CEE 5614: Analysis of Air Transportation Systems Spring 2024

Final Project

Date Due: May 7, 2023 by Midnight Instructor: Trani

Rules:

Groups of 2 students allowed if solving both problems
Include a brief writeup of the answers and explain your solution
Include the Excel or Matlab files used to solve the problem
Send me the Excel or Matlab scripts for review
Include VT Honor Code Pledge

Problem 1

The goal is to perform a basic noise study for the Virginia Tech Montgomery Executive airport (BCB). The configuration of the airport is shown in Figure 1.

Figure 1. Runway Configuration for Problem 1. Source: Google Earth. A 1,000-foot Runway Extension was Completed on July 2021 (during Covid).

Task 1: Make Noise Contour Plots Using LA_{Max} Metric

This is a new task because we could not collect actual data on April 13, 2024. The task is to illustrate and compare the noise contours for popular aircraft used at BCB: 1) Cessna 172, 2) Raytheon King Air B350, 3) Cessna 560Xl, and Bombardier Challenger CL300. Use the noise metric called the maximum sound level - LA_{MAX} 75 dBA for the analysis. Also, the analysis should use departure operations (straight or runway heading is fine) to illustrate the possible impact to the population around the airport.

The comparisons are useful to communicate the noise levels generated by individual aircraft. Figure 1a shows an example of noise levels (LA_{MAX}) for two aircraft and two numerical values (70 and 75).

According to the US Department of Transportation, the definition of LA_{MAX} is:

"The LMAX, or Maximum Sound Level, descriptor is the highest sound level measured during a single noise event (such as a vehicle pass by), in which the sound level changes value as time goes on. The maximum sound level is important in judging the interference caused by a noise event with common activities. LMAX ignores the number and duration of these events, and cannot be totaled into a one-hour or a 24-hour cumulative measure of impact."

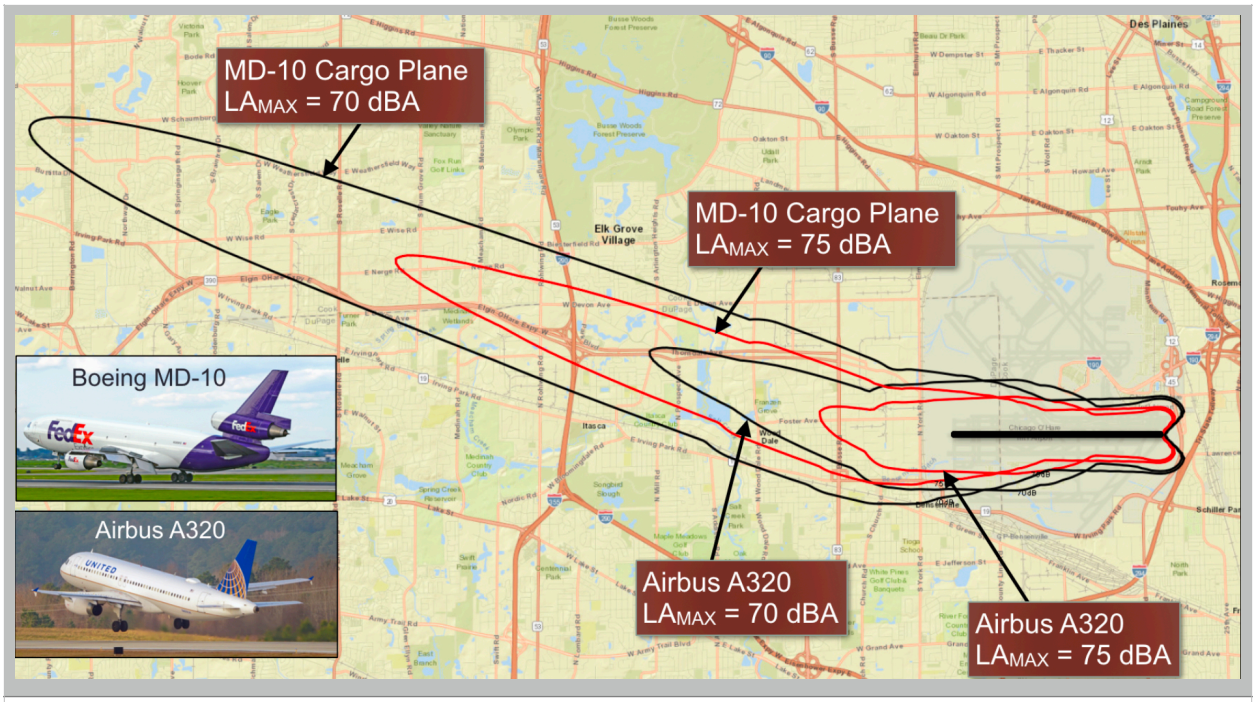

Figure 1a. Comparison of Noise Contours for Two Aircraft.

