CEE 5614: Analysis of Air Transportation Systems **Spring 2020**

Quiz 2 : Open Notes

Date Due: April 29, 2018 (5 PM via email) Instructor: Trani

Instructions

Write your solutions in the spaces provided. Add any additional pages with calculations as needed. Make sure each additional page has your name.

Honor Code Pledge

The information provided in this exam is my own work. I have not received information from another person while doing this exam.

____ (your signature/name)

Problem 1

The airport shown in Figure 1 is the subject of a capacity analysis under IMC conditions. The airport has two runways as shown in Figure 1. Arrival traffic is controlled in time and space at two Navaids called Fix1 and Fix2. For metering purposes, aircraft are required to cross the arrival Fixes at FL 220 and about 380 knots (true airspeed). Figure 2 shows sample velocity profiles obtained at a similar airport. Figure 2 shows the nominal speed vs. distance for arrivals at a similar airport. Figure 2 shows the runway located 78 nm from the point where aircraft are initially tracked inside the terminal area. Figure 3 shows the altitude vs. distance traveled profiles for the same airport. In your analysis use the nominal descent profiles (red lines). The runway configuration is such that landing aircraft touchdown near the intersection (i.,e., neglect wake vortex effects of a landing aircraft on a departure on the intersecting runway departure). Aircraft accelerate on a runway at 2.3 m/s^2 and the touchdown speed is close to 95% of the runway threshold speed.

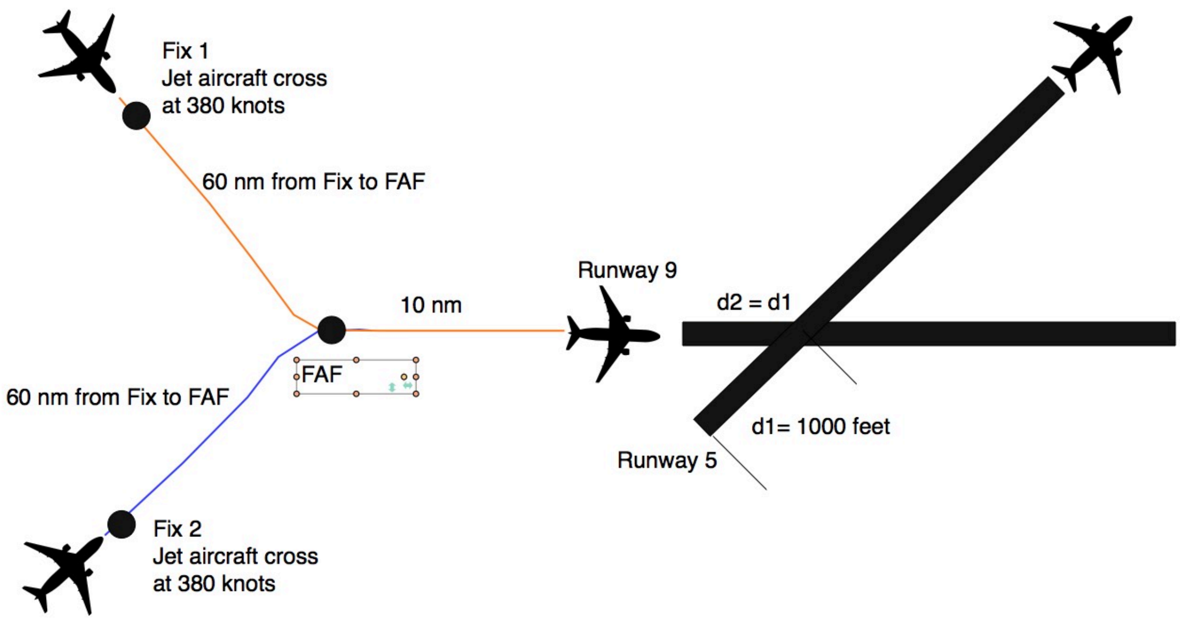

Figure 1. Runway configuration for Problem 1.

