Assignment 8: Runway Capacity and Airspace Capacity

Date Due: April 17, 2023 Instructor: Trani

Problem 1

Figure 1 illustrates the configuration of the runways at the airport. Runways 9L and 9R are close parallel runways used in **mixed runway operations**. Runway 09L is the primary landing runway. Runway 09L is used as secondary landing runway. In the configuration shown runway 13 (Southeast departures) is used for departures. The proximity of the departure threshold 13 to runway 09L creates an interaction where Class B aircraft (Heavy) departing the runway generate a strong exhaust contour behind the aircraft at full thrust. Figure 2 shows the takeoff engine exhaust velocity profiles for a Boeing 747-8 aircraft. When a class B aircraft departs runway 13, ATC requires any arrival to runway 09L to be 1.5 nm or more from the arrival threshold of 09L allowing the jet exhaust to dissipate.

Assume that all aircraft landing on runway 09R touchdown before the intersection with runway 13/31. Based in typical values observed in the VT Landing Events Database, the touchdown location for this class of aircraft is 2,200 feet from runway threshold 09R. We also know that the typically touchdown speed is 95% of the final approach speed. Landing aircraft decelerate at a typical 2.3 m/s^2 after touchdown. Departing aircraft aircraft accelerate at 2.2 m/s^2.

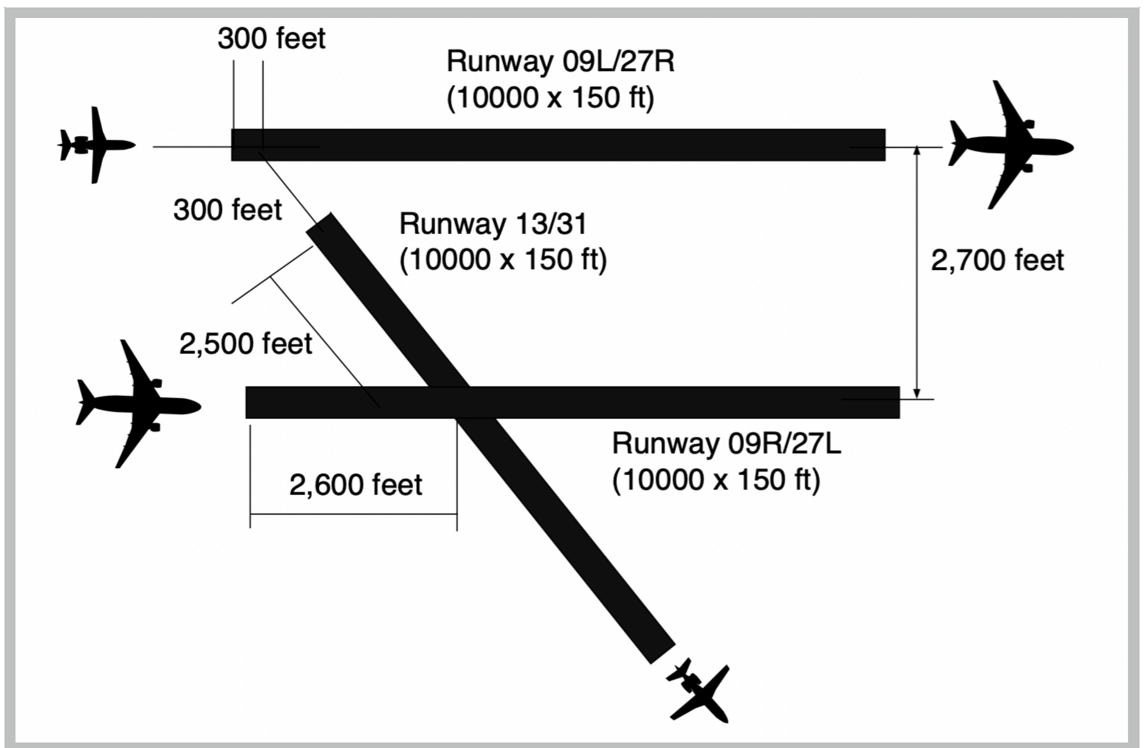

Figure 1. Runway Configuration for Problem 1.

