

Assignment 4

Date Due: September 26, 2025

Instructor: Trani

Problem 1

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

An airport is evaluating the need for a runway arrestor system (EMAS). The airport has two grassy areas on both sides of a runway (see Figure 1). The critical aircraft is the Boeing 757-200 also shown in Figure 1. The airport has instrument approach procedures with runway visibility minima lower than 3/4 of a mile but not lower than 1/2 mile (RVR). The airport is located at an elevation 1,200 feet above mean sea level conditions.

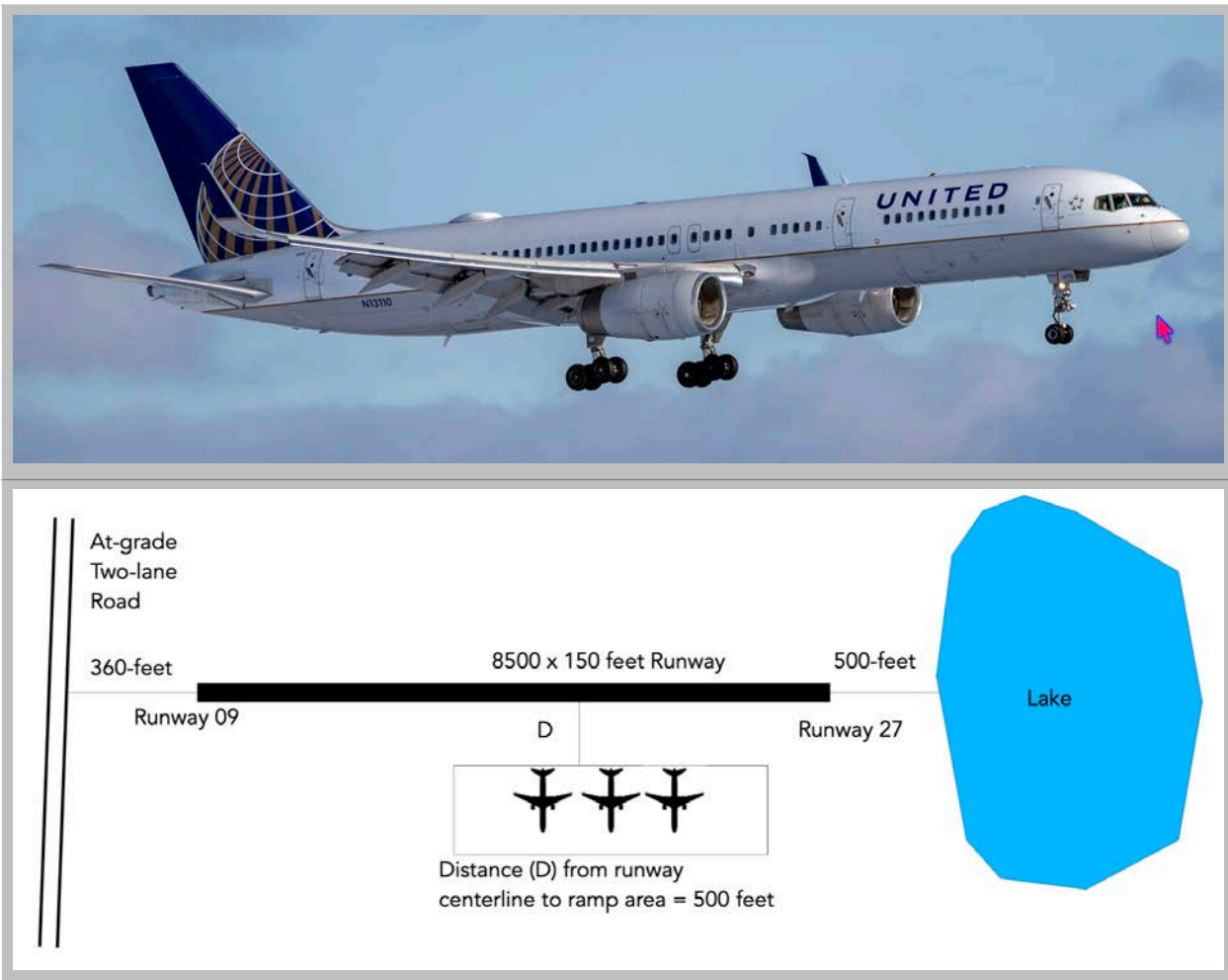


Figure 1. Boeing 757-200 Landing at CLE Airport (top) and Runway Graphic for Problem 1. Source: A. Trani.

- a) Find the RDC code for the runway design to accommodate the Boeing 757-200. State all three parameters of RDC.

RDC is C-IV-2400

Consult the Table 1-3 to assess the RVR values.

