Assignment 8: Runway Exit Placement and Geometric Design

Solution

Groups of Two - answer all questions

Individual Effort - answer Problems 1 and 3

Problem 1

Use the latest version (4.02) of the Runway Exit Design Model (REDIM) developed by Virginia Tech for FAA to evaluate the performance of runway 36L at Charlotte-Douglas International Airport (CLT). Figure 1 shows the configuration of the runway with four runway exits. Tables 1 and 2 show the runway exits and aircraft fleet mix at CLT.

The current version (REDIM 4) can be downloaded at the link below:

https://atsl.cee.vt.edu/products/runway-exit-design-interactive-model--redim-1.html

The updated MATLAB Runtime should install automatically. However, you can install it separately by downloading it here:

https://atsl-software-downloads.s3.amazonaws.com/redim/MATLAB_Runtimes/MATLAB_Runtime_R2021b_Update_3_win64.exe

Use the example described in the notes to do this exercise.

Use Arnav to find the airport elevation of CLT. Assume an operating temperature of 80 deg.F. and use 90% dry pavement conditions. Run your analysis with Pilot Motivation Factors of 1.0 (default).

Table 1. Runway Exit Characteristics of Runway 36L at CLT Airport.

Runway Exit	PC Location	Runway Exit Type
W7	5600	High-speed exit (~1800-foot radius)
W8	6750	High-speed exit(~1800-foot radius)
W9	8500	Right-angle
W	8800	Right-angle