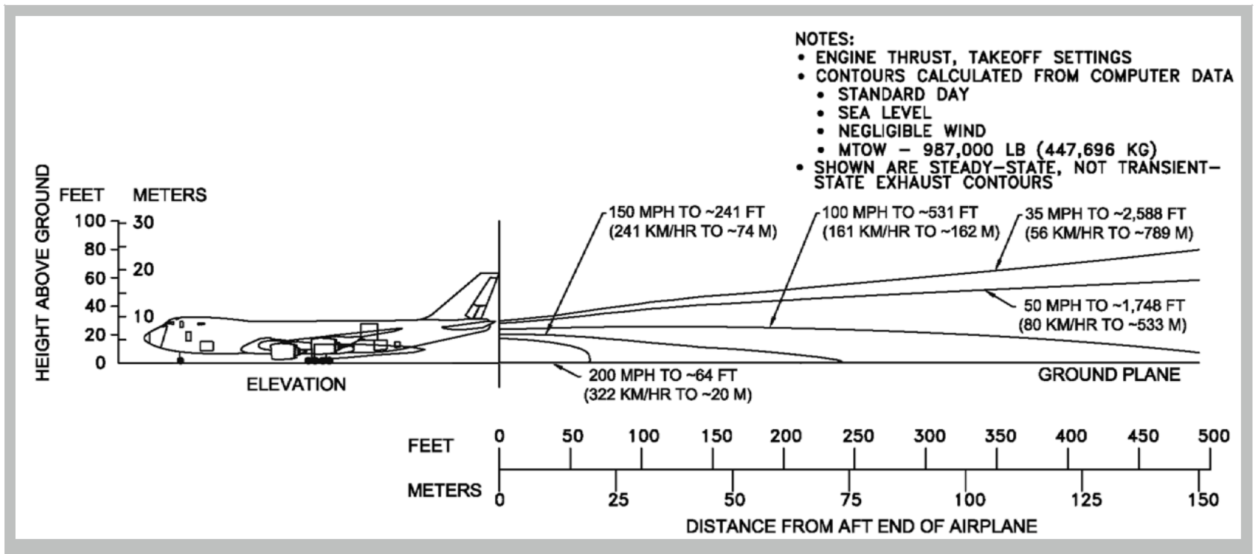

Figure 2. Exhaust Velocity Profile Contours for Boeing 747-8 (Class B). Source: Boeing.

Assume IMC conditions prevail in the solution to the problem. Tables 1 and 2 show the airport fleet mix for all runways. For this analysis we use the following technical parameters: a) in-trail delivery error of 15 seconds under IMC conditions, b) probability of violation is 5%. Arriving aircraft are “vectored” by ATC to the Final Approach Fix (FAF) for each runway, and c) two miles minimum separation between an arrival and a departure. Similarly, departures on runway 13 need to cross the intersection with runway 09R when the next arrival on 09R is at least 2.0 nm from the runway 09R threshold.

Use the minimum arrival-arrival separations for on-approach operations described in the consolidated wake vortex separation document. Table 3 shows the departure-departure separation matrix employed.

Table 1. Airport Operational Parameters and Fleet Mix. CWT Groups.

Aircraft CWT Group	Percent Mix (%)	Runway Occupancy Time (s)	Average Approach Speed (knots) from FAF
B	8	63	150
F	78	60	141
G	14	58	136
Totals	100		

*Table 2. **Departure-Departure Separations** with **Buffers Included**. Columns 2-6 are the Following Aircraft. First Column Presents the Lead Aircraft. Values in are seconds (including departure buffers).*

	Following Aircraft		
Lead Aircraft (Below)	**B**	**E**	**G**
B	130	130	135
F	70	70	70
G	70	70	70

a) Estimate the IMC arrival-departure runway capacity diagram when runways 9L and 9R are operated in mixed mode (only the two parallel runways are operated).

b) Estimate the additional IMC departure capacity when runway 13 is used. For this first analysis, do not consider the interaction of class B aircraft with arrivals on runway 09L.

c) Comment on the additional departure capacity added by runway 13.

d) Briefly describe how would you consider the interaction of class B aircraft departing runway 13 into the problem.

e) Estimate the loss of departure capacity loss if the class B aircraft interaction is in place.

Note: You can employ the Excel spreadsheet provided. However, you must show me some sample calculations.