Table 1-3. Visibility Minimums

RVR *	Instrument Flight Visibility Category (statute mile)
5,000 ft (1,524 m)	Not lower than 1 mile (1.6 km)
4,000 ft (1,219 m)	Lower than 1 mile (1.6 km) but not lower than $\frac{3}{4}$ mile (1.2 km)
2,400 ft (732 m)	Lower than $\frac{3}{4}$ mile (1.2 km) but not lower than $\frac{1}{2}$ mile (0.8 km)
1,600 ft (488 m)	Lower than $\frac{1}{2}$ mile (0.8 km) but not lower than $\frac{1}{4}$ mile (0.4 km)
1,200 ft (366 m)	Lower than $\frac{1}{4}$ mile (0.4 km)

Note: * RVR values are not exact equivalents.

Runway Visibility Conversion Values.

- b) State the dimensions of the RSA, ROFA, and RPZ for the Boeing 757-200. Draw to scale in the CAD software of your choice the three surfaces above. Comment on the relative dimensions.

Table G-10 in the FAA Advisory Circular 150/5300-13B applies to the Boeing 757-200. Use the last column to select the design standards.

Table G-10. Runway Design Standards Matrix, C/D/E-IV

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – IV			
ITEM	DIM 1	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end ^{9, 10}				1,000 ft	
Length prior to threshold ¹¹				600 ft	
Width				500 ft	
Runway Object Free Area (ROFA)					
Length beyond runway end				1,000 ft	
Length prior to threshold ¹¹				600 ft	
Width				800 ft	
Approach Runway Protection Zone (RPZ)					
Length				2,500 ft	
Inner Width				1,000 ft	
Outer Width				1,750 ft	
Departure Runway Protection Zone (RPZ)					
Length				1,700 ft	
Inner Width				500 ft	
Outer Width				1,010 ft	
RSA, ROFA and RPZ Dimensions.					

- c) Find the size of the EMAS required to bring the runway end into compliance (i.e., to have a legal RSA) on both runway ends. State the recommended design exit speed used in your design. Comment if both runway ends can be made compliant with safety standards installing EMAS.

Runway 09 threshold

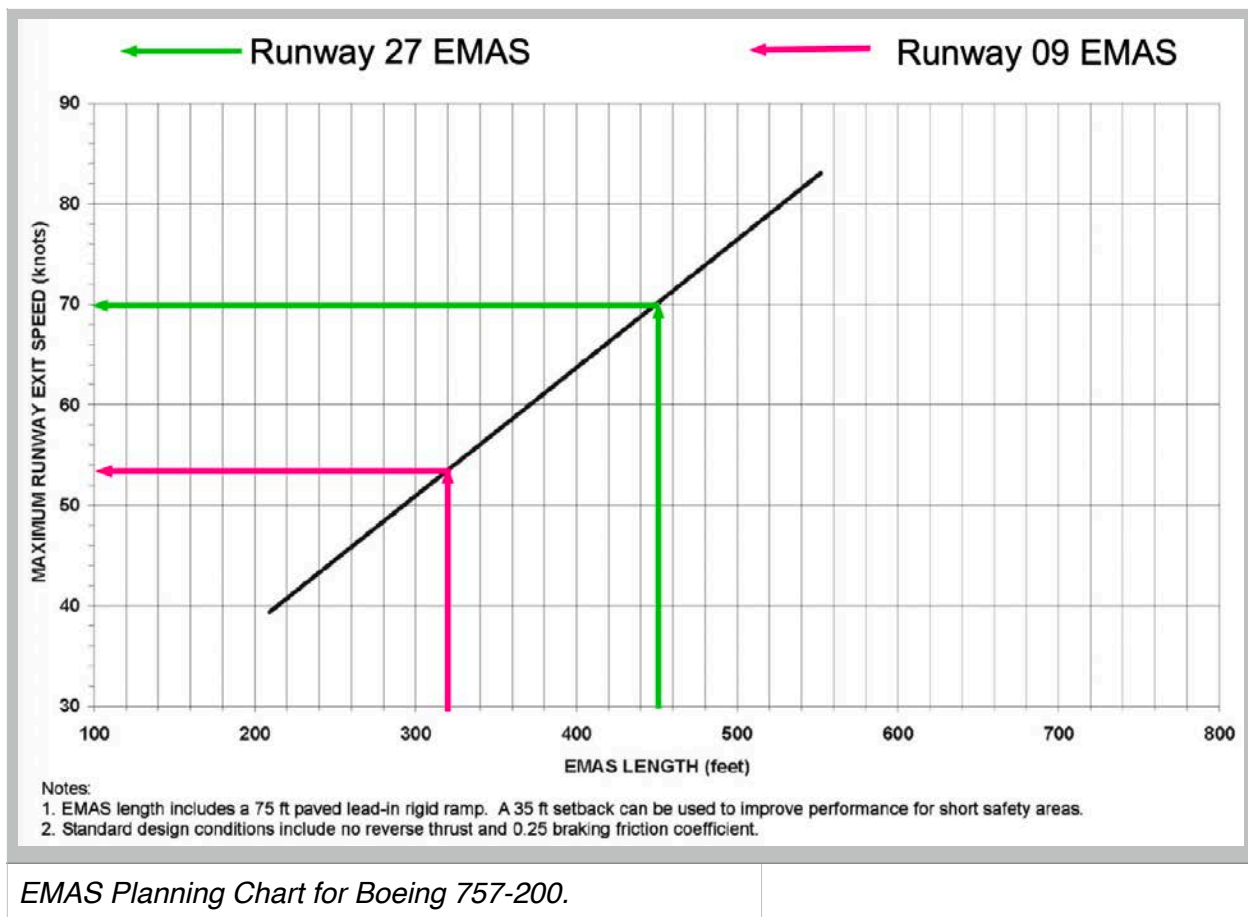
Consider a 35-foot setback (distance from runway end to start of lead EMAS ramp). Note that the EMAS planning charts in FAA AC 150-522-22b assume a 75-foot lead EMAS ramp.

