Assignment 8: Runway Exit Placement and Capacity

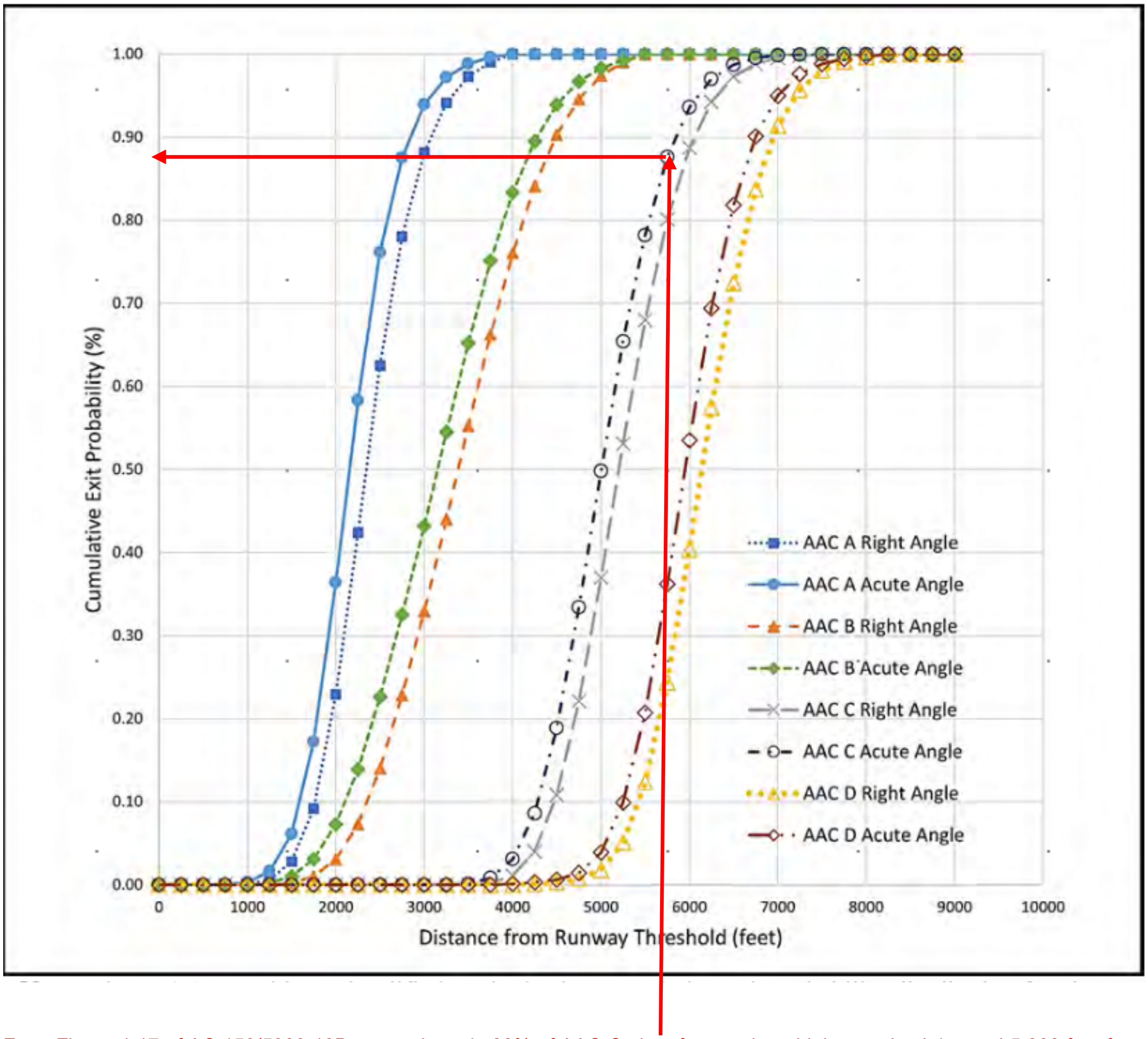
Date Due: November 8, 2023 **Instructor: Trani**

Problem 1

Using the cumulative runway exit distribution charts provided in class (or Figure 4-17 in the FAA AC 150/5300-13B), briefly answer the following questions:

a) Estimate the percent of AAC C aircraft that could take a high-speed runway exit located at 5800 feet at an airport located at sea level conditions.

Figure 4-17. Cumulative Probability of Aircraft Able to Exit by AAC at Airports With an Elevation Less Than 2,000 feet (610 m) MSL



From Figure 4-17 of AC 150/5300-13B, approximately 88% of AAC C aircraft can take a high-speed exit located 5,800 feet from the threshold of a sea level runway.

b) if the same high-speed runway exit is built at an airport located 2,000 feet above sea level, estimate the new location of the runway exit Point of Curvature (PC).

The location of the exit should increase 185 feet for every 1,000 ft increase in the airfield's elevation. Therefore, if the airport was located 2,000 feet above sea level, then the location of the new exit would be:

$$5{,}800\ ft + 185\ ft\left(\frac{2{,}000\ ft}{1{,}000\ ft}\right) = 6{,}170\ ft$$

c) Runway exit A4 (see Figure 1) is a legacy right-angle exit located 2,950 feet from runway threshold 31 at the Virginia Tech Montgomery Executive Airport (BCB). Estimate the percent of medium size corporate jets like the Cessna Citation XLS that could use runway exit A4.