Task 2: BCB Aircraft Data Summary

Use the airport log file provided to estimate the airport fleet mix. Plot a Cumulative Density Function (CDF) of the number of operations by aircraft type and select the 20 most used aircraft at the airfield. Based on the aircraft class, you should adjust the 20 most used aircraft accordingly to make up all the operations logged by the airport.

Construct an Excel (or Matlab) file to summarize your findings. List the top 20 most used aircraft and the number of annual operations estimated.

	Date	N-Number	Aircraft Manufacturer	Aircraft Model	ACFT Class	Engine Type	# Eng	Based or Transient
2	7/1/22	N112RM	Mooney	M-20	SEP	Piston	S	Based
3	7/1/22	N2823S	Cessna	C-150	SEP	Piston	S	Based
4	7/1/22	N249DS	Diamond	DA40	SEP	Piston	S	Transient
5	7/1/22	N95103	Cessna	C-152	SEP	Piston	S	Based
6	7/1/22	N864M	Lancair	360	SEP	Piston	S	Based
7	7/1/22	N758LJ	Cessna	C-172	SEP	Piston	S	Transient
8	7/1/22	N68TT	Beechcraft	Bonanza	SEP	Piston	S	Based
9	7/1/22	N34208	Cessna	C-177	SEP	Piston	S	Based
10	7/1/22	N194V	Mooney	M-20	SEP	Piston	S	Transient
11	7/1/22	N7763M	Mooney	M-20	SEP	Piston	S	Based
12	7/1/22	N95103	Cessna	C-152	SEP	Piston	S	Based
13	7/1/22	N27WV	Cirrus	SR22	SEP	Piston	S	Transient
14	7/1/22	N50EC	Mooney	M-20	SEP	Piston	S	Based

Figure 2. Airport Log Data Provided by the Airport Manager.

Notes:

1) The log file only records arrival operations so the records need to be multiplied by two for most aircraft. Few exceptions to note:

2) Cessna 150 (N2823S) is a local flight trainer. Each record in the log file should be multiplied by 4 instead.

3) Cessna 152 (N95103) is another a local flight trainer. Each record in the log file should be multiplied by 4 instead.

4) Cessna 172 (N1359U) is also a training aircraft. Each record in the log file should be multiplied by 4 instead.

Task 3: BCB Flight Tracks

Use the airport log file provided to estimate the airport fleet mix. Plot a Cumulative Density Function (CDF) of the number of operations by aircraft type and select the 20 most used aircraft at the airfield. Based on the aircraft class, you should adjust the 20 most used aircraft accordingly to make up all the operations logged by the airport.

Notes about flight track operations at BCB.

A) Each runway end has three departure tracks (South, North and Straight). See the examples provided. Departing aircraft fly runway heading for 2 miles after crossing the threshold of the debating runway and then turn. Estimate the turn radii using the analysis presented in class and knowing that jets fly at 160 knots, turboprops at 130 knots and piston power aircraft at 100 knots in the initial climb. Assume bank angles limited to 25 degrees.

B) Each departure runway has a Touch-and-Go operation flight track for small aircraft. See the examples provided.

C) Each runway has three arrival tracks (South, North and Straight). Assume that all arrivals line up with the runway 3 nm from the arrival threshold. This does not apply to touch and go operations. For TG operations see examples provided.

D) Based on wind rose analysis, the airport operates on **runway 31 67% of the time**. **33% of the time, runway 13 is used**.