Largest EMAS bed size is 325 feet (360-35 feet) constrained by the available space. With an EMAS 325 feet long, the maximum runway exit speed for a Boeing 757-200 is 54 knots (see Figure below).

Runway 27 threshold

Consider a 35-foot setback (distance from runway end to start of lead EMAS ramp). Note that the EMAS planning charts in FAA AC 150-522-22b assume a 75-foot lead EMAS ramp.

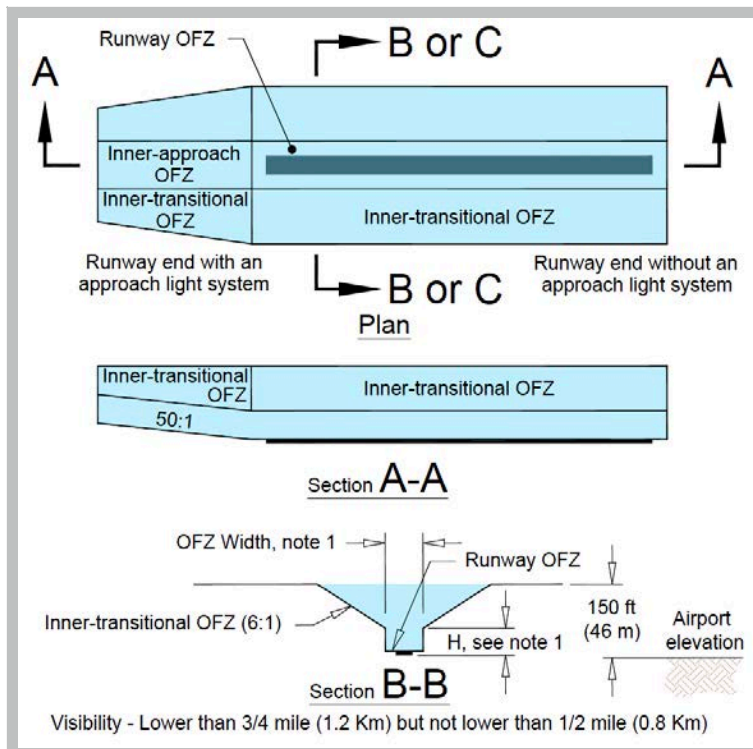
Largest EMAS bed size is 475 feet (500-35 feet). There is sufficient space on runway 27 end to design an EMAS 435 feet long, the maximum runway exit speed for a Boeing 757-200 is 70 knots (see Figure below). The additional 40 feet could be added to the setback distance to further improve safety.



- d) State the dimensions of the OFZ surfaces associated with the runway (including the POFZ).

POFZ is 200 (length) x 800 (width) feet. The dimensions are obtained from Table G-10 in Appendix G.

The OFZ contains multiple elements its shown in Figure 3-22 in the FAAAC 150/5300-13B. The graphic is reproduced below.



OFZ Diagram for Large Aircraft and Visibility Lower than 3/4 Mile.

The runway OFZ is 400 feet wide.

The inner transitional slope is 6:1.

