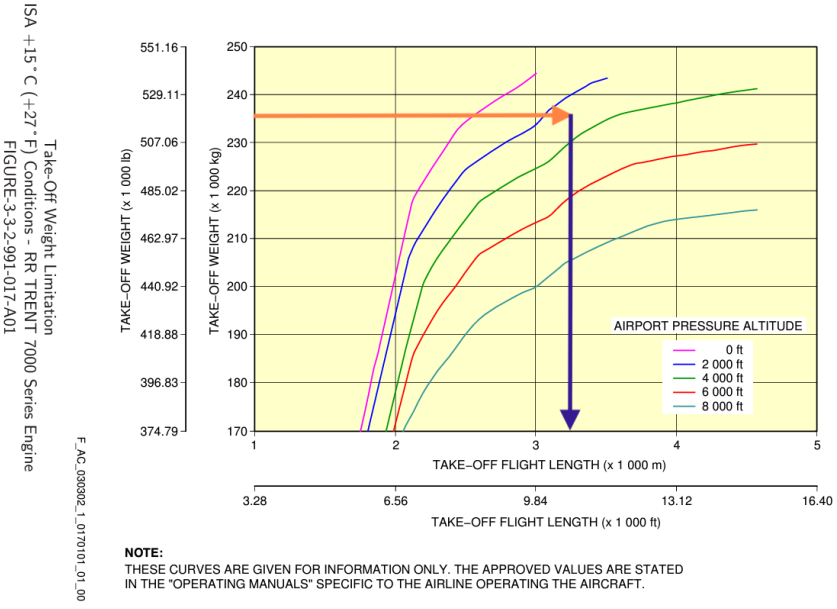
Problem 3

A site located 3,000 feet above mean sea level is proposed for a new international airport. The critical aircraft is the Airbus A330-900 with Rolls-Royce Trent 7000 Series Engines (see Figure 3). The airport's design temperature is ISA + 15 degrees C. The airline would like to fly routes requiring takeoff weights up to 235 metric tons. The airlines suggest a runway visibility minimum of 1/2 nm.

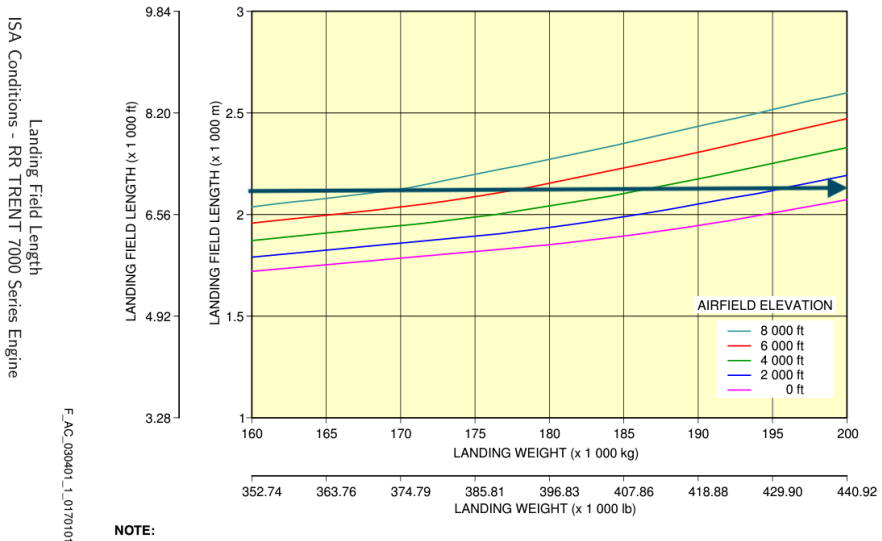
Figure 3. Airbus A330-900 at Atlanta Hartsfield International Airport (A.A. Trani).

a) Find the runway length needed to satisfy the design constraints.