Problem 2

This problem is a similar to the non-tower airport example provided in class (BCB airport example in the airport capacity notes). The airport approach geometry has an 11-nm total distance between the Initial Fix (IF) and the runway (see Figure 3). The operational procedure is for ATC TRACON controllers to hold aircraft at the Initial Fix (IF) point until the lead arrival is on the ground before releasing a new arrival inbound from the IF. Similarly, departures can only be released if the inbound arrival is at least 7 nm from the runway (at the FAF). At the 7 nm location, inbound aircraft are no longer "visible" to the ATC TRACON controller using radar due to line-of-sight limitations. Successive departures can be released if the lead departure reaches 5,000 feet AGL which normally occurs at a point 6.5 nm from the departure end of the runway. Table 3 shows the parameters of the problem. Assume the in trail delivery error for this application is 20 seconds at the IF fix.

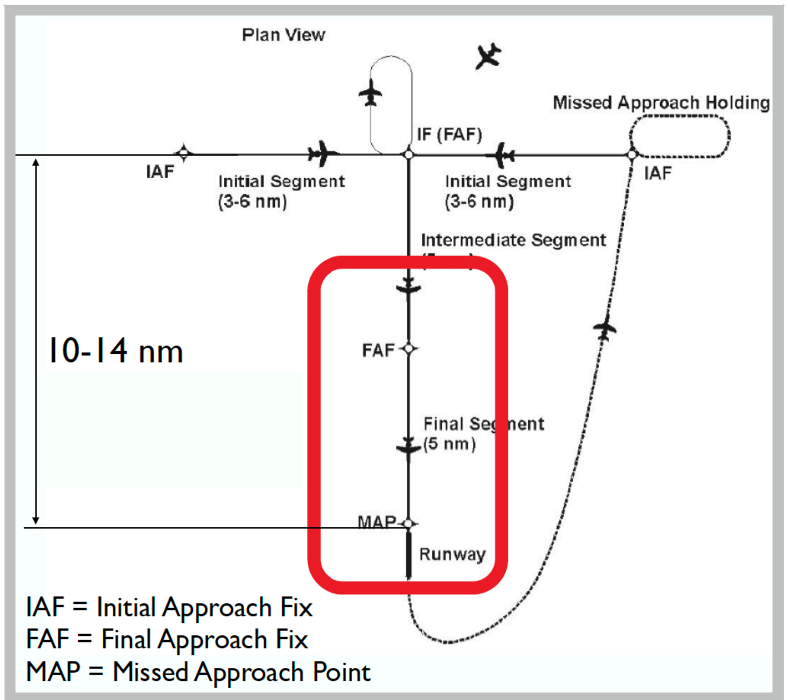

Figure 3. Runway and Airspace Configuration for Problem 2.

Table 3. Parameters for Problem 2.

Aircraft CWT Group	H	I
ROT (s)	53	54
Percent Mix (%)	75	25
Average Approach Speed (knots)	115	130
Average Departure Speed (knots)	120	170

a) Construct the arrival-departure diagram (Pareto frontier) for the airport with the current technology.

b) Suppose that in the future, a dedicated ADS-B antenna is installed at the airport with a remote video camera to monitor arrivals and departures with more precisions. The new setup is estimated to reduce the arrival-arrival separation to 7nm between successive arrivals and the departure-arrival separation to 5 nm. Similarly, successive departure may be reduced to 4 nm from each other.

c) Construct the arrival-departure diagram (Pareto frontier) for the airport with future technology.

d) Read Sections 1, 2, 2.1, 2.2 and 6 of the paper: *How much is too much on monitoring tasks? Visual scan patterns of single air traffic controller performing multiple remote tower operations (by Wen-Chin Li , Peter Kearney, Graham Braithwaite, John J.H. Lin)* to understand the context of Remote Tower Operations. State the potential cost savings of an RTO operations and some of the challenges of using such technology.

Problem 3

A computer modeling study of the airspace capacity problem in airway A593 in China demonstrated that 78% of the flights cannot be assigned to their optimal flights levels.

a) Use the aircraft characteristics of a Boeing 777-class aircraft (http://128.173.204.63/cee5614/cee5614_pub/B777_class.m) to estimate the fuel burn difference in cruise flight level assignment for FL360 and FL320. Assume conditions at the TOC are mass = 305000 kilograms and aircraft cruise at Mach 0.81.

b) If the same Boeing 777-class aircraft holds at 290 knots indicated at FL200, estimate the fuel used in executing one standard holding pattern (4 minutes of total flight). Consider the effect of turning in your calculations.

c) Compare the fuel burn while holding at FL200 and FL100. Explain the benefits of holding at higher altitudes.