The critical height (H_{feet}) of the inner transitional surface is:

$$H_{feet} = 61 - 0.094(S_{feet}) - 0.003(E_{feet})$$

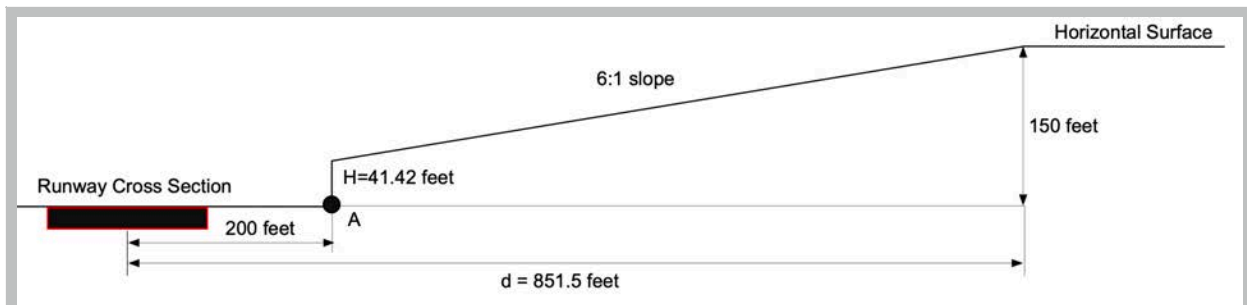
S_{feet} - critical aircraft wingspan (feet)

E_{feet} - airport elevation (feet)

The most demanding wingspan of the RDC group is (ADG IV) is 170 feet (see Table 1-2 in the FAA AC 150/5300-13B). The airport elevation is 1,200 feet.

$$H_{feet} = 61 - 0.094(170) - 0.003(1200) = 41.42 \text{ feet}$$

At a slope of 6:1 starting 200 feet from the runway centerline (400-foot total width of runway OFZ), the inner transitional sloping surface intersects the horizontal surface (150 feet above the airport elevation) 651.5 feet

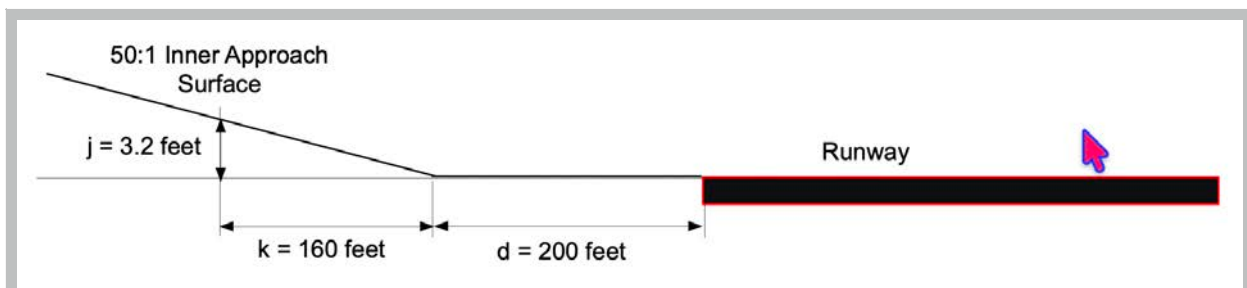


Inner Transitional (IT) OFZ Diagram for RDC C-IV and Visibility Lower than 3/4 Mile.

- e) Find if the Inner Approach OFZ surface is violated by the passing trucks on the two-lane road on the runway end 09. Tell me the critical height of the vehicle on the highway. Show your calculations.

The FAA states "The IA-OFZ begins 200 feet (61 m) from the runway threshold at the same elevation as the runway threshold and extends 200 feet (61 m) beyond the last light unit in the ALS" (see paragraph 3.11.3 in AC 150/5300-13B).

For airport design we use 17 feet (Highway design standards use 16 feet). The maximum height of the inner approach surface 360 from from the runway end is 3.2 feet. Clearly, a vehicle on the highway (car or truck) violates the 50:1 surface.

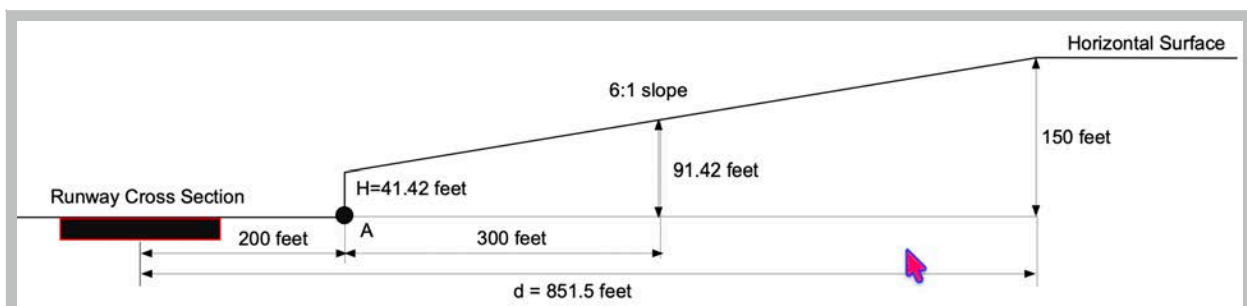


Inner Approach OFZ Diagram for RDC C-IV and Visibility Lower than 3/4 Mile.