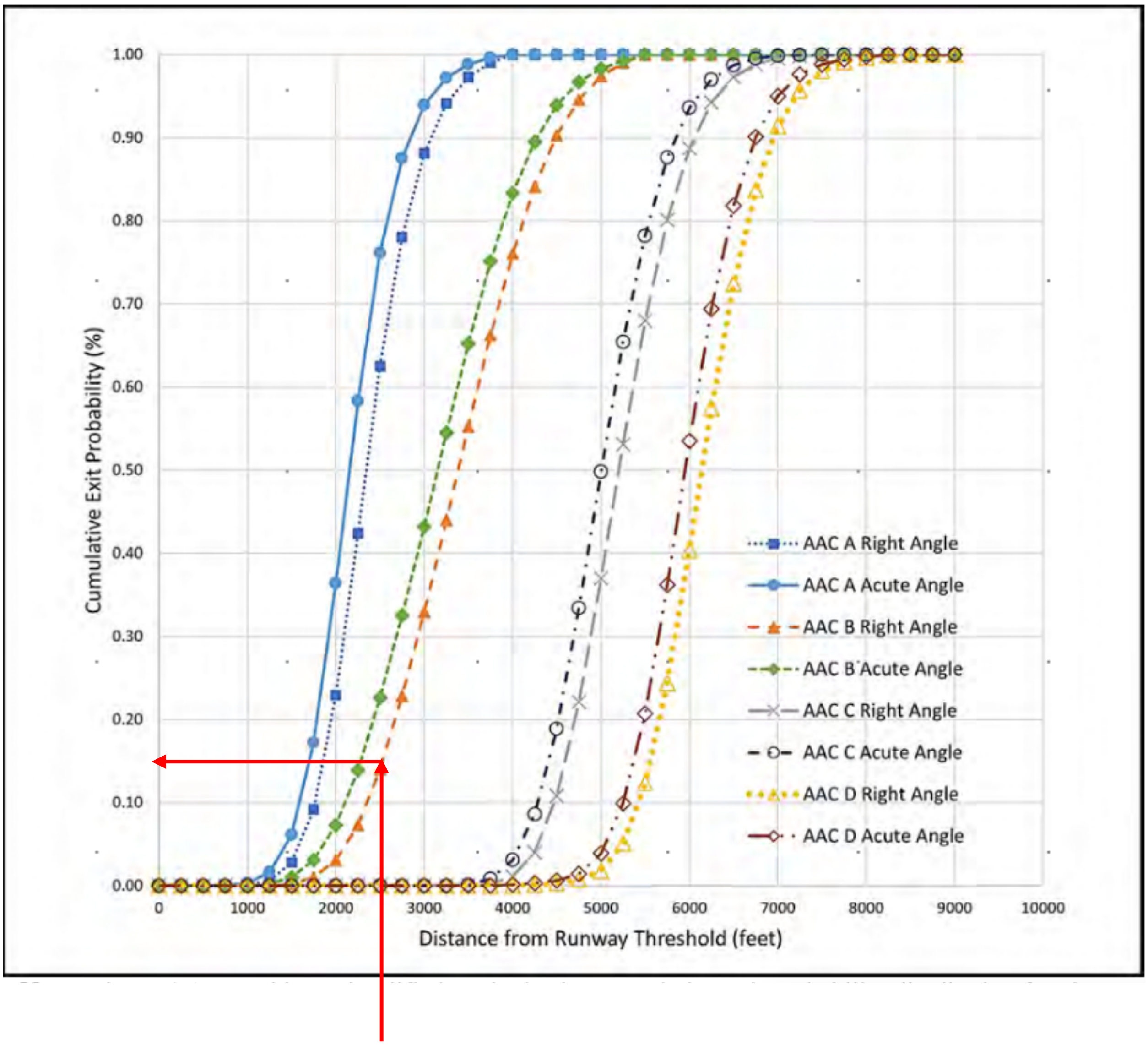
BCB runway 31 is located 2,120 ft above sea level. Therefore, we first need to scale this elevation down to sea level in order to use the figure from the Advisory Circular:

$x + 185\ ft\left(\frac{2{,}120\ ft}{1{,}000\ ft}\right) = 2{,}950\ ft$

$x = 2{,}560\ ft$

Since the representative aircraft is AAC B, then we look at where the cumulative exit probability intersects the graph at 2,560 ft for AAC B aircraft taking right angle exits:

Figure 4-17. Cumulative Probability of Aircraft Able to Exit by AAC at Airports With an Elevation Less Than 2,000 feet (610 m) MSL



From the Figure, approximately 15% of AAC B aircraft can take a right-angle exit located 2,560 feet from the threshold of BCB runway 31.

d) Runway exit A3 (see Figure 1) is a new right-angle exit located 4,200 feet from runway threshold 31 at the Virginia Tech Montgomery Executive Airport. Estimate the percent of medium size corporate jets like the Cessna Citation XLS that could use runway exit A3.