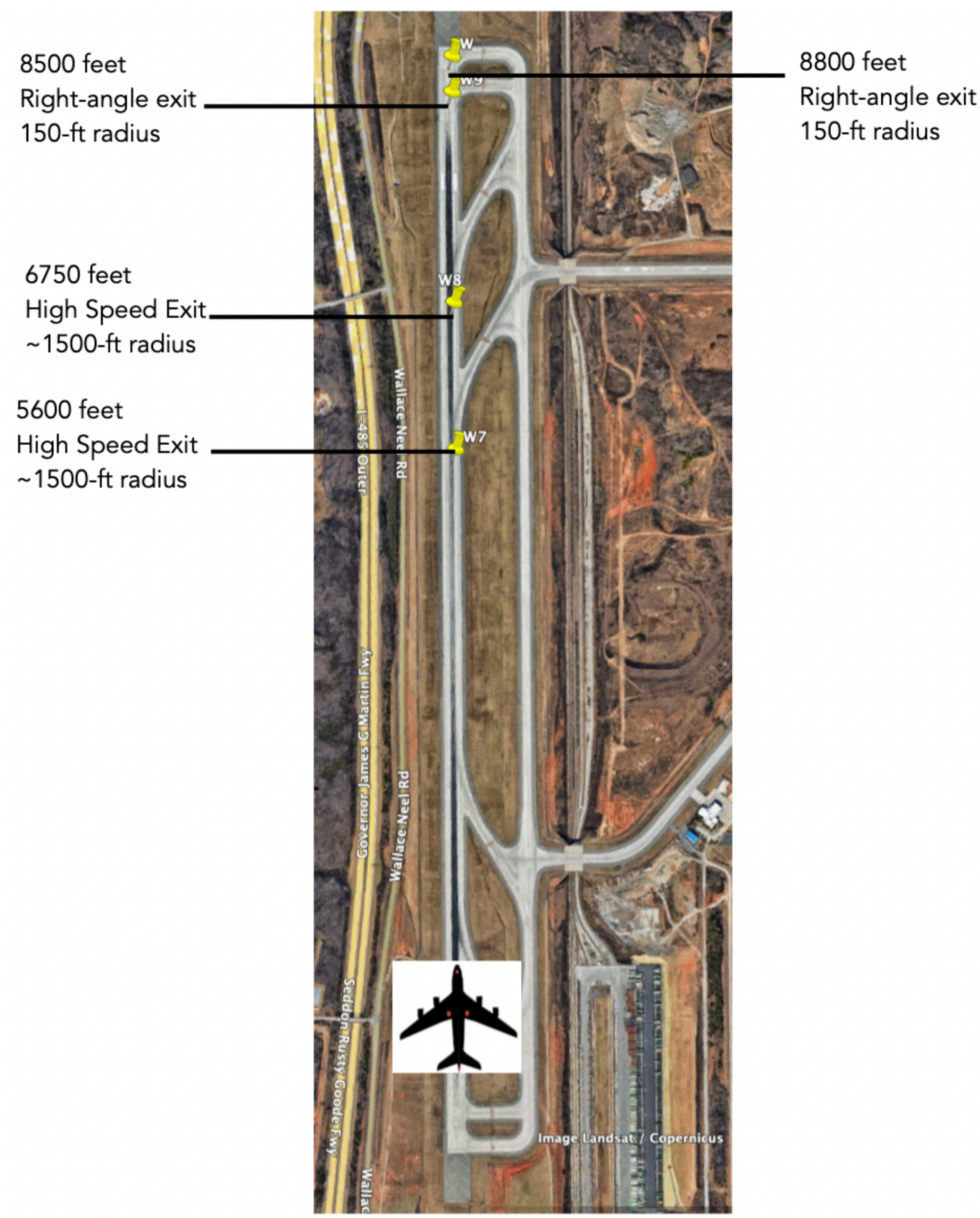


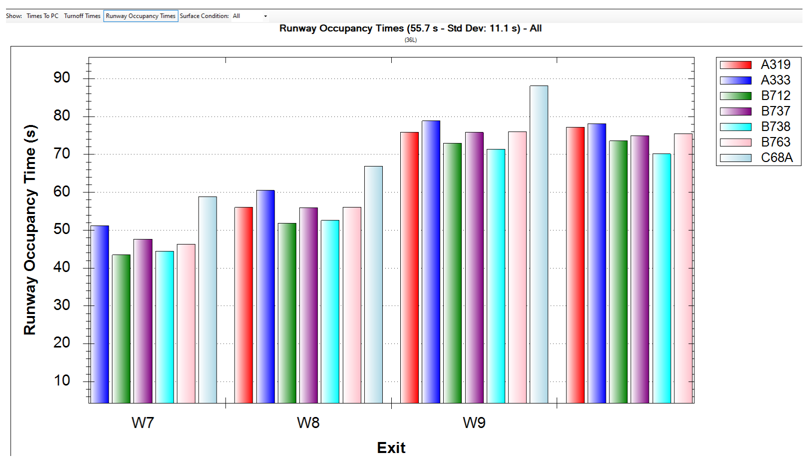
Figure 1. Runway 36L Landing Exit Locations at Charlotte-Douglas International Airport.

Table 2. Aircraft Fleet Mix to Model Runway Occupancy Times on Runway 36L at CLT Airport.

Aircraft ID	Aircraft	Fleet Mix (%)
C68A	Cessna Citation Latitude	10
A319	Airbus 319	35
B738	Boeing 737-800	28

Aircraft ID	Aircraft	Fleet Mix (%)
B712	Boeing 717-200	10
B737	Boeing 737-700	8
A330	Airbus 330-300	5
B763	Boeing 767-300	4
Totals		100