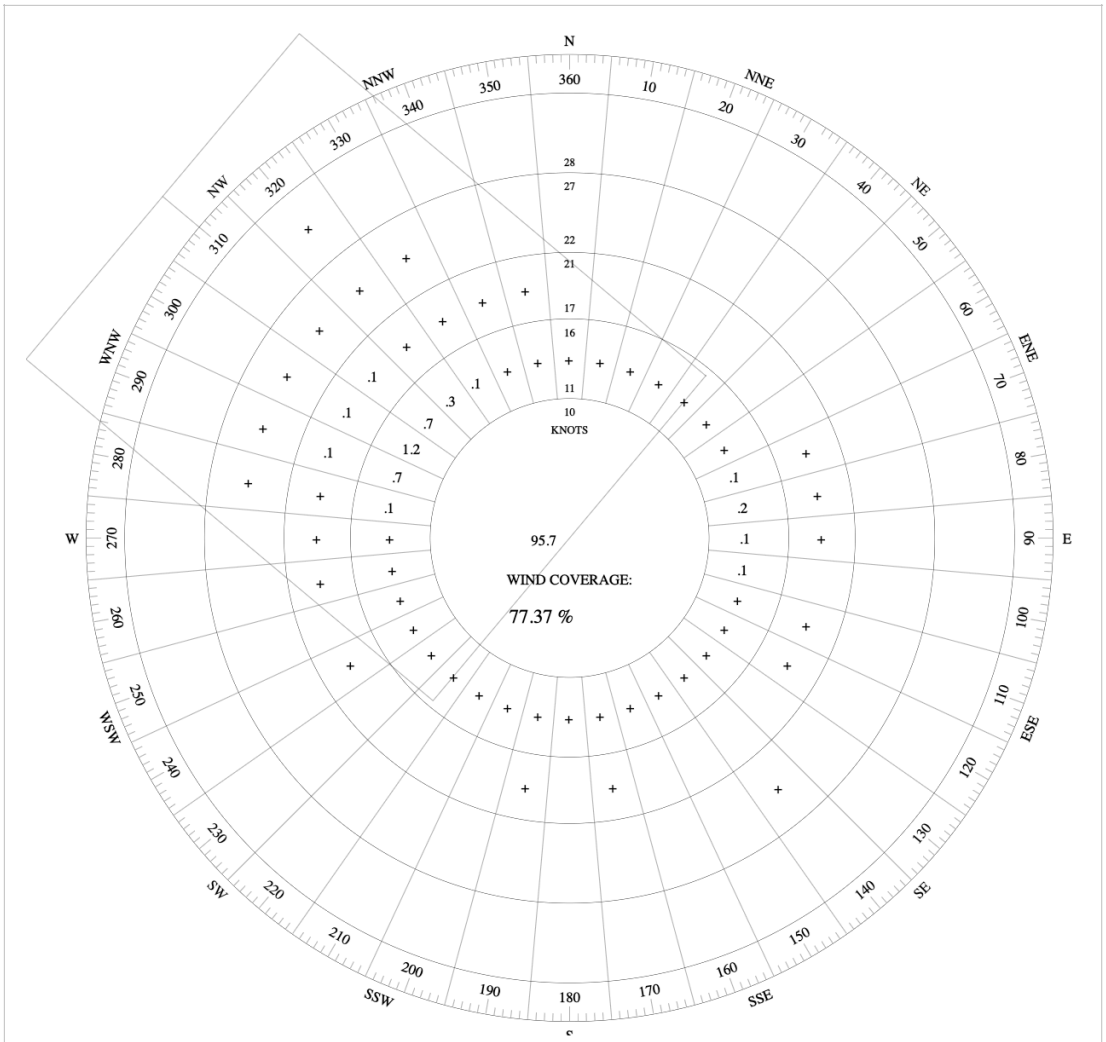

Figure 2a. Wind Rose for BCB. Runway 31 in Use. No Tailwind Allowance.