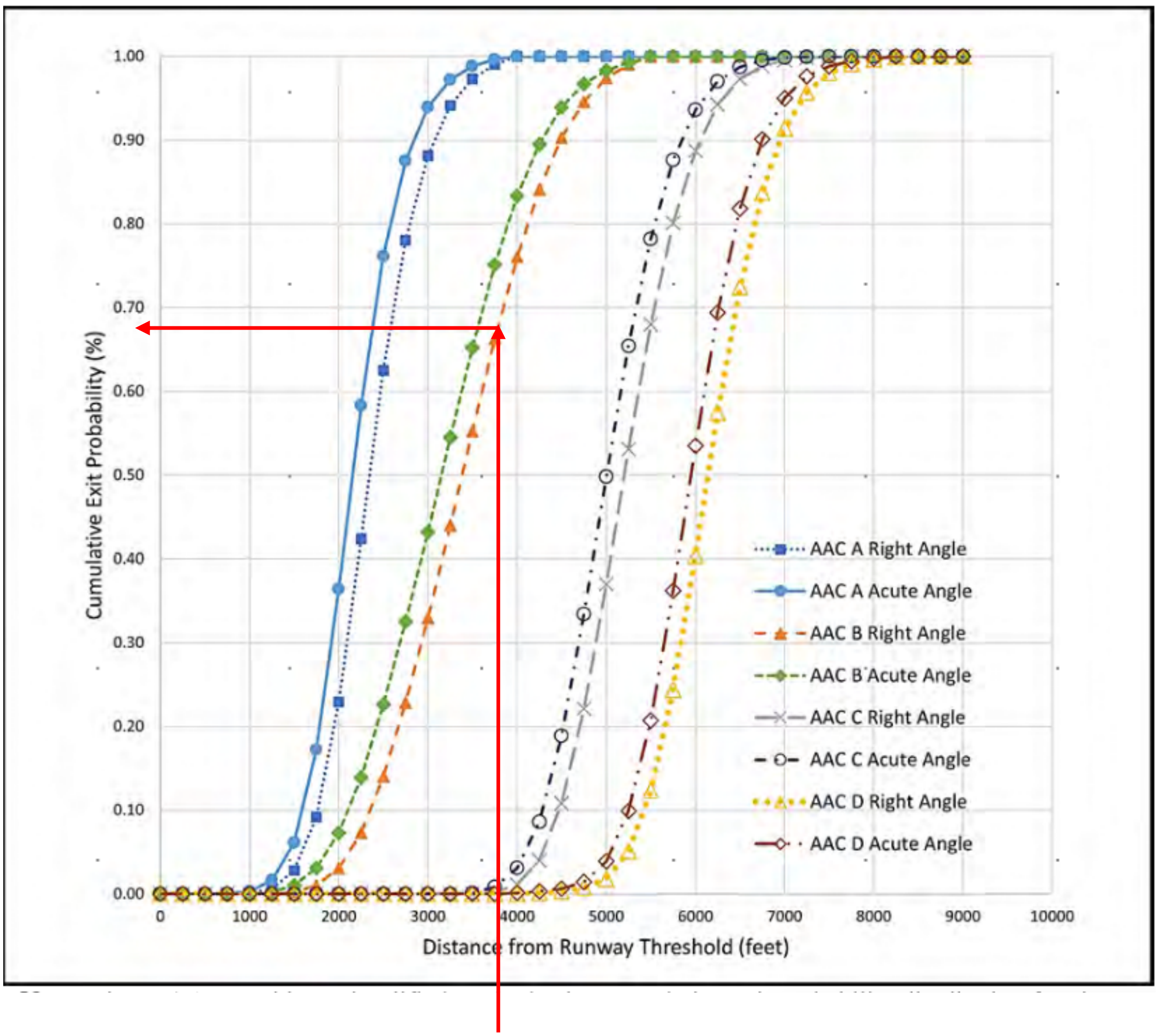
As before, we first need to scale this elevation down to sea level in order to use the figure from the Advisory Circular:

$$x + 185\ ft\left(\frac{2{,}120\ ft}{1{,}000\ ft}\right) = 4{,}200\ ft$$

$$x = 3{,}808\ ft$$

Since the representative aircraft is still AAC B, then we look at where the cumulative exit probability intersects the graph at 3,808 ft for AAC B aircraft taking right angle exits:

Figure 4-17. Cumulative Probability of Aircraft Able to Exit by AAC at Airports With an Elevation Less Than 2,000 feet (610 m) MSL



From the Figure, approximately 68% of AAC B aircraft can take a right-angle exit located 3,808 feet from the threshold of BCB runway 31.