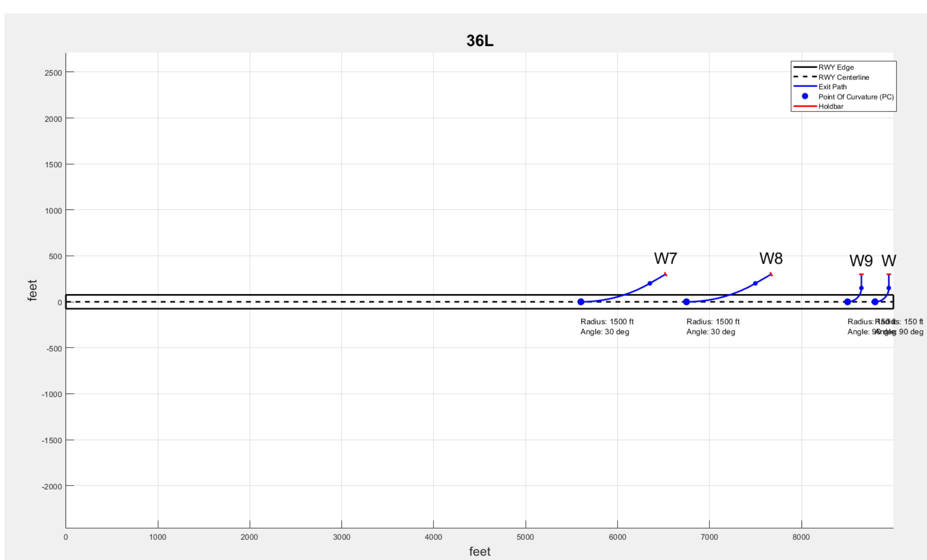
a) Estimate the weighted average runway occupancy time (ROT) and the standard deviation of ROT at runway 36L.



The weighted average ROT = 55.7 seconds

The standard deviation of ROT = 11.1 seconds

b) Show me the runway exit configuration diagram provided by REDIM 4.



c) Estimate the percent of Airbus A319 landings likely to use runway exits W7 and W8. Show the full table of runway exit assignments provided by the model.

Runway Exit Aircraft Assignment - All

(36L)

Aircraft Name	W7	W8	W9	W	Aircraft Mix
A319	45.1%	40.5%	13.3%	1.0%	35.0%
A333	19.6%	45.4%	32.2%	2.8%	4.9%
B712	29.4%	50.2%	18.8%	1.6%	9.7%
B737	55.4%	35.5%	8.7%	0.4%	8.1%
B738	32.6%	48.7%	17.8%	0.9%	28.1%
B763	25.0%	45.6%	26.6%	2.7%	4.0%
C68A	78.2%	15.1%	6.0%	0.7%	10.2%
Exit Mix	42.2%	41.2%	15.5%	1.1%	

From the table above, the following estimates can be made.

Percent of Airbus A319 landings likely to use runway exit W7 = 45.1%

Percent of Airbus A319 landings likely to use runway exit W8 = 40.5%

d) Estimate the percent of Boeing 737-800 landings likely to use runway exits W7 and W8. Show the full table of runway exit assignments provided by the model.

Percent of Boeing 737-800 landings likely to use runway exit W7 = 32.6%

Percent of Boeing 737-800 landings likely to use runway exit W8 = 48.7%

e) Compare the runway exit utilization of the Airbus A319 and the Boeing 737-800. Comment on the reasons for possible differences.

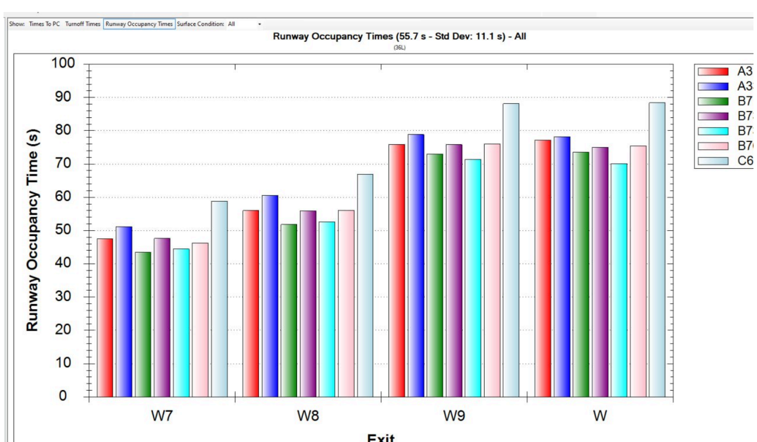
A319's higher utilization of exit W7 compared to B738 is related to the lower approach speed of the Airbus A319 compared to B737-800. Lower approach speeds translate into shorter landing distances, assuming similar braking effort on the runway. The lower approach speed of the A319 allows a higher percentage of landings of the type to use high-speed runway exit W7.