- DTW = 235,000 kg ~ 518,086 lb
- **Required runway length for takeoff (dry) = 33,00 m ~ 10,826 ft**



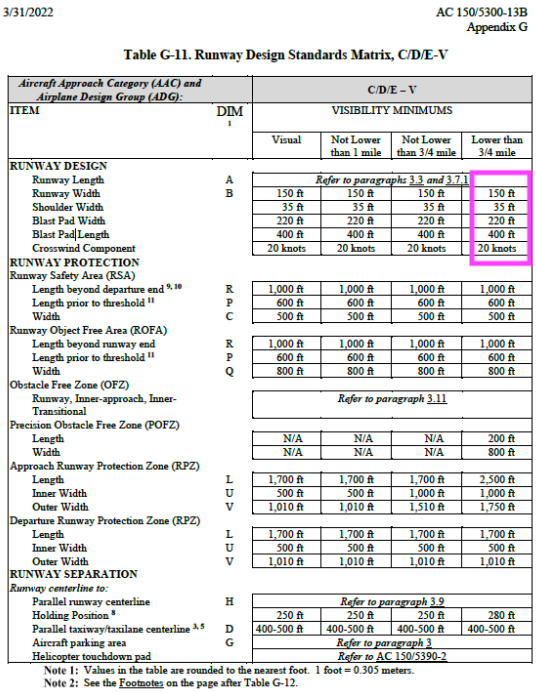
- Comment: use the ISA diagram for landing.
- Required runway length for landing (wet) $= 2080\ \text{m} \times 1.15$ (wet coefficient) $= 2392\ \text{m} \approx 7847\ \text{ft}$
- **Therefore, the required runway length is 10,826 ~ <u>10,800 ft. The takeoff field length is critical.</u>**



NOTE:
THESE CURVES ARE GIVEN FOR INFORMATION ONLY. THE APPROVED VALUES ARE STATED IN THE "OPERATING MANUALS" SPECIFIC TO THE AIRLINE OPERATING THE AIRCRAFT.

b) Find the runway width, blast pad area, and runway shoulder width needed to support the Airbus A330-900.

- AAC: C
- ADG: V
- TDG: 5
- RVR = 1/2 nm
- Runway width = 150 FT
- Blast pad area $= 220\ \text{ft} \times 400\ \text{ft} = 88{,}000\ \text{ft}^2$
- Runway shoulder width = 35 ft



3/31/2022 AC 150/5300-13B
Appendix G

Table G-11. Runway Design Standards Matrix, C/D/E-V

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – V			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs 3.3 and 3.7.1*			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		35 ft	35 ft	35 ft	35 ft
Blast Pad Width		220 ft	220 ft	220 ft	220 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional		*Refer to paragraph 3.11*			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 3.9*			
Holding Position [8]		250 ft	250 ft	250 ft	280 ft
Parallel taxiway/taxilane centerline [3, 5]	D	400-500 ft	400-500 ft	400-500 ft	400-500 ft
Aircraft parking area	G	*Refer to paragraph 3*			
Helicopter touchdown pad		*Refer to AC 150/5390-2*			

Note 1: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.
Note 2: See the Footnotes on the page after Table G-12.

- Note: AC 150/5300-13B is available for download here:

  AC-150-5300-13B-Change1

  You may also use the FAA Runway Design Standards Matrix (https://www.faa.gov/airports/engineering/airport_design/rdsm).

c) Find the dimensions of the RSA, ROFA, OFZ (various components), and RPZ surfaces required for the Airbus A330-900. Assume the airport will have a Category I instrument landing system with visibility down to 1/2 mile. Make a table with your answers. Consult the FAA Runway Design Standards Matrix (https://www.faa.gov/airports/engineering/airport_design/rdsm).

- RVR = 1/2 nm

Runway Protection
Runway Safety Area (RSA)
Main: C/D/E - V

RSA Dimension	DIM (1)	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length beyond departure end (9,10)	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold (11)	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft

Related Footnotes
Note: Footnote numbers are within parentheses in the tables above.

1. Letters correspond to the dimensions in Figure 3-1.
9. The RSA length beyond the runway end begins at the runway end when a stopway is not present. When a stopway is present, the length begins at the stopway end.
10. The RSA length beyond the runway end may be reduced to that required to install an Engineered Materials Arresting System (EMAS) (the designed set-back of the EMAS included). See the latest edition of AC 150/5220-22 for additional guidance.
11. This value only applies if that runway end is equipped with electronic or visual vertical guidance. ILS, GLS, LPV, VNAV, and RNP lines of minima provide electronic vertical guidance. A PAPI or VASI provides visual vertical guidance. If there is no such visual guidance for that runway, use the value for "length beyond departure end."

- RSA:
- Length beyond departure end = 1,000 ft
- Length prior to threshold = 600 ft
- Width = 500 ft

Runway Protection
Runway Protection (ROFA)
Main: C/D/E - V

ROFA Dimension	DIM (1)	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Length prior to threshold (11)	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft

Related Footnotes
Note: Footnote numbers are within parentheses in the tables above.