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

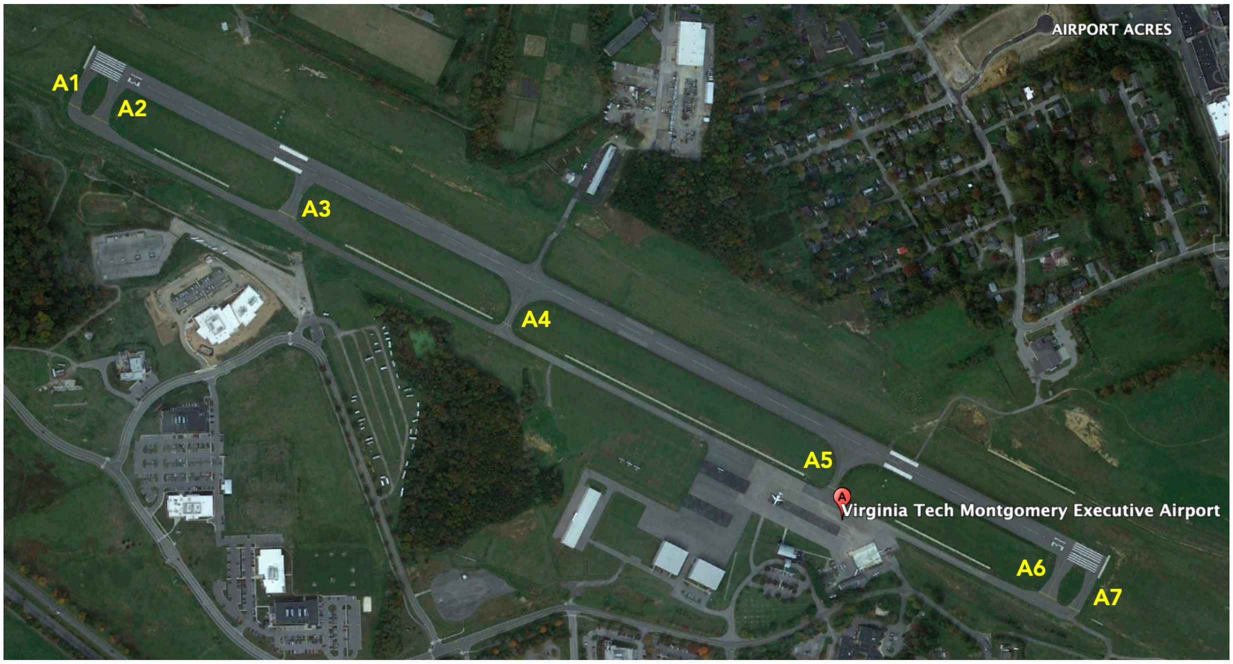


Figure 1. Blacksburg Montgomery County Executive Airport.

Although both exits are right-angles, they have different radii. The exit closer to the runway 31 threshold (A2) has wider throat, allowing larger aircraft to use it.

Problem 2

Use the latest version of the Runway Exit Design Model (REDIM) developed by Virginia Tech for FAA to evaluate the performance of runway 31 at the Virginia Tech Montgomery Executive Airport (BCB). Tables 1 and 2 show the runway exits and aircraft fleet mix at BCB.

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

https://atsl-software-downloads.s3.amazonaws.com/redim/V4.0.0.beta6/redim.exe

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.

Table 1. Runway Exit Characteristics of Runway 31 at BCB Airport.

Runway Exit	PC Location	Runway Exit Type
A5	1200	Right-angle
A4	2950	Right-angle
A3	4200	Right-angle
A2	5250	Right-angle
A1	5440	Right-angle

Use Arnav to find the airport elevation of BCB. 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 2. Aircraft Fleet Mix to Model Runway Occupancy Times on Runway 31 at BCB Airport.

Aircraft ID	Aircraft	Fleet Mix (%)
C172	Cessna 172	24
SR22	Cirrus SR22	10
C152	Cessna 152	30
B350	Beechcraft King Air 350	18
C25C	Cessna Citation CJ4	7
C68A	Cessna Citation Latitude	6
CL35	Bombardier Challenger 350	5
Totals		100

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

Weighted ROT is reported by REDIM 4 to be: 54.5 seconds (13.5 second standard deviation)

Evaluate an Existing Runway - Runway Occupancy Times (54.5 s - Std Dev: 13.5 s) - All (Runway Name) - Table

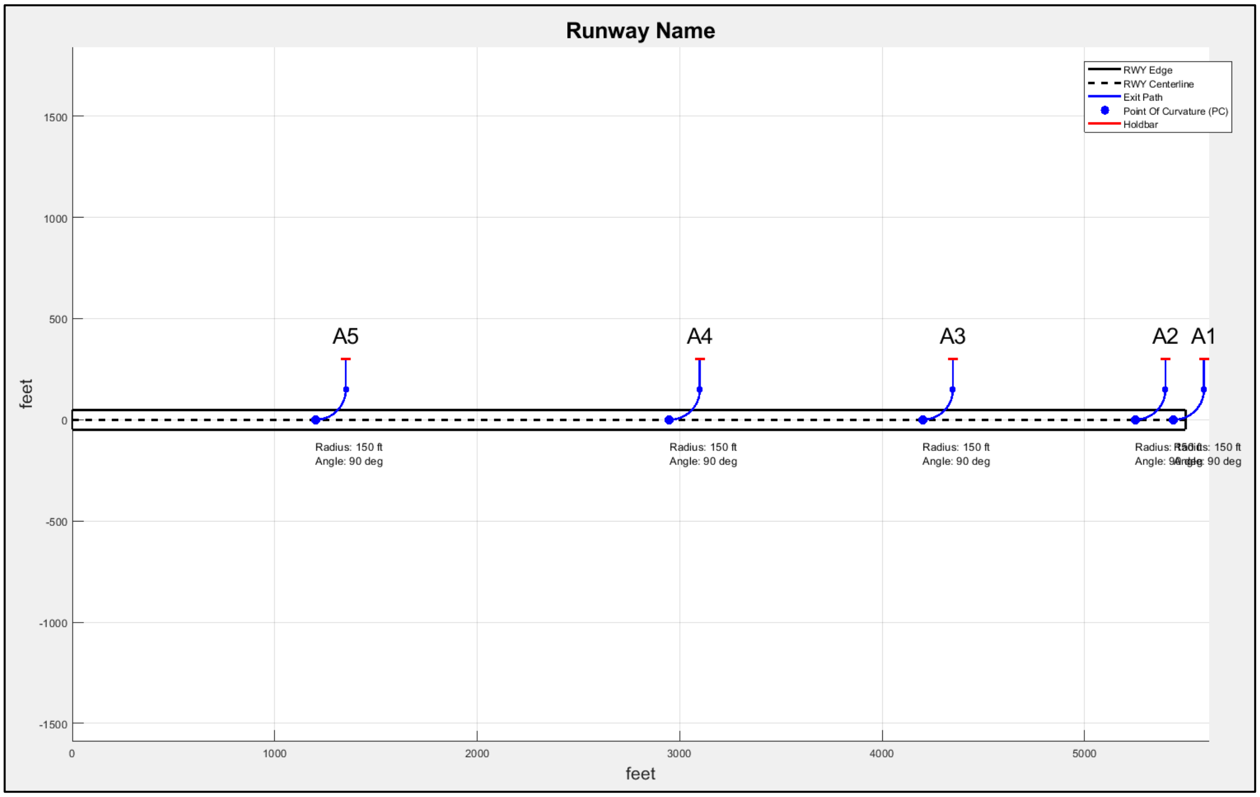
Show: Times To PC | Turnoff Times | Runway Occupancy Times | Surface Condition: All