If we search for the runway threshold (approach) speed in the Aircraft Characteristics Database (ACD), we see that the Airbus A319 has an approach speed of 126 knots. The Boeing 737-800 has approach speeds ranging from 140 to 144 knots.

f) Find the runway exit at CLT runway 36L that will likely be used the most. Estimate the percent of all the landings using that exit.

The runway exit on runway 36L that is most likely to be used is W7, which accommodates approximately 42.2% of landing events considering the fleet mix operating at the airport.

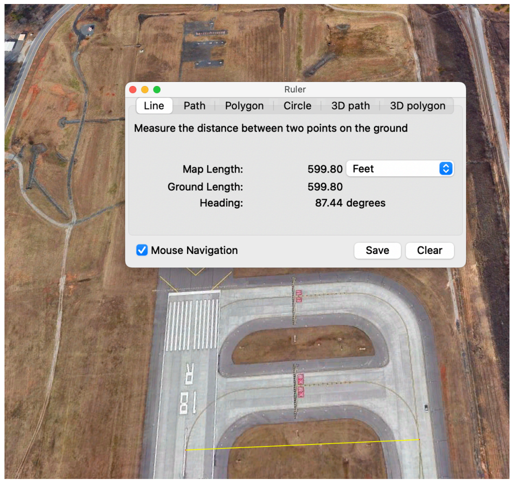
g) Show me the plot of REDIM 4 with runway occupancy times for each exit and aircraft.



h) Find if the parallel taxiway W at CLT is compliant with RDC D-V.

Note: the elevation of runway 36L at CLT is 744 ft.

The minimum runway centerline to parallel taxiway centerline separation distance is 450 feet for airports at or below an elevation of 1,345 feet (reference: AC 150/5300-13B). Therefore, taxiway W satisfies this requirement because is loctaed 600 feet from the runway centerline.

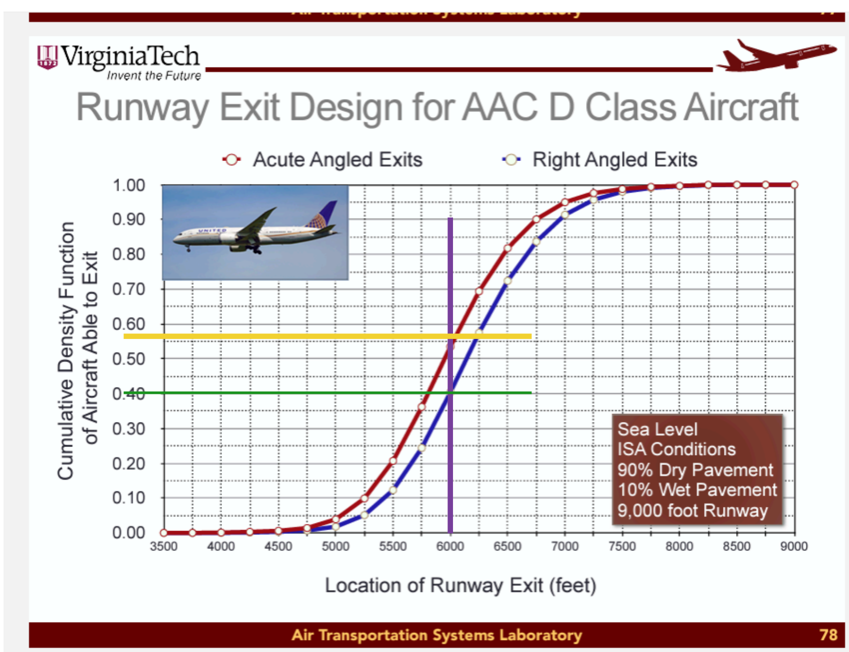


Problem 2

Using the cumulative runway exit distribution charts (see Figure 4-17 in the FAA AC 150/5300-13B) provided in class on pages 73-78 of the Runway Exit Design handout answer the following questions:

a) Estimate the percent of AAC D aircraft that could take a high-speed runway exit located at 6000 feet at an airport located at sea level conditions.