1. Letters correspond to the dimensions in Figure 3-1.
11. This value only applies if that runway end is equipped with electronic or visual vertical guidance. ILS, GLS, LPV, VNAV, and RNP lines of minima provide electronic vertical guidance. A PAPI or VASI provides visual vertical guidance. If there is no such visual guidance for that runway, use the value for "length beyond departure end."

- ROFA:
- Length beyond runway end = 1,000 ft
- Length prior to threshold = 600 ft
- Width = 800 ft

- OFZ:
- Note: we use section B.B. of the following screenshot.
- Extends 200 ft beyond the runway threshold
- Width = 400 ft
- Height $= 61 - 0.094 \times S_{\text{feet}} - 0.003 \times E_{\text{feet}}$
- S is equal to the most demanding wingspan of the RDC of the runway, and E is equal to the runway threshold elevation above sea level.
- Height $= 61 - 0.094(210) - 0.003(3000) = 32.26$ ft
- Inner-transitional OFZ (6:1) $= (150 \text{ ft} - 32.26 \text{ ft}) \times 6 = 706.4$ ft

- POFZ:
- Length = 200 ft
- Width = 800 ft

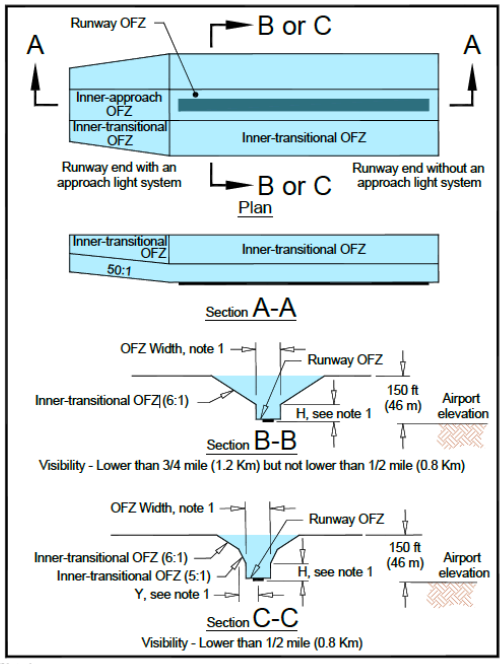
Runway Protection
Precision Obstacle Free Zone (POFZ)
Main: C/D/E - V

POFZ Dimension	DIM (1)	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft

Related Footnotes
Note: Footnote numbers are within parentheses in the tables above.

1. Letters correspond to the dimensions in Figure 3-1.

Figure 3-22. OFZ for Operations on Runways by Large Aircraft with Lower Than ¾ Statute Mile (1.2 km) Approach Visibility Minimums



Note 1: Refer to paragraphs 3.11.2, 3.11.3, and 3.11.4 for

- Approach RPZ:
- Length = 2,500 ft
- Inner width = 1,000 ft
- Outer width = 1,750 ft

Runway Protection

Approach Runway Protection Zone (RPZ)

Main: C/D/E - V

RPZ Dimension	DIM (1)	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length	L	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft

Related Footnotes

Note: Footnote numbers are within parentheses in the tables above.

1. Letters correspond to the dimensions in Figure 3-1.

- Departure RPZ:
- Length = 1,700 ft
- Inner width = 500 ft
- Outer width = 1,010 ft

Departure Runway Protection Zone (RPZ)

Main: C/D/E - V

RPZ Dimension	DIM (1)	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft

Related Footnotes

Note: Footnote numbers are within parentheses in the tables above.

1. Letters correspond to the dimensions in Figure 3-1.

d) Draw to scale (use Autocad or any CAD program of your choice) a plan view of the runway, RSA, ROFA, OFZ, and RPZ surfaces.

e) If the airport authority wants to build a new 67-foot-tall airport terminal 730 feet from the runway edge (perpendicular to the runway—see Figure 4), estimate whether the building violates the inner OFZ surface for Instrument Landing System Category I operations.

Calculation: $730 + \frac{150 \text{ (runway width)}}{2} - 200 = 605 \text{ ft}$

$$(X - 32.6) \times 6 = 605 \quad \Rightarrow \quad X = \frac{605}{6} + 32.6 = 133.5 \text{ ft}$$

X is the authorized height of a building at a point 605 ft far away from the runway centerline (730 ft from the runway edge).

$133.5 \text{ ft} > 67 \text{ ft}$

Therefore, the new terminal building does not violate the inner OFZ surface.