- f) Find if the proposed distance D violates the ROFA or the Inner Transitional OFZ.

The runway width for ADG IV is 150 feet (see Table G-10). The ROFA width for RDC C-IV is 800 feet (400 feet from the runway centerline per side). The ramp is not in violation of the ROFA. Nevertheless, the tail of the critical aircraft should not violate the Inner Transitional OFZ.

The critical tail height for ADG IV is 60 feet. Using the Inner Transitional surface calculations (see below), we see that for an object located 500 feet from the runway centerline, the maximum permissible height is 91.42 feet. That value is higher than critical tail height for ADG IV (60 feet). Therefore, the ramp is not in violation of the ROFA not the Inner Transitional OFZ.

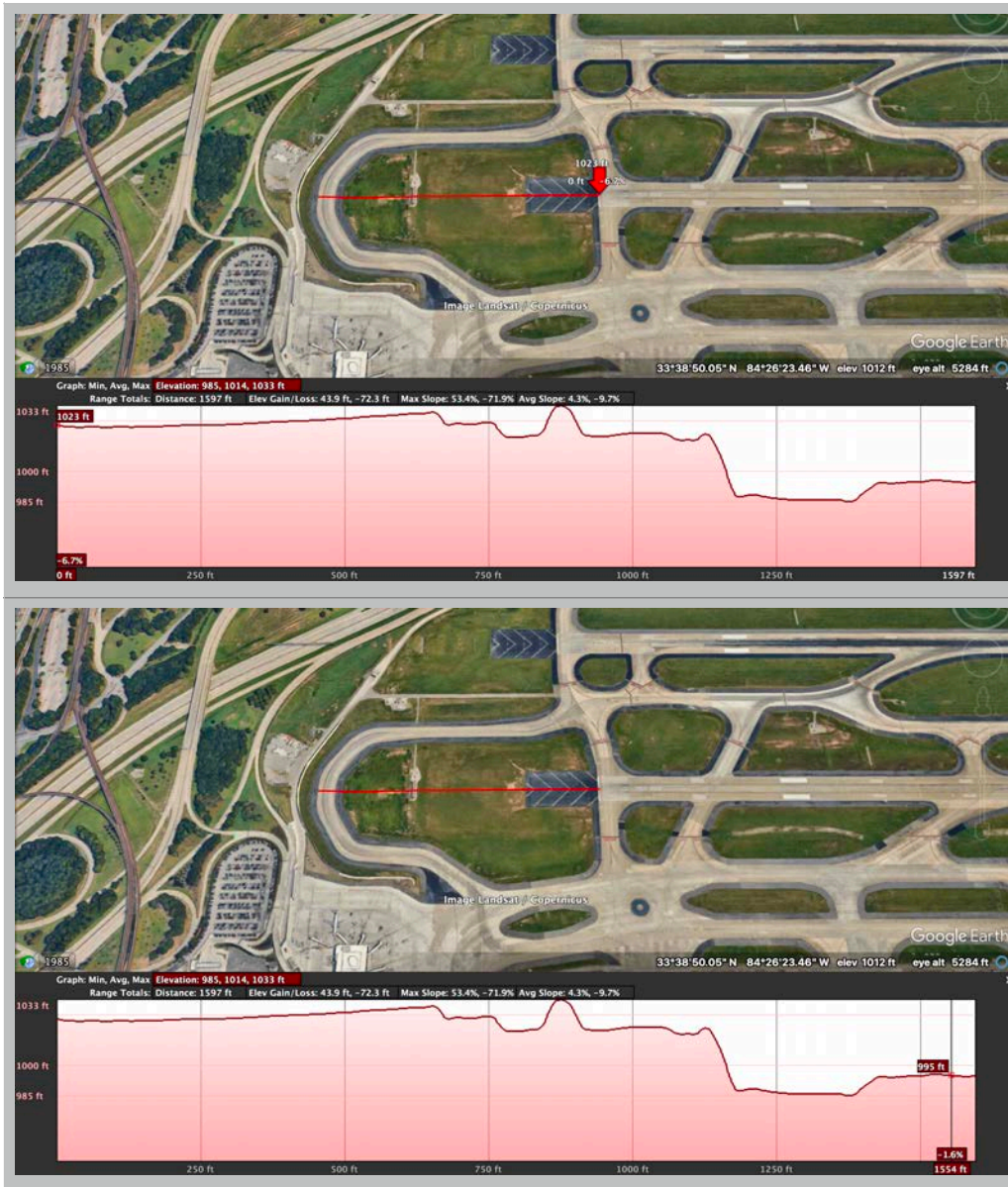


Inner Transitional (IT) OFZ Diagram for RDC C-IV and Visibility Lower than 3/4 Mile.