The percent of AAC D aircraft that could take a high-speed runway exit located at 6000 ft at an airport located at sea level conditions is 55%.



b) Estimate the percent of AAC D aircraft that could take a right-angle runway exit located at 6000 feet at an airport located at sea level conditions.

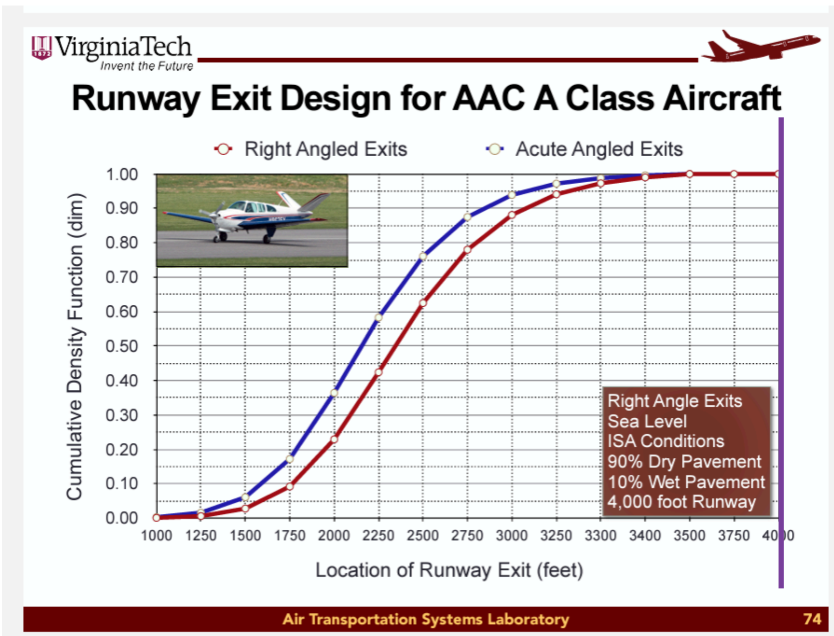
The percentage of AAC D aircraft that could take a right-angle runway exit at 6000 ft at an airport in sea level conditions is 40%.

c) Explain the difference in your estimates for parts (b) and (c).

The average speed at the PC point of high-speed exits is typically higher compared to right-angle exits. Consequently, if we assume both exit types are located at the same distance from the runway threshold, a greater number of aircraft can take high-speed exits.

d) Runway exit A3 (see Figure 2) is a right-angle exit located 4,200 feet from runway threshold 31 at the Virginia Tech Montgomery Executive Airport. Estimate the percent of single-engine piston-powered aircraft like the Beechcraft Bonanza V35 that could use runway exit A3 while landing on runway 31.

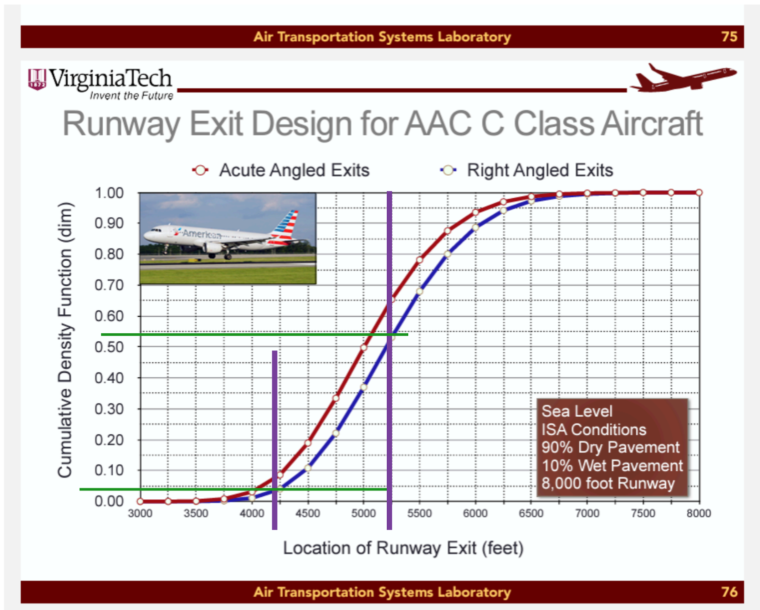
Beechcraft Bonanza V35 approach speed is 70 knots. Therefore, it is AAC A. Therefore, 100% of landing events with aircraft belonging to AAC A, such as Bonanza V35, could take a right-angle exit located 4,200 feet from the runway threshold.