Runway Occupancy Times (54.5 s - Std Dev: 13.5 s) - All

(Runway Name)

Aircraft Name	A5	A4	A3	A2	A1
B350		35.6s	47.7s	57.5s	57.2s
C152	23.2s	54.0s	72.9s	92.0s	92.6s
C172	24.5s	53.1s	69.4s	86.5s	89.9s
C25C		32.1s	43.6s	52.2s	51.3s
C68A		33.4s	44.0s	53.2s	52.3s
CL35		28.1s	40.5s	49.8s	49.2s
SR22	17.4s	42.2s	57.1s	69.3s	71.1s

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



c) Estimate the percent of Cessna CJ4 landings likely to use runway exit A3. Show the full table of runway exit assignments provided by the model.

Cessna CJ4 would use runway exit A3 40.4% of the time while landing on runway 31.

Evaluate an Existing Runway - Runway Exit Aircraft Assignment - All (Runway Name) - Table

Surface Condition: All

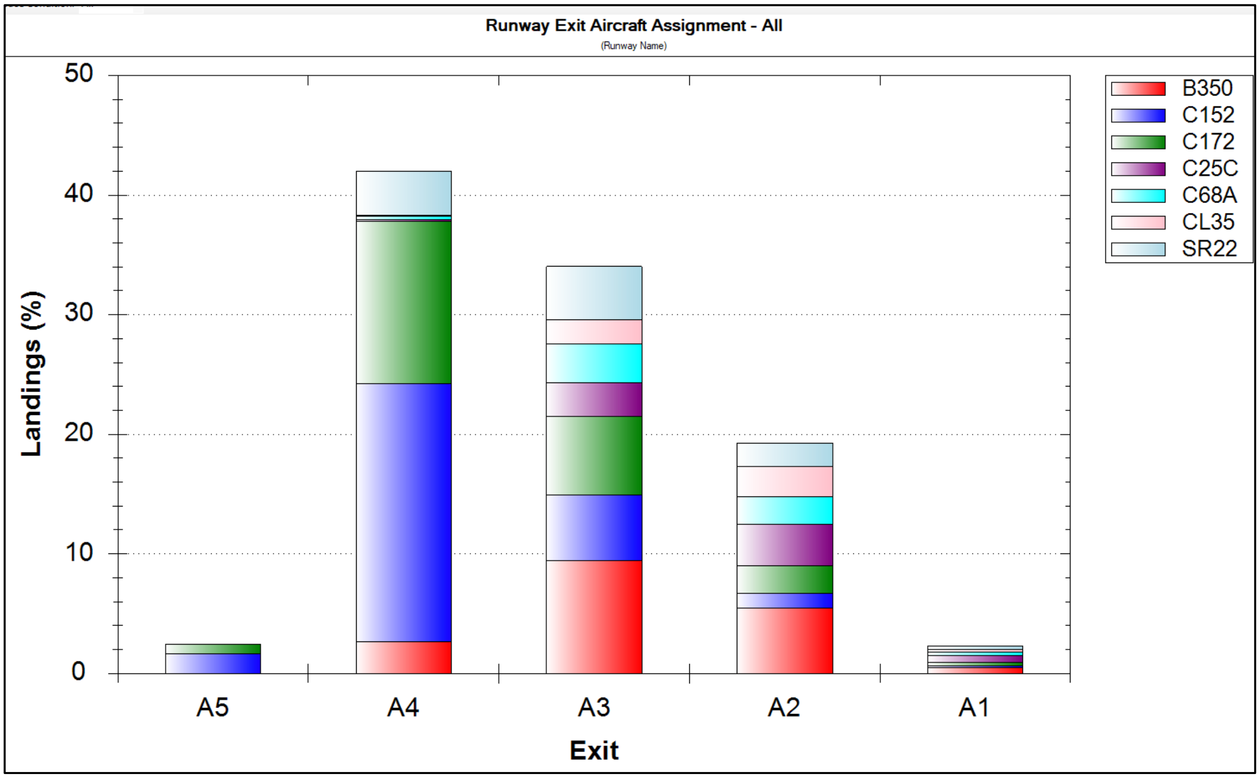
Runway Exit Aircraft Assignment - All

(Runway Name)

Aircraft Name	A5	A4	A3	A2	A1	Aircraft Mix
B350		14.8%	52.2%	30.3%	2.7%	18.1%
C152	5.4%	71.9%	18.3%	4.1%	0.4%	30.0%
C172	3.6%	57.4%	27.9%	9.7%	1.5%	23.6%
C25C		2.0%	40.4%	49.5%	8.0%	7.0%
C68A		5.2%	52.5%	37.8%	4.4%	6.1%
CL35		0.3%	41.9%	52.5%	5.3%	4.9%
SR22	0.1%	36.1%	42.9%	18.8%	2.1%	10.3%
Exit Mix	2.5%	42.0%	34.0%	19.3%	2.3%	

d) Find the runway exit at BCB that is likely to be used the most. Estimate the percent of all the landings using that exit.