Problem 2

Use Google Earth and FAA airport diagrams to examine runway and taxiway geometric features and provide brief answers.

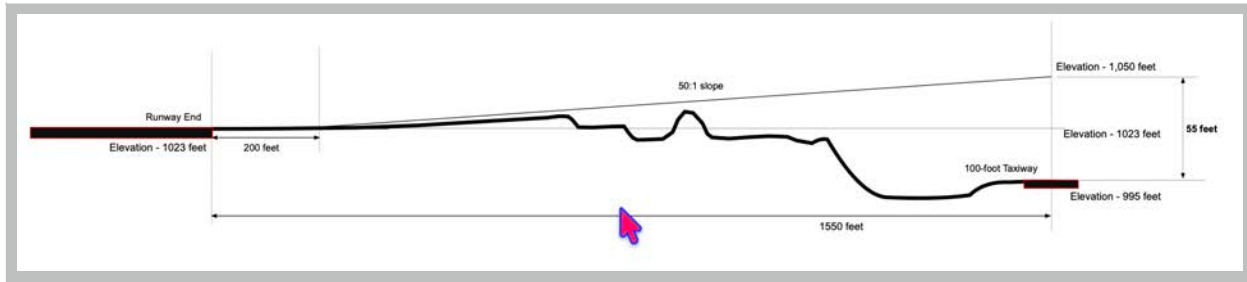
- Study the Northside airport diagram for Atlanta Hartsfield-Jackson Airport. Airport diagrams can be obtained at : https://www.faa.gov/airports/runway_safety/diagrams/ (link available on the interesting web sites). A section of the airport diagram is shown in Figure 2.
- Use Google Earth to create an elevation profile starting at the end of runway 08R and moving West to include the taxiway V (Victor). Show the profile in your solution.



Profile of Runway End 08R and West.

The runway end 08R elevation reported by Google Earth is 1,023 feet. The elevation of taxiway V (Victor) is 995 feet. The profiles show an elevation difference of 28 feet.

- c) Estimate the tallest aircraft tail height that can use taxiway V (Victor) without violating the Inner Approach OFZ surface at the runway 08R end (see Figure 2). Show your calculations. State the runway elevation at threshold 08R and how the elevation at the centerline of taxiway V (Victor).



Profile of Runway End 08R and West.

The tallest aircraft tail is limited to 55 feet or less.

- d) Based on your calculations in part (c), what is the largest ADG group that can be accommodated on the End Around taxiway without violating the Inner Approach OFZ surface on runway 08R.

The largest ADG group is III with a maximum tail height of 45 feet. Table 1-2 in the FAA AC 150/5300-13B is reproduced below.

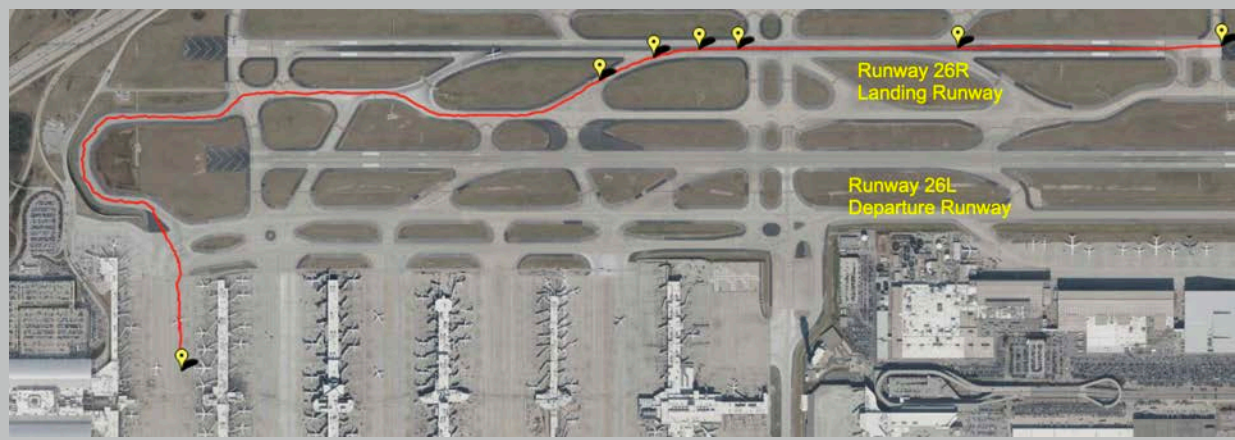
Table 1-2. Airplane Design Group (ADG)