e) Consider runway exits A3 (4,200 feet from runway threshold 31) and runway exit A2 (5,250 feet from runway threshold 31) at the Virginia Tech Montgomery Executive Airport. Estimate the cumulative percent of corporate jets like the Dassault Falcon 2000 (see Figure 3) that could use runway exits A3 and A4, respectively.

Dassault Falcon 2000 is AAC C. (Note: the approach speed might be less than 121 knots in most cases. Therefore, AAC B is also acceptable in the answer.)

The cumulative % of corporate jets like Dassault Falcon 2000 that could use runway exit A3 is 4%. This percentage for exit A2 is 54%.



f) Why do we design two entrance runway exit at the end of runway 31 at BCB? Briefly explain.

This design enables pilots to take off from runway 13 even if an aircraft is holding on either entrance A1 or A2. In such cases, the departing pilot can use the unoccupied entrance (A1 or A2) to access runway 13 and proceed with takeoff.

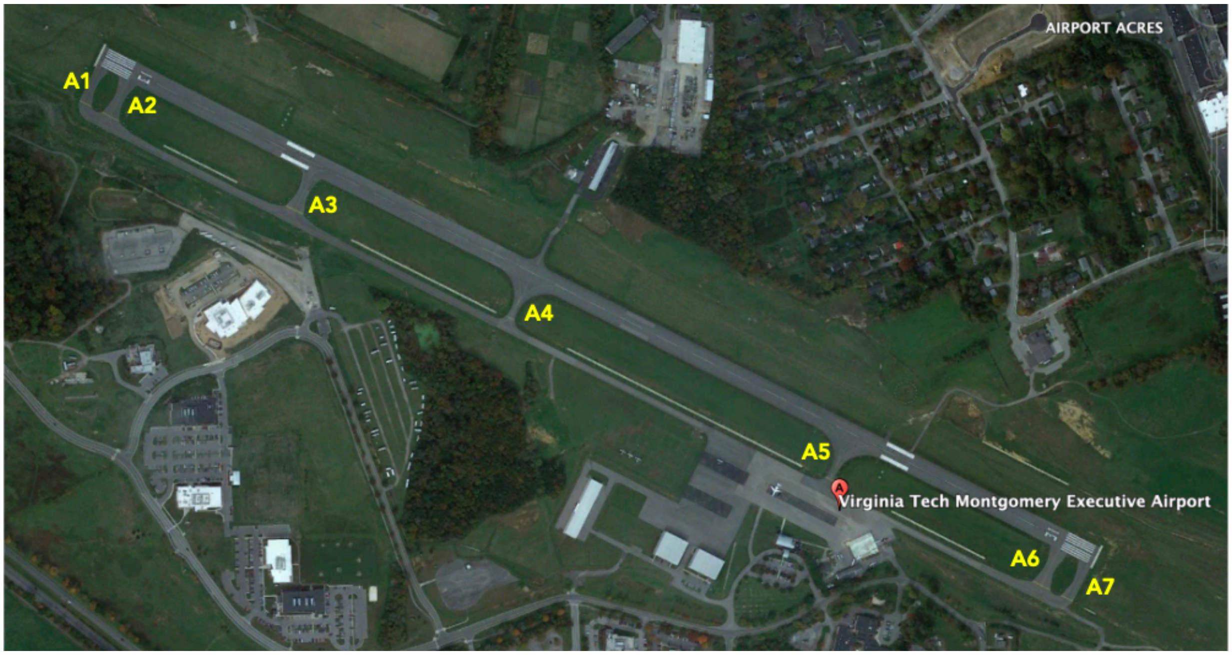


Figure 2. Runway Exit Locations at Virginia Tech Montgomery County Executive Airport.