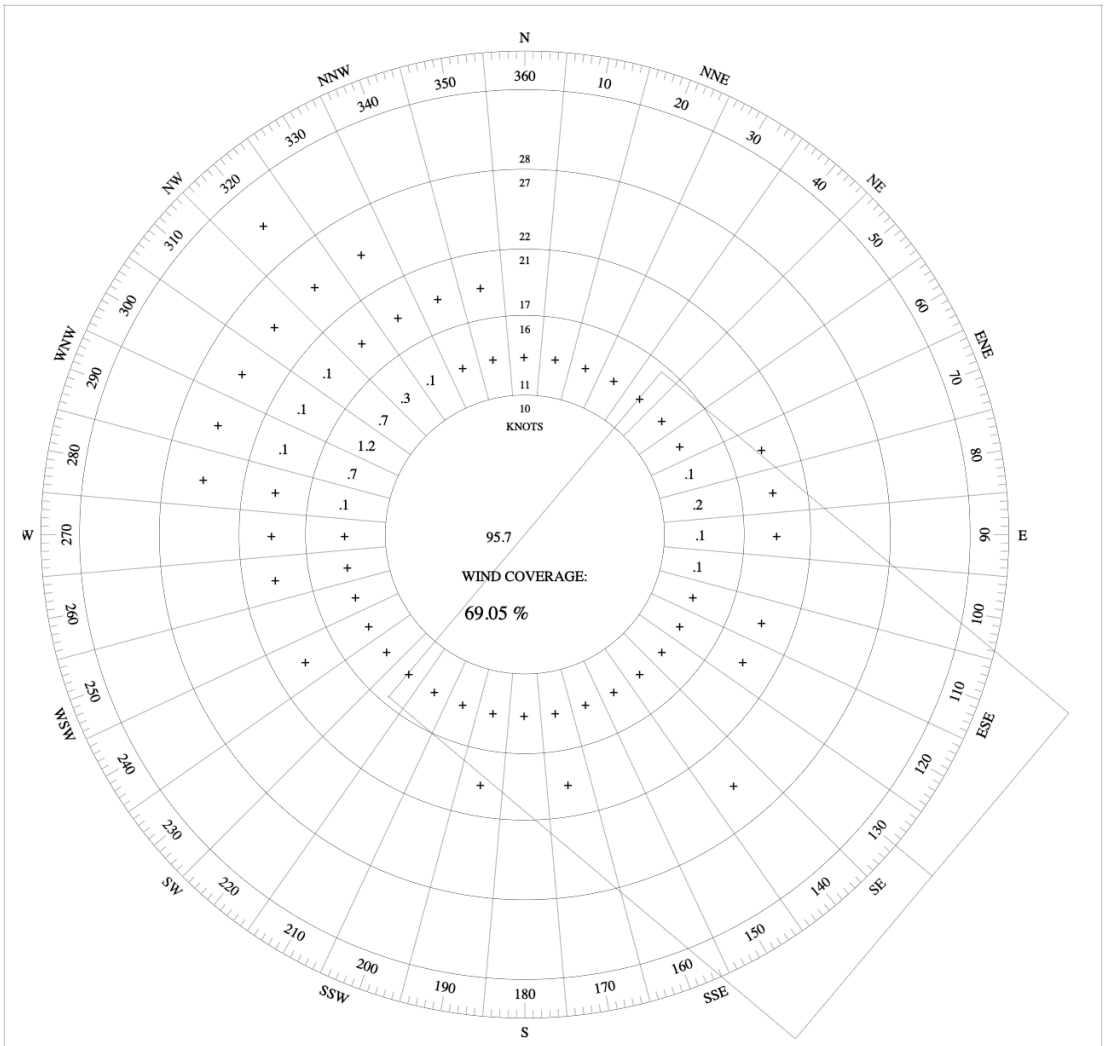

Figure 2a. Wind Rose for BCB. Runway 13 in Use. No Tailwind Allowance.