Runway exit A4 with has more than 42% of the landings at BCB assigned to it (see Figure below).



e) Find if the parallel taxiway A (Alpha) at BCB is compliant with RDC C-II.

Yes, 300 feet of separation between the runway centerline and the taxiway centerline is good for C-II RDC code.

Problem 3

A proposed 9,000 ft runway at a mid-west airport is expected to have a total of eight runway exits. The runway configuration is similar to the configuration of runway 18R/36L at Charlotte-Douglas International Airport (CLT). Four exits are high-speed acute angle exits (two HS exits per direction) and the remaining exits are right-angle exits. The critical aircraft is the Airbus A321neo (see Figure 3).

Figure 2. Airbus A321neo Landing at BWI Airport (A. Trani).

(a) Use the cumulative curves to locate two high speed exits allowing 55% and 95% of the critical aircraft AAC class to exit.

55% of AAC D requires a high-speed exit located at: 6,000 feet.

95% of AAC class requires a high-speed exit located at: 7,000 feet.

The distance between the first and second exits is 1,000 feet. This meets the minimum recommended distance of 800 feet.

(b) Find the minimum separation between runway and taxiway centerlines.

Table 4-5 in the FAA Advisory Circular (150/5300-13B) shows the minimum distance between runway and taxiway centerlines (reproduced below).

Table 4-5. Runway to Taxiway Separation for Reverse Turns from a High-Speed Exit Based on TDG

Runway Centerline to Taxiway/ Taxilane Centerline	TDG			
	3	4	5	6
Recommended separation	350 ft (107 m)	450 ft (137 m)	450 ft (137 m)	600 ft (183 m)
Radius for 150-degree turn after 30-degree exit	79 ft (24.1 m)	121 ft (37 m)	121 ft (37 m)	152 ft (46 m)
Minimum separation [1]	348 ft (106 m)	427 ft (130 m)	427 ft (130 m)	485 ft (148 m)

Note 1: Minimum separation distance based on the standard 30-degree high speed exit and maximum 50-degree steering angle for the reverse turn.

350 feet is needed for TDG 3 (Airbus A321neo) at sea level conditions. Looking at the Appendix G in the same advisory circular, we find minimum distances between runway centerline and taxiway centerline. Note that 400 feet is needed for the Airbus A321neo (RDC D-III) is 400 feet. Always use the most demanding case. 400 feet is the minimum distance between runway centerline and taxiway centerline.

Table G-9. Runway Design Standards Matrix, C/D/E-III

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – III			
ITEM	DIM 1	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph* 3.9			
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	*Refer to paragraph* 5.4.1.2			
Helicopter touchdown pad		*Refer to* AC 150/5390-2			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Note: See the Footnotes on the page after Table G-12.

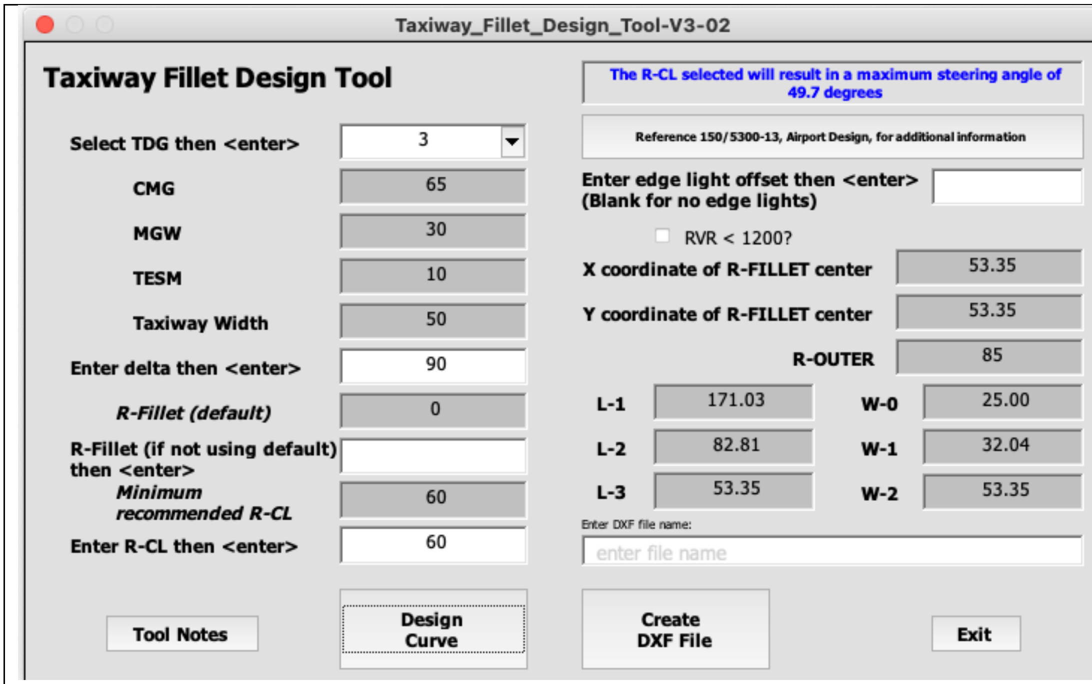
(c) What is the recommended distance between the runway and parallel centerlines to allow efficient runway operations.