The airport has an advanced Precision Runway Monitor surveillance radar which tracks aircraft up to 80 miles form the airport site. Assume that 60% of the flights operating at the airport are RECAT Group D (similar to the Boeing 737-800), the remaining 40% of the traffic are RECAT Group E (similar to a small regional jet such as the CRJ-200) traffic. Assume the ATC probability of violation is 5% with standard deviation of the in-trail delivery error at 12 seconds due to the installation of a PRM radar (i.e., faster update rate). Page 29 of the Aircraft Classification handout has the minimum arrival-arrival separations. The airport has good runway exits and hence minimum radar separation is 2.5 nm. Table 1 shows other technical parameters.

Table 1. Runway Operational Parameters and Fleet Mix for ORD Airport. RECAT Groups.

Aircraft RECAT Group	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) at Threshold VREF	Typical Approach Speed (knots) at FAF (10 nm out)
D	60	58	142	VREF + 25 knots
E	40	54	136	VREF + 25 knots
Totals	100			

Table 2. Departure-Departure Separations with Buffers Included. Columns 2-7 are the Following Aircraft. First Column Presents the Lead Aircraft. Values in are seconds (include departure buffers).

Aircraft	D	E
D	70	70
E	70	70

a) Find the saturation arrival capacity of the airport under IMC conditions. In your solution consider the speed difference between the FAF and the runway threshold. Comment on how this changes the solution.

b) Find the saturation departure capacity of the airport under IMC conditions.

c) Find **two additional points** (your choice) along the Pareto frontier to estimate the complete arrival-departure saturation capacity diagram.

d) Draw the Pareto diagram for the airport under IMC conditions.

e) Estimate the in-trail separations between successive arrivals at Fix1 and Fix2 to match the saturation capacity of the runway under IMC conditions. State the desired separations at Fix1 and Fix2 in nautical miles and also estimate the headways in seconds. Assume the traffic per hour using the blue and orange routes in one hour is split at 50/50%.

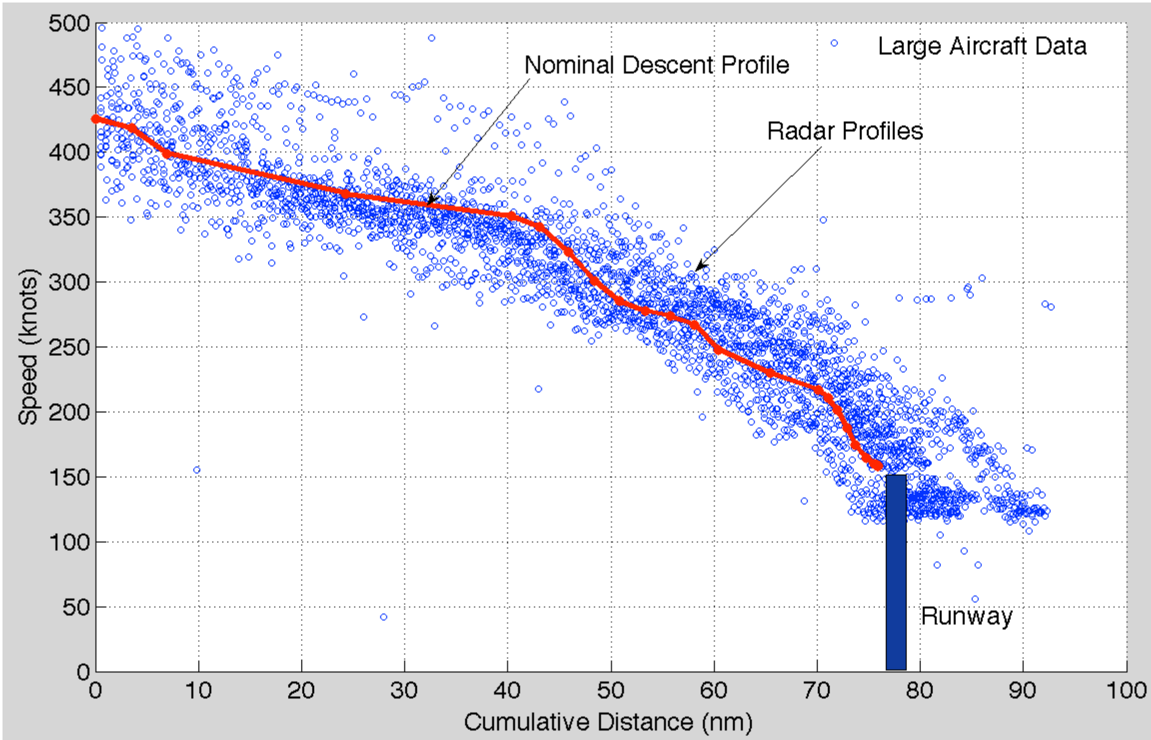

Figure 2. Radar velocity profiles. Speed shown is true airspeed.