Group #	Tail Height	Wingspan
I	< 20 ft (< 6.1 m)	< 49 ft (< 14.9 m)
II	20 ft to < 30 ft (6.1 m to < 9.1 m)	49 ft to < 79 ft (14.9 m to < 24.1 m)
III	30 ft to < 45 ft (9.1 m to < 13.7 m)	79 ft to < 118 ft (24.1 m to < 36.0 m)
IV	45 ft to < 60 ft (13.7 m to < 18.3 m)	118 ft to < 171 ft (36.0 m to < 52.1 m)
V	60 ft to < 66 ft (18.3 m to < 20.1 m)	171 ft to < 214 ft (52.1 m to < 65.2 m)
VI	66 ft to < 80 ft (20.1 m to < 24.4 m)	214 ft to < 262 ft (65.2 m to < 79.9 m)

ADG Group Dimensions (Source; FAA).

- e) Explain in simple words the value of End Around Taxiways at airports like Atlanta.

End Around taxiway are described in the FAA AC 150/5300-13B in paragraph 4.12. They improve the operational efficiency and improve departure capacity of runways. In the case of Atlanta, runway 26L (opposite to runway 08R) is used for departures. Runway 26R (opposite to 08L) is used for arrivals. Arrivals are routed to take taxiway Victor (V) and avoid crossing the departure runway 26L. This improves capacity of runway runway 26L and improves safety since arrivals do not cross runway 26L. The graphic below shows the path of a Boeing 737-800 (ADG III) routed through taxiway V to avoid crossing the departure runway 26L.



Typical Landing Route for an Aircraft Landing on Runway 26R at ATL (Source: Landing Events Database).

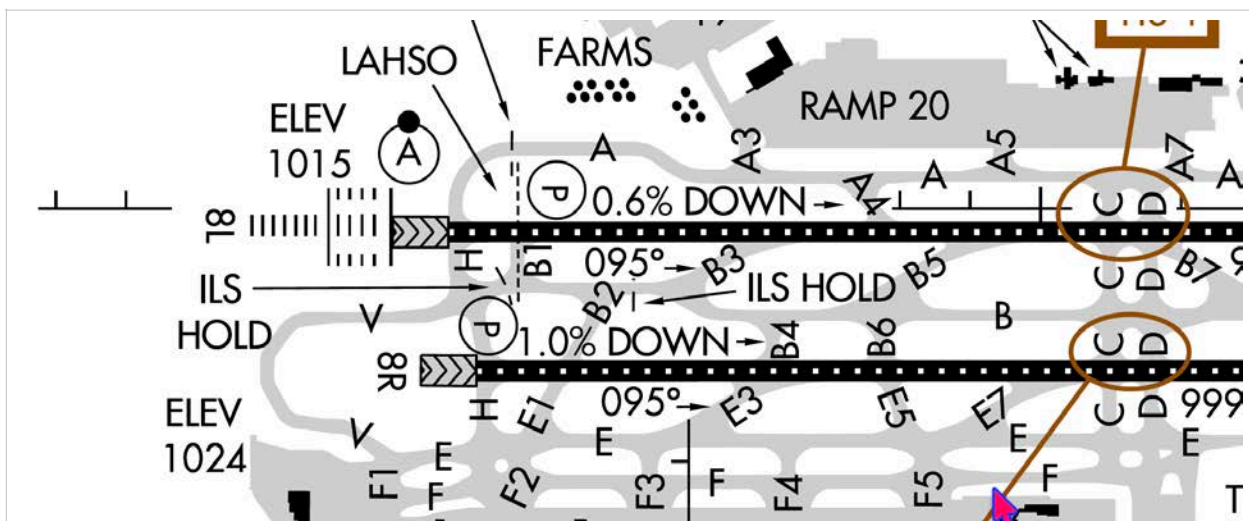


Figure 2. Airport Diagram of the North side of Atlanta Hartsfield International Airport (Source: FAA).

Problem 3

Use Google Earth and familiarize yourself with Cleveland Hopkins Airport (see Figure 3). Use Google Earth to measure distances and make comments about the design features.

- a) The Bombardier CRJ-200 is the critical aircraft to operate on runway 10-28 (see Figure 3). The runway can operate at lower than 3/4 mile but not lower than 1/2 miles visibility. Determine the size of the runway RSA area on both runway ends.

Runway 10 End

EMAS bed is 370 feet long and there is a 70-foot setback.

Runway 28 End

EMAS bed is 280 feet long and there is a 170-foot setback.