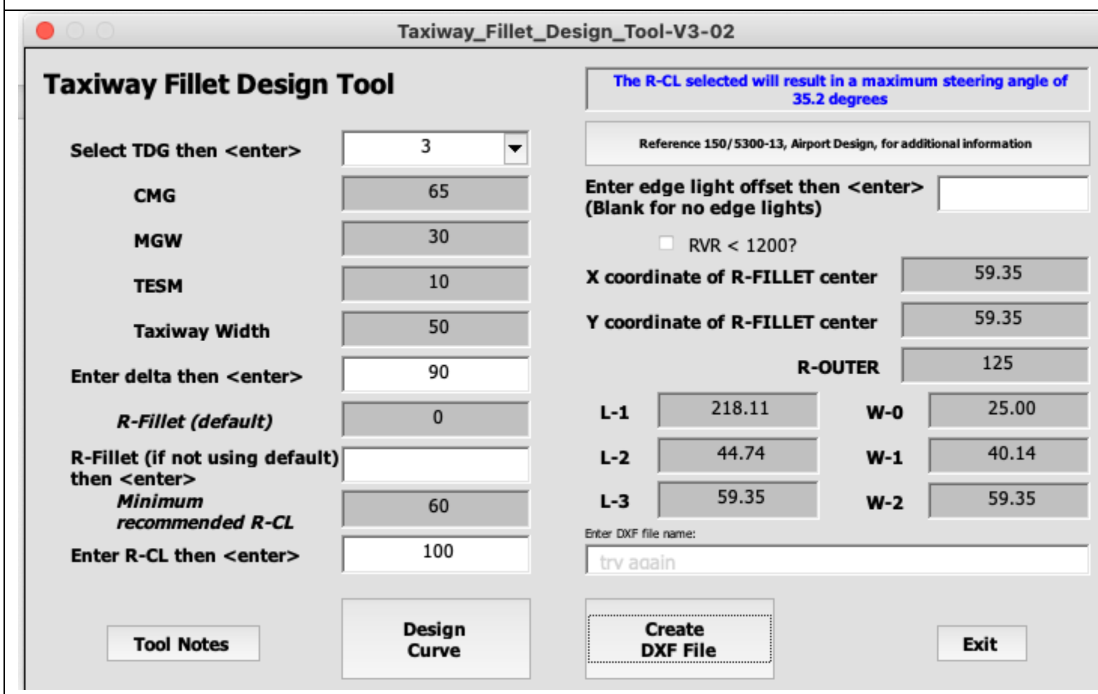
600 feet is recommended for efficient operations.

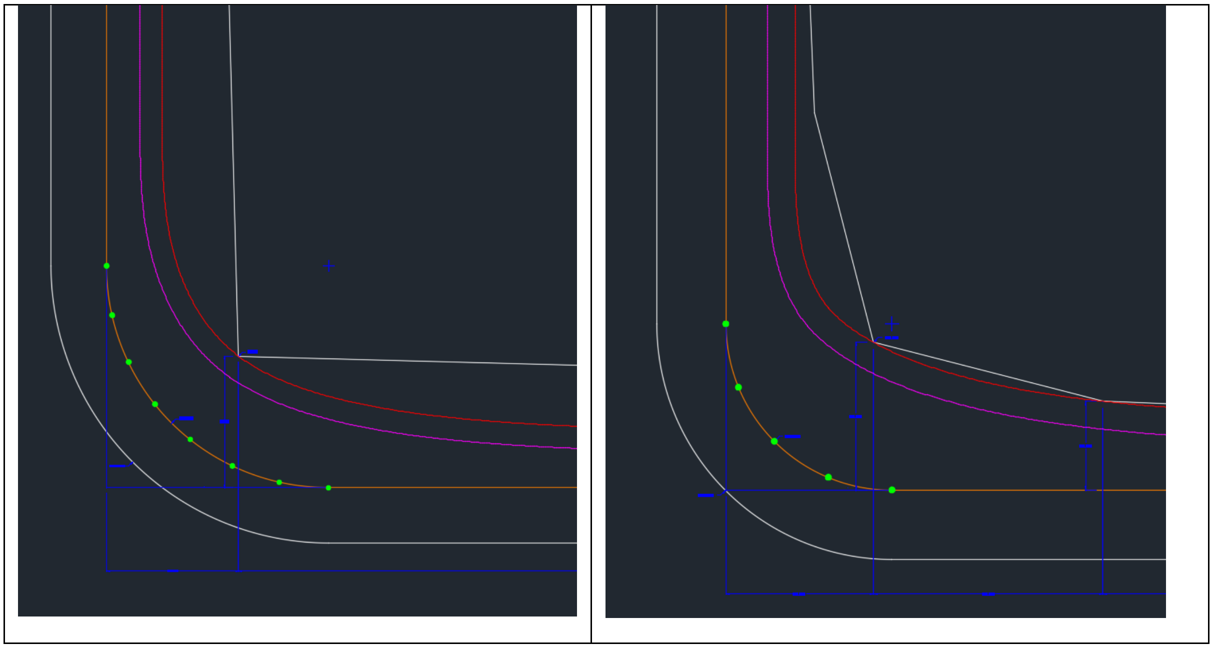
(d) Draw to scale the last runway entrance exit for the new runway. Include dimensions.