Figure 3. Dassault Falcon 2000 Landing at BCB Runway 31 (A. Trani).

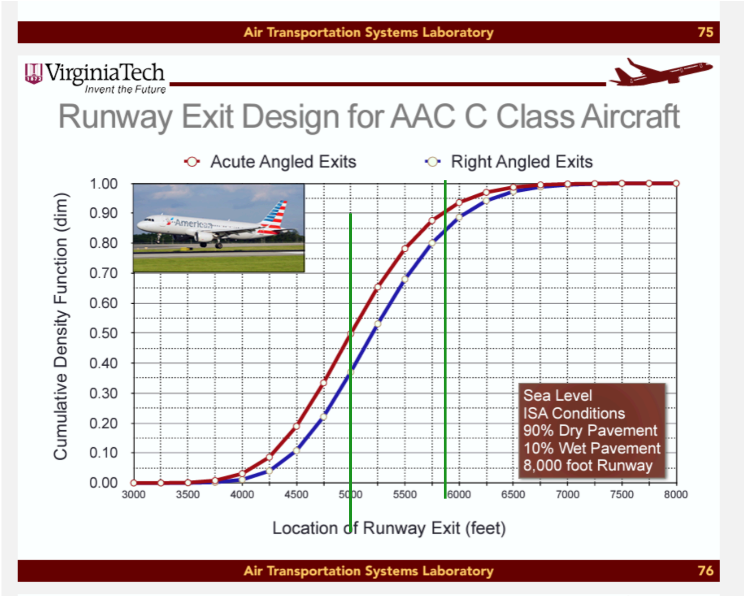
Problem 3

A proposed 7,500 ft runway planned for a regional airport is expected to have a total of seven runway exits. The critical aircraft is the Embraer 190 (see Figure 4).

Figure 4. JetBlue Embraer 190 Landing at Reagann National Airport (A. Trani).

(a) Use the cumulative curves to locate two high-speed exits, allowing 50% and 90% of the critical aircraft AAC class to exit.

Embraer 190 AAC is C.



The first high-speed exit, which allows 50% of the critical aircraft to exit, is located 5,000 feet away from the runway threshold.

The second high-speed exit, which allows about 90% of the critical aircraft to exit, is located approximately 5,900 feet from the runway threshold.

(b) Find the **minimum separation between** the runway and a parallel taxiway centerline for your design.

Embraer 190 AAC is C

ADG is III, and TDG is 3.

9/28/2012 AC 150/5300-13A

Table 3-5. Runway design standards matrix

Aircraft Approach Category (AAC) and Airplane Design Group (ADG): *(select from pull-down menu at right)* C – III

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 302 and 304*			
Runway Width [12]	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width [12]		25 ft	25 ft	25 ft	25 ft
Blast Pad Width [12]		200 ft	200 ft	200 ft	200 ft
Blast Pad Length		200 ft	200 ft	200 ft	200 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots
Runway Protection					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1000 ft	1000 ft	1000 ft	1000 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	1000 ft	1000 ft	1000 ft	1000 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
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph 308*			
Width		*Refer to paragraph 308*			
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	1700 ft	1700 ft	1700 ft	2500 ft
Inner Width	U	500 ft	500 ft	1000 ft	1000 ft
Outer Width	V	1010 ft	1010 ft	1510 ft	1750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1700 ft	1700 ft	1700 ft	1700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1010 ft	1010 ft	1010 ft	1010 ft
Acres		29.465	29.465	29.465	29.465
Runway Separation					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 316*			
Holding position [8]		250 ft	250 ft	250 ft	250 ft
Parallel Taxiway/Taxilane centerline [2]	D	400 ft	400 ft	400 ft	400 ft
Aircraft parking area	G	500 ft	500 ft	500 ft	500 ft
Helicopter touchdown pad		Refer to AC 150/5390-2			

Notes:

- Appendix 7 contains non-interactive tables for all RDCs.
- Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

The required separation distance is 400 ft.

