Assignment 8: Runway Exit Placement and Capacity

Date Due: November 9, 2022
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 D aircraft that could take a high-speed runway exit located at 6100 feet at an airport located at sea level conditions.

b) if the same high-speed runway exit is built at an airport located 3,500 feet above sea level, estimate the new location of the Point of Curvature (PC).

c) Runway exit A5 is a right-angle exit located 4,450 feet from runway threshold 13 at Virginia Tech Montgomery Executive Airport. Estimate the percent of medium size corporate jets like the Cessna Citation XLS or the Bombardier Challenger 300 that could use runway exit A5.

d) Why do we use 90% dry pavement conditions to design the locations of runway exits?

Problem 2

Use the latest version of the Runway Exit Design Model (REDIM) developed by Virginia Tech for FAA to evaluate a proposed runway with the characteristics and aircraft fleet mix shown on Tables 1 and 2.

The current beta 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 Characteristics for Problem 1.

Runway Exit	PC Location	Runway Exit Type
E1	1750	Right-angle
E2	4900	Right-angle
E3	6300	Right-angle
E4	9550	Right-angle
E5	9800	Right-angle

The proposed 10,000-foot runway will be constructed at an airport located 450 feet above mean sea level conditions. The design temperature if 70 deg.F. and use 90% dry pavement conditions. Run your analysis with Pilot Motivation Factors of 1.0 (default).

Table 2. Aircraft Fleet Mix.

Aircraft ID	Aircraft	Fleet Mix (%)
BE36	Beechcraft Bonanza 36	10
SR20	Cirrus SR20	10
B350	Beechcraft King Air 350	10
CL35	Bombardier Challenger 350	10
A320	Airbus A320	10
A321	Airbus A321	10
B38M	Boeing 737 Max8	10
B738	Boeing 737-800	10
B752	Boeing 757-200	10
E190	Embraer 190	10
Totals		100

a) Estimate the weighted average runway occupancy time (ROT) and the standard deviation for the proposed configuration.

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

c) Estimate the percent of Embraer 190 landings likely to use runway exit E3. Show the full table of runway exit assignments provided by the model.

d) Find the runway exit that is likely to be used the most at the new runway. Estimate the percent of landing using that exit.

e) Explain why is that there are two exits E4 and E5 close to each other at the end of the runway.

Problem 3

Improve the runway design of Problem 1 by evaluating a new runway configuration with the following runway exit locations:

Table 3. Runway Characteristics for Problem 2.

Runway Exit	PC Location	Runway Exit Type
E1	1750	Right-angle
E2	4000	Right-angle
E3	5500	Acute-angle (30-deg angle)
E4	6800	Acute-angle (30-deg angle)
E5	8000	Right-angle
E6	9550	Right-angle

Runway Exit	PC Location	Runway Exit Type
E7	9800	Right-angle

a) Estimate the weighted average runway occupancy time (ROT) and the standard deviation for the proposed configuration.

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

c) Find the runway exit with the highest utilization for the new configuration. Estimate the percent of landing using that exit.

d) Compare the solution obtained in Problem 1 and Problem 2. Comment.

Problem 4

The objective of the problem is to find the capacity of busy single runway airport in the US West Coast. The airport has an airport surveillance radar (ASR) and ADS-B surveillance to track aircraft up to 75 nautical miles form the airport site. The ADS-B system can update the position of aircraft every one second. Tables 4 through 6 show technical parameters and the typical ATC separations at the airport under Instrument Meteorological Conditions (IMC). Four aircraft groups (of the nine groups included in the Consolidated Wake Categories defined by FAA) operate at the airport. The airport has the following technical parameters: a) in-trail delivery error of 15 seconds, b) **departure-arrival separation for both VMC and IMC conditions is 2.4 nautical miles** (includes a small ATC buffer), c) probability of violation is 5%. Air traffic controllers direct traffic to intercept a final approach fix (fix point in space) located 13 miles from the runway threshold. Arrivals follow in-trail after crossing the final approach fix. The airport aircraft mix, runway occupancy times and approach speeds are shown in Table 4.

You are allowed to modify the spreadsheet provided in class to solve the problem. Show me sample calculations for both opening and closing cases so that I know that you can do such calculations by hand.

a) Calculate the arrivals-only saturation capacity under IMC conditions.

b) Calculate the departures-only saturation capacity under IMC conditions.

c) Calculate the arrival-departure saturation capacity diagram (Pareto diagram) under IMC conditions. In your diagram, include at least one point to estimate the departure capacity with 100% arrival priority under mixed runway operations. Show me a sample of explicit calculations of parameters Tij and Bij so that I can judge your analysis.

d) Compare the solution obtained in part (c) with the FAA runway capacity diagram (https://www.faa.gov/airports/planning_capacity/profiles/media/SAN-Airport-Capacity-Profile-2014.pdf). Comment on the possible sources of error.

Table 4. Runway Occupancy Times and Fleet Mix for a Busy Single Runway Airport in the US West Coast (Source: FAA/Virginia Tech Landing Database, Year 2019 Data).

Aircraft RECAT Group	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) from FAF
G	10	47	128
F	81	52	138
E	5	61	143
B	4	64	151
Totals	100		

Table 5. Minimum arrival-arrival separations under IMC conditions. Values in are nautical miles. ***Values Shown Do Not Include Buffers.*** *Full Table Available on Page 54 of Aircraft Classifications Handout.*

	Trailing Aircraft (Columns 2-5)			
Lead (Column 1)	**G**	**F**	**E**	**B**
G	3	3	3	3
F	3	3	3	3
E	3	3	3	3
B	5	5	5	3

Table 6. Minimum departure-departure separations under IMC conditions. Values in are seconds. ***ATC Buffers are Included.***

	Trailing Aircraft (Columns 2-5)			
Lead (Column 1)	**G**	**F**	**E**	**B**
G	70	70	70	70
F	70	70	70	70
E	95	90	70	70
B	130	120	120	120