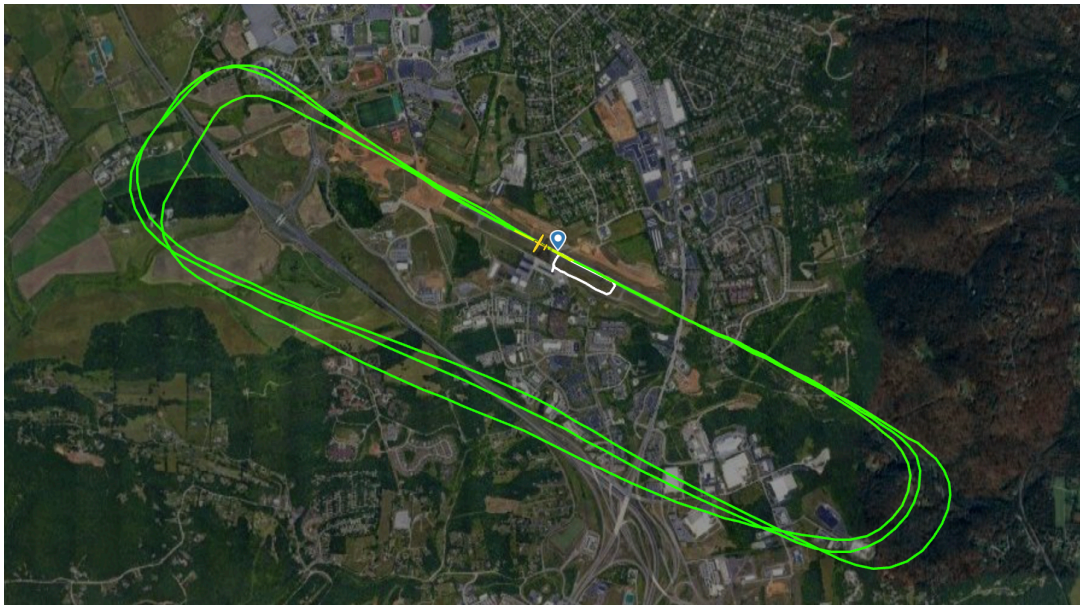

Figure 3. Typical Touch and Go Pattern for Cessna 152 Trainer. Touch and Go Operations on Runway 31. Source: Flightradar24 March 14, 2024.

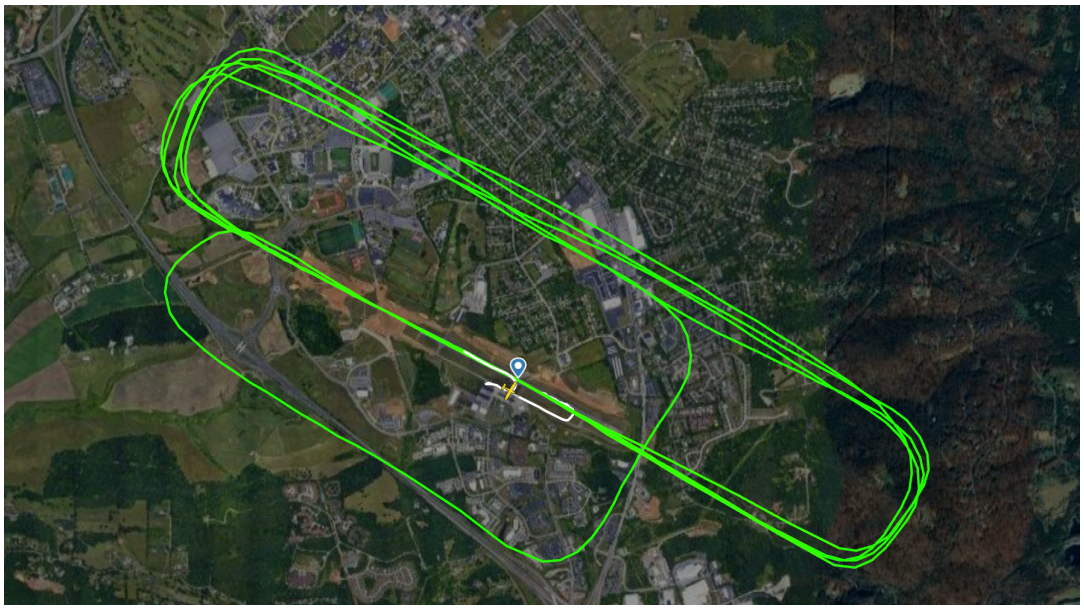

Figure 4. Typical Touch and Go Pattern for Cessna 152 Trainer. Touch and Go Operations on Runway 13. Source: Flightradar24.