Use the FAA Taxiway design Tool to design the 90-degree runway exit geometry that meets the requirements of TDG 3. The objective here is to draw the runway exit solution showing both runway and taxiway. The FAA Taxiway Design Tool provides only 50% of the geometry needed. The other 50% of the runway exit geometry is a mirror image of the geometry produced by the FAA Design Tool.

Two solutions are offered below: 1) using the minimum recommended R-CL of 60 feet for TDG 3, and 2) using a more generous 100-foot R-CL value for the same TDG 3 aircraft. The minimum R-CL geometry requires a steering angle of 49.7 degrees (maximum used for design purposes). The 100-foot R-CL radius requires a steering angle of 32.5 degrees. The key dimension to both solutions are shown below.

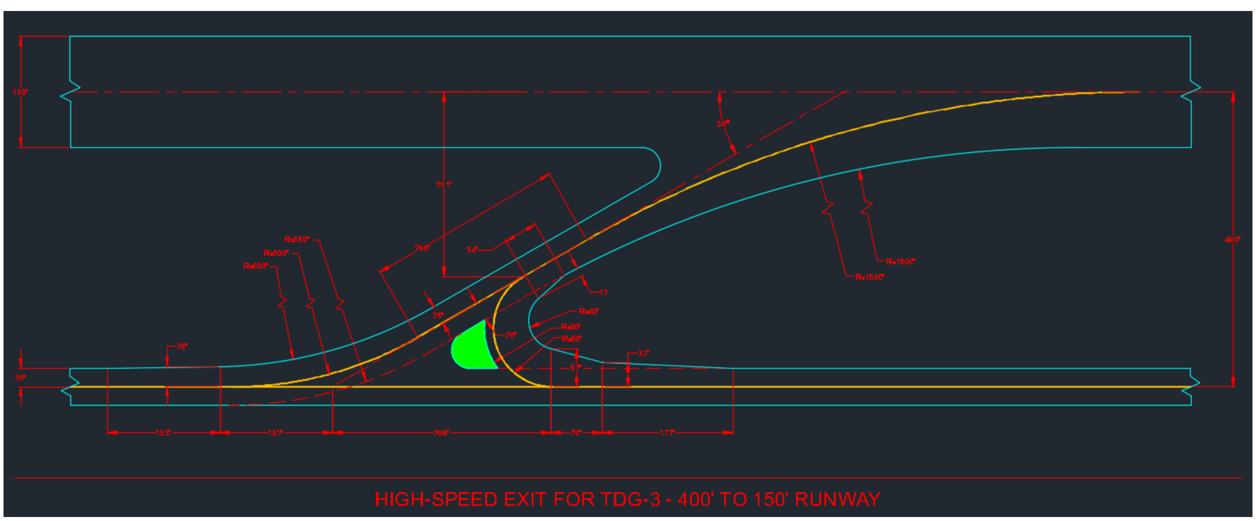

Taxiway_Fillet_Design_Tool-V3-02
Taxiway Fillet Design Tool
The R-CL selected will result in a maximum steering angle of 49.7 degrees
Reference 150/5300-13, Airport Design, for additional information
Select TDG then <enter>
3
CMG
65
MGW
30
TESM
10
Taxiway Width
50
Enter delta then <enter>
90
R-Fillet (default)
0
R-Fillet (if not using default) then <enter>
Minimum recommended R-CL
60
Enter R-CL then <enter>
60
Enter edge light offset then <enter> (Blank for no edge lights)
RVR < 1200?
X coordinate of R-FILLET center
53.35
Y coordinate of R-FILLET center
53.35
R-OUTER
85
L-1
171.03
L-2
82.81
L-3
53.35
W-0
25.00
W-1
32.04
W-2
53.35
Enter DXF file name:
enter file name
Tool Notes
Design Curve
Create DXF File
Exit


Taxiway_Fillet_Design_Tool-V3-02
Taxiway Fillet Design Tool
The R-CL selected will result in a maximum steering angle of 35.2 degrees
Reference 150/5300-13, Airport Design, for additional information
Select TDG then <enter>
3
CMG
65
MGW
30
TESM
10
Taxiway Width
50
Enter delta then <enter>
90
R-Fillet (default)
0
R-Fillet (if not using default) then <enter>
Minimum recommended R-CL
60
Enter R-CL then <enter>
100
Enter edge light offset then <enter> (Blank for no edge lights)
RVR < 1200?
X coordinate of R-FILLET center
59.35
Y coordinate of R-FILLET center
59.35
R-OUTER
125
L-1
218.11
L-2
44.74
L-3
59.35
W-0
25.00
W-1
40.14
W-2
59.35
Enter DXF file name:
try again
Tool Notes
Design Curve
Create DXF File
Exit



Left: Solution with R-CL = 100 feet. Right: Solution with Minimum R-CL = 60 feet.

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



High-speed runway exit for TDG-3 with 400-feet distance between runway and taxiway centerlines.