Assignment 9: Airport Runway Capacity and Delays

Date Due: November 17, 2021
Instructor: Trani

Problem 1

This problem analyzes the runway capacity for an airport with runway configuration shown in Figure 1. Assume landing aircraft on runway 07 touchdown before the intersection with runway 03 (i.e., no wake vortex effect for departures on runway 03). Use IMC conditions to solve the problem. The airport fleet mix is shown in Table 1. Note that the regional airport uses the new Re-Categorization developed by FAA with 6 groups (see page 43 of the Aircraft Classification handout). Assume the departing aircraft acceleration is 2.0 m/s^2. Consider the interactions between arrivals on runway 07 and departures on runway 03. For this analysis we use the following technical parameters: a) in-trail delivery error of 19 seconds under IMC conditions, b) probability of violation is 5%. Arriving aircraft are "vectored" by ATC to intercept the extended centerline off the runway 07 at a fix located 10 miles from the runway 07 threshold. Tables 2 and 3 show the arrival-arrival and departure-departure separations.

The ATC operations at the airport are such are such that, if an arrival is 2.5 nm from runway 07 threshold, the departure on runway 03 can be cleared for takeoff. The 2.5 nm distance provides a margin of safety for the departure to accelerate on runway 03 and cross the intersection.

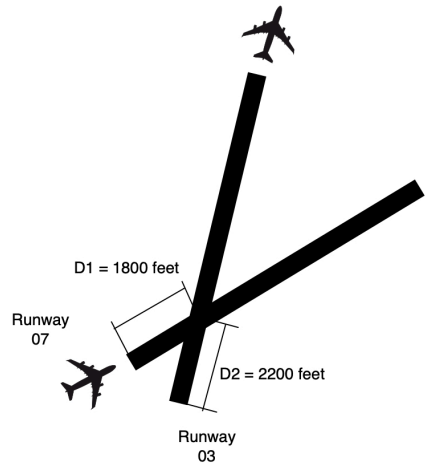

Figure 1. Runway Configuration for Problem 1.

Table 1. Runway Operational Parameters and Fleet Mix for Problem 1. RECAT Phase 1 Groups.

Aircraft RECAT Group	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) from FAF
D	82	50	140
E	18	48	134
Totals	100		

Table 2. Minimum arrival-arrival separations under IMC conditions. Values in are nautical miles. ***Values Shown Do Not Include Buffers.***

Minimum Separation Matrix (nm)		Arrivals-Arrivals		
		Trailing Aircraft (Header Columns)		
Lead (column 1)	E	D	C	B
E	2.5	2.5	2.5	2.5
D	3	2.5	2.5	2.5
C	3	3	3	3
B	5	5	4	3

Table 3. Minimum departure-departure separations under IMC conditions. Values in are seconds. ***Buffers are Included.***

Departure-Departure Separation Matrix (seconds)				
		Trailing Aircraft (Header Columns)		
Lead (column 1)	E	D	C	B
E	70	70	70	70
D	70	70	70	70
C	120	120	120	120
B	120	120	120	120

a) Derive the critical equation to estimate the time gaps needed to account for the dependency between operations on runways 07 and 03.

b) Estimate the arrival and departure capacities for the airport.

c) Plot the IMC arrival-departure capacity diagram for this airport.

d) Name two popular aircraft operated in the National Airspace System that belong to RECAT D group.

Problem 2

This problem analyzes the runway capacity for an airport with runway configuration shown in Figure 2. To solve the problem, assume the same technical parameters and aircraft fleet mix used in Problem 1.

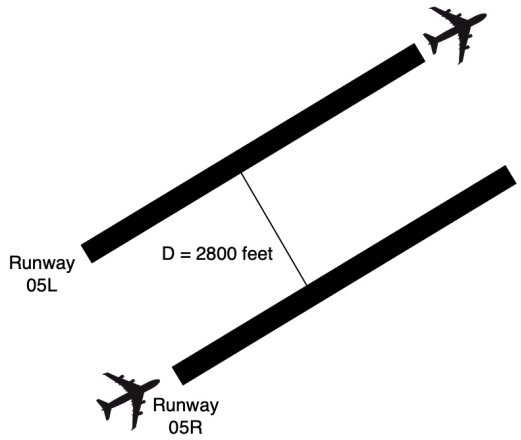

Figure 2. Runway Configuration for Problem 2.

a) Estimate the arrival and departure capacities for the runway configuration shown in Figure 2.

b) Plot the IMC arrival-capacity capacity diagram for this airport.

c) Compare the capacity of the two runway configuration with that obtained in Problem 1.

d) Name an important airport in the United Kingdom that operates two runways in segregated mode.

Problem 3

This problem analyzes the runway delays for an airport with runway configuration similar to that shown in Figure 2. The fleet mix for this problem is different than Problem 2. Calculation of runway capacity for this airport yields 34 arrivals per hour and 48 departures per hour. Airlines schedule arrivals according to the demand function shown in Figure 3.

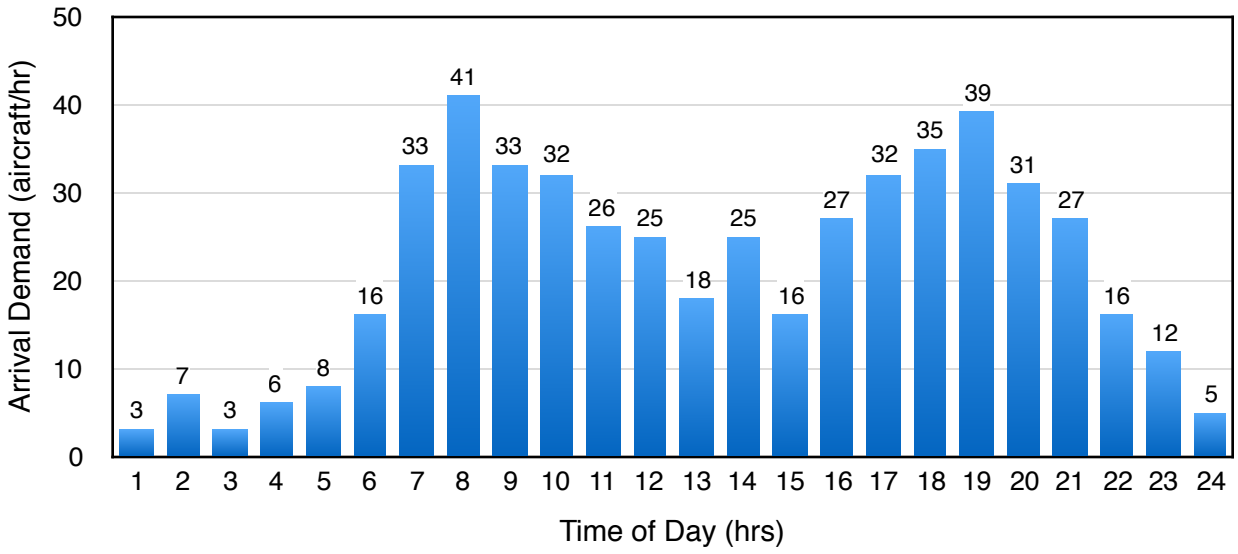

Figure 3. Arrival Demand for Problem 3.

a) Draw the rate diagram (supply and demand) for the arrival runway.

b) Use Deterministic Queueing theory to estimate the total delay (in units aircraft-hours) to arriving aircraft for the configuration shown. You can use the MATLAB code provided in class. Show me the input parameters that you changed to solve the problem.

c) Find the average queue length for the morning period.

d) Find the average delay per aircraft for aircraft that are affected by the limited runway capacity of the airport.