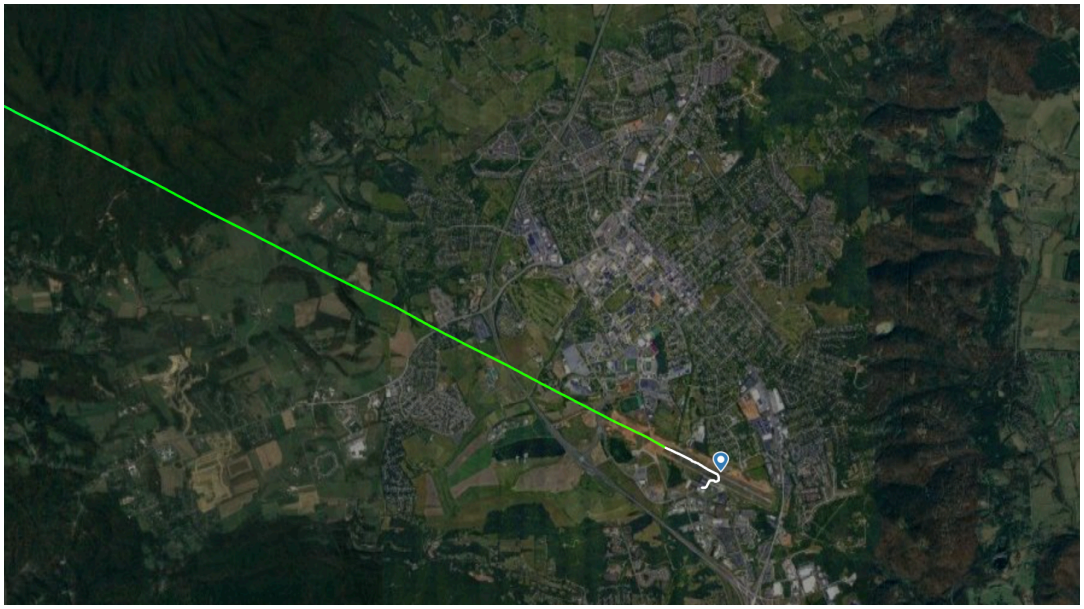

Figure 5. Typical Arrival Flight Track for a Jet Aircraft. Landing on Runway 13. Source: Flightradar24.

Figure 6. Typical Arrival Flight Track for a Jet Aircraft. Landing on Runway 31. Source: Flightradar24.

Figure 7. Typical Departure Flight Track for a Jet Aircraft. Departure from Runway 31 to the South. The Aircraft Turns Quickly to the South as the Pilot is a Local Pilot who Knows the Airfield Well. Source: Flightradar24.

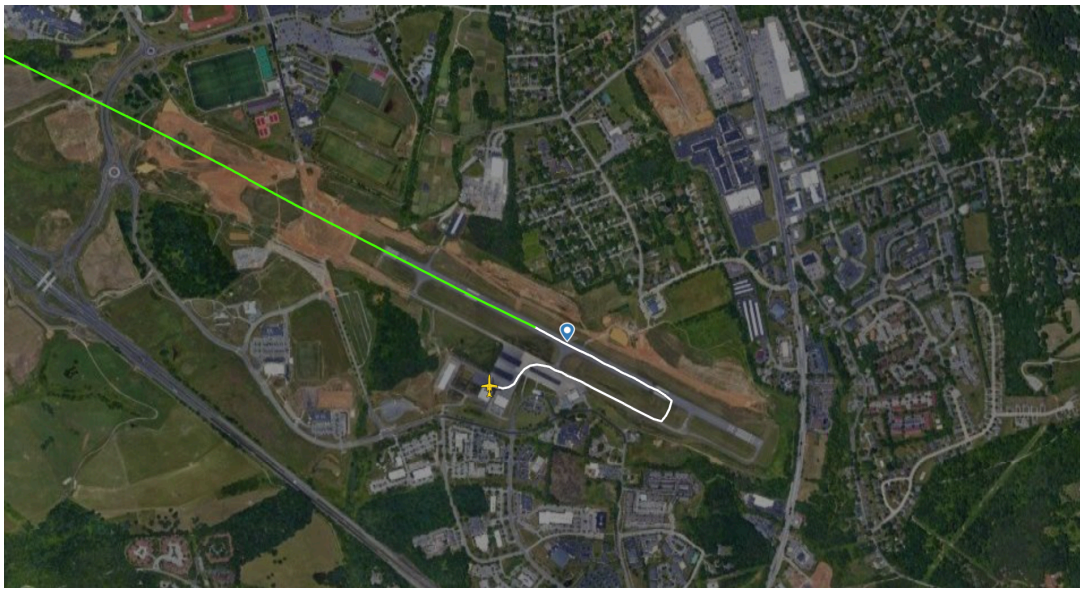

Figure 8. Typical Departure Flight Track for a Jet Aircraft. Departure from Runway 31 to the West. Source: Flightradar24.