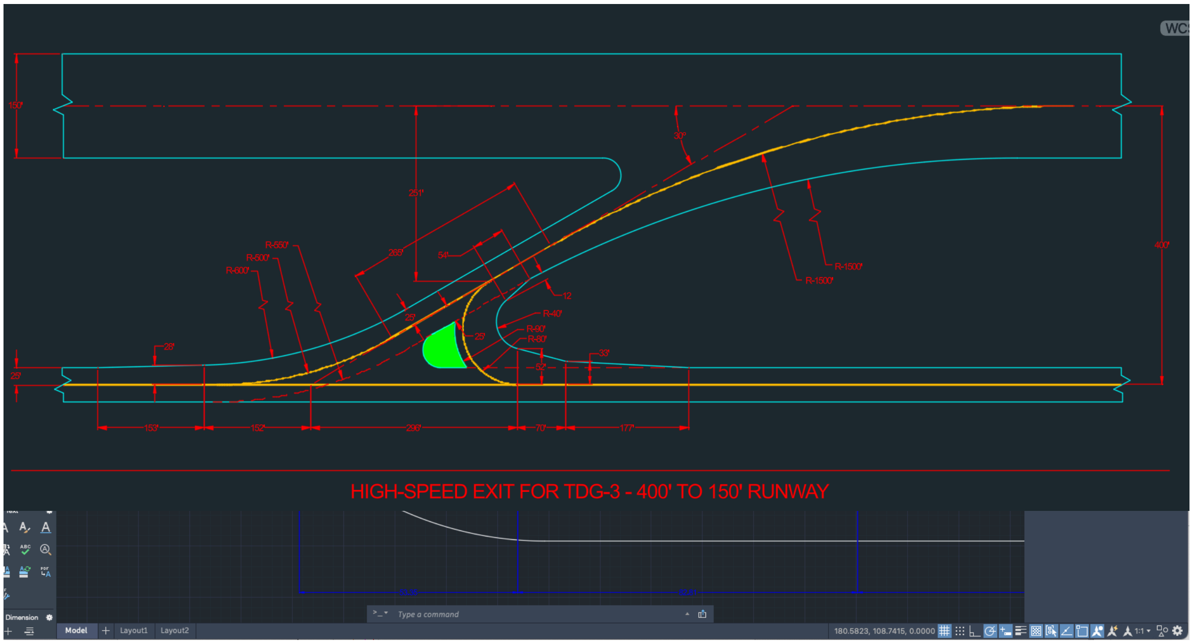
(c) What is the recommended distance between the runway and parallel centerlines to allow efficient runway operations?

The recommended separation distance is 600 ft.

(d) Draw to scale the last runway entrance exit for the new runway. Include dimensions. Follow the example on page 43 of the class notes (Runway Design and Exit Locations). In your design, use the recommended distance between the runway and the parallel taxiway (part c).

The last runway entrance exit should be a right-angle entrance exit.

(e) Draw one of the high-speed runway exits (including dimensions) using the FAA templates provided at: https://www.faa.gov/airports/engineering/airport_design.


150'
30°
251'
265'
54'
R-550'
R-500'
R-600'
25'
25'
12
R-40'
R-90'
R-80'
R-1500'
R-1500'
400'
28'
25'
33'
52'
153'
152'
296'
70'
177'
HIGH-SPEED EXIT FOR TDG-3 - 400' TO 150' RUNWAY
Model
Layout1
Layout2
Type a command
Dimension