- b) Explain the rationale of the EMAS systems installed on both runway ends.

Runway 10/28 is constrained by roads on both runway ends. The space available beyond the runway ends does not allow a standard 1,000-ft. RSA. Hence EMAS beds are installed. Note, the size of each EMAS is different because the runway was constructed many years ago. Similarly, the roads surrounding the airport were built sometime ago.

- c) Find the maximum runway end departure speeds on each end to stop the CRJ-200 within the EMAS dimensions.



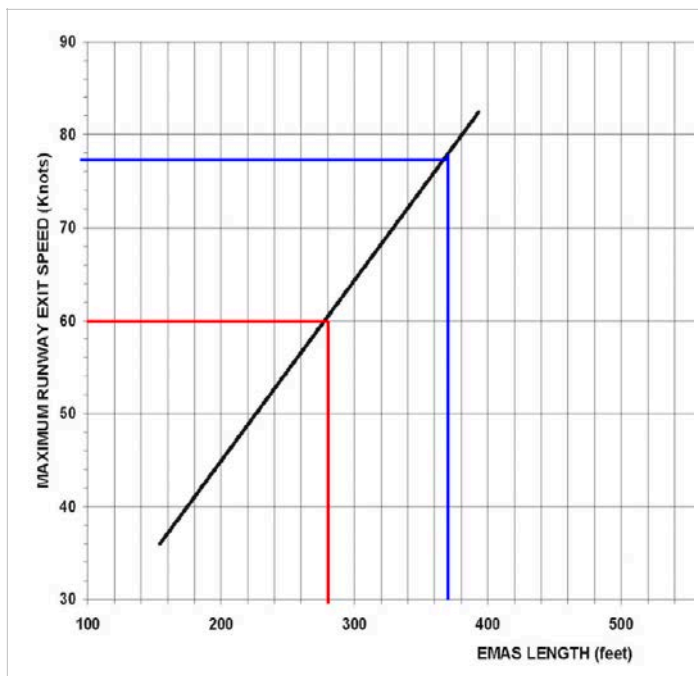
Figure 3. Bombardier CRJ-200 Departs RDU. Source: A. Trani.

Runway 10 End

EMAS bed is 370 feet long and there is a 70-foot setback. Maximum exit speed is 77 knots.

Runway 28 End

EMAS bed is 280 feet long and there is a 170-foot setback. Maximum exit speed is 60 knots.



Bombardier CRJ-200 EMAS Planning Document.

Problem 4

Short answers. Show your calculations.

Question	Answer
Estimate the hydroplaning speed of a Boeing 787-9 using Horner's equation. Use the nose gear tire pressure in your calculations (consult Section 7 of the Boeing 787 Airplane Characteristics for Airport Planning document).	Nose gear tire pressure is 182 psi (see Boeing document Section 7.2) 121 knots
Find the width of the Runway OFZ for small aircraft (< 12,500 lbs.)	250 feet if approach speed > 50 knots 120 feet if approach speed < 50 knots
ROFA dimensions for a runway designed for the Beechcraft King Air B350ER. Visibility is not lower than 3/4 of a mile. State all three dimensions.	RDC is B-II-4000
Estimate the maximum speed that a Boeing 757-200 can depart the runway end 31 at LGA and come to a full stop using the existing EMAS system.	330-foot EMAS bed 55 knot maximum speed at the runway exit point.
Horizontal distance from the runway centerline to the point of intersection of the horizontal surface (150 feet) and the inner transitional surface for a runway designed for a Boeing 747-8i at an airport elevation 2,300 feet. Visibility minima is lower than 1/2 mile.	947.5 feet See solution calculations below.

The RDC for the runway is: D-VI-1200.

The runway OFZ is 400 feet wide.

The inner transitional slopes at 5:1 and changes to 6:1 at a location Y from the runway centerline.

The critical height (H_{feet}) of the inner transitional surface is:

$$H_{feet} = 53 - 0.13(S_{feet}) - 0.0022(E_{feet})$$

$$Y_{feet} = 440 + 1.08(S_{feet}) - 0.024(E_{feet})$$

S_{feet} - the most demanding wingspan of the RDC group (feet)

E_{feet} - airport elevation (feet)

The most demanding wingspan of the RDC group is (ADG VI) is 262 feet (see Table 1-2 in the FAA AC 150/5300-13B). The airport elevation is 2,300 feet.

$$H_{feet} = 53 - 0.13(262) - 0.0022(2300) = \mathbf{13.9 \text{ feet}}$$

$$Y_{feet} = 440 + 1.08(262) - 0.024(2300) = \mathbf{667.8 \text{ feet}}$$

The diagram below illustrates the solution.