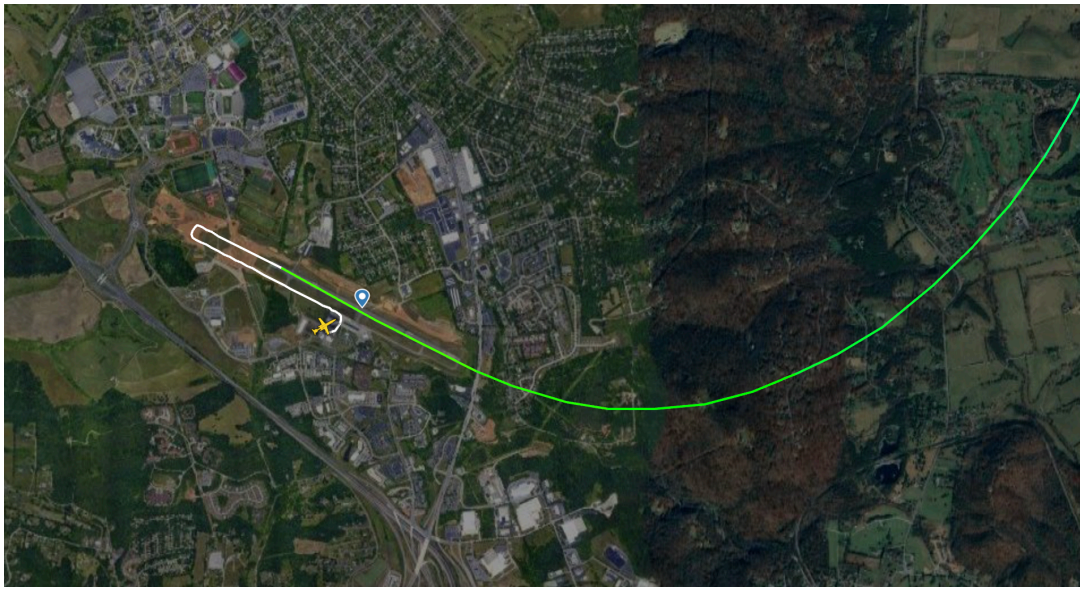

Figure 8. Typical Departure Flight Track for a Jet Aircraft. Departure from Runway 13 to the North. Source: Flightradar24.

Task 4: Add Ground Operations

The airport has a single taxiway that should be modeled as part of this study. Taxiway Alpha runs parallel to the runway and is connected to the runway via seven runway exits (see Figure 1). Also, add 0.25 daily operations (1 of every four days) of running a small turbofan engine (TFE-731-4R) at the airport at the location shown in Figure 9. At larger airports, these kind of operations are called runup operations.

Figure 9. Location of the Turbofan Engine Test Cell at the Airport.

Task 5: Estimate the DNL Contours for the Airport

Generate the DNL contours (45-70 every 5 dBA) at the airport. Your solution should highlight any areas of concern where population may be affected. Use the recent FAA survey of level of annoyance to discuss any issues related to noise at the airport.

Bonus: Estimate the population impacted by DNL 50, 60 and 65 dBA levels. Discuss the results obtained.

Problem 2

Solve an updated version of the Airline Scheduling Problem (ASP-1) explained in class with the following characteristics. The airline is evaluating the purchase of new generation regional aircraft (i.e., Transonic Truss-Braced Aircraft - TTBW) to operate out of DCA. The new airline wants to operate in the markets shown in Table 1. The following aircraft are potential contenders for possible use by the airline.

a) Maximize profit solving for the fleet size and frequency assignment **without a minimum frequency constraint**. Clearly state the number of aircraft of each type needed (use an **integer solution if desired to make the problem more realistic**) and the number of flights between each origin-destination pair to satisfy the two basic constraints (demand and supply constraints). Use Excel Solver to solve the problem.

b) Calculate the fares to be charged in each O-D pair if the airline wants to recover its full cost for service plus a 10% profit. In your calculation assume the hourly operating cost of the aircraft shown in Table 2 is 75% of the total operating cost of the carrier. That is, 25% of the cost of running is due to administrative and other costs not related to operation of the aircraft.

c) Comment your assessment of the economics of using new generation TTBA in the proposed routes.

All other parameters of the model are the same as ASP-1.

Table 1. Aircraft Operating Cost and Performance.

Aircraft	TTBA	Boeing 737-700
Seats	128	132
Block Speed (knots) Gate-to-Gate	390	400
Operating Cost ($/hr)	4,400	5,800
Typical maximum aircraft utilization (hrs/day) in service	12.5	13.0

Table 2. OD Markets for the Proposed New Airline.

Origin-Destination Airports	Daily Demand (passengers)
DCA-ATL	700
ATL-DCA	680
DCA-BOS	510
BOS-DCA	490
DCA-LGA	530
LGA-DCA	540