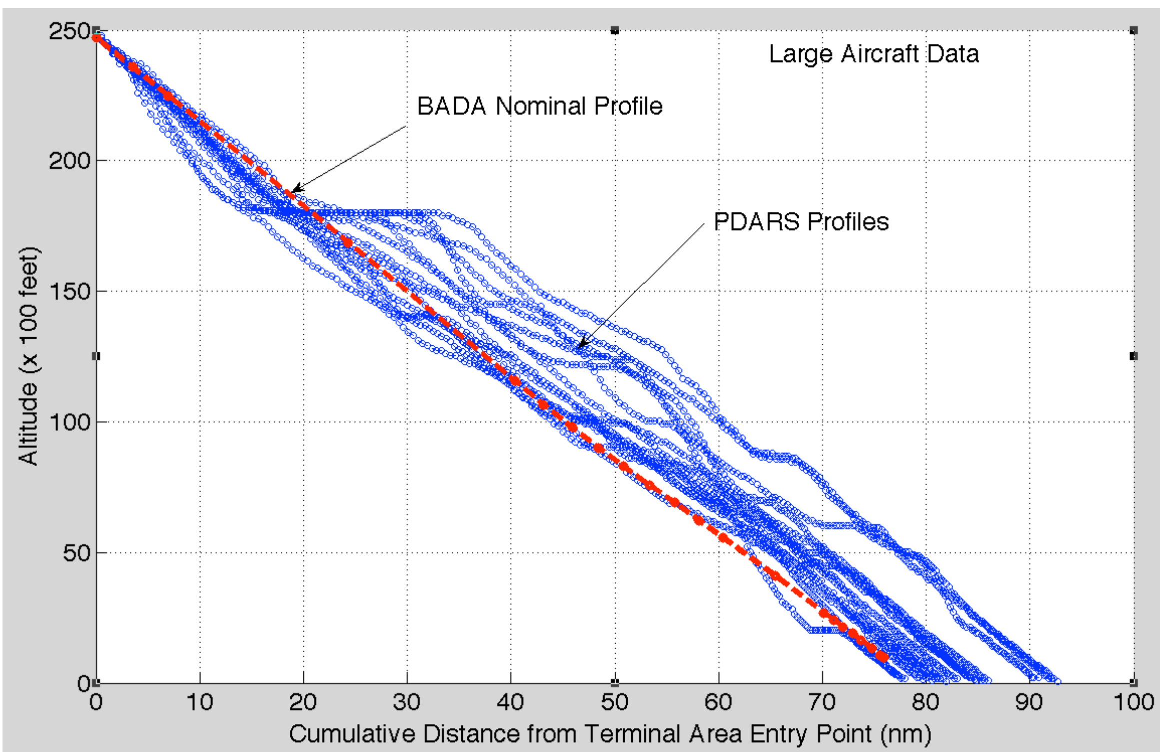

Figure 3. Nominal and observed descent profiles.

Problem 2

Use the new generation, long-range transport aircraft performance file provided in the Matlab files for CEE 5614 (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing787_class.m) to answer the following questions.

a) Calculate a C**ontinuous Descent Profile** (CDA) of the aircraft to an airport located at sea level conditions if the pilot reduces the engine thrust to idle conditions. Figure 3 shows a sample continuous descent profile in red. Assume idle thrust for the aircraft is 1/10 of the maximum continuous thrust condition. The ATC controller advises the pilot to descend from 37,000 feet and directs the pilot to fly a 300 knots indicated airspeed constant descent profile until reaching 10,000 feet. The pilot is instructed to fly at 250 knots from 10,000 to 4,000 feet and finally 180 knots in the final approach phase. Plot the distance traveled vs. altitude and altitude vs. time.

b) Find the fuel consumed in the continuous descent profile.

c) Today's operations seldom allow for continuous descent profiles. Estimate the fuel burn in the descent procedure stated in part (a) but now ATC holds the aircraft for one minute at 16,000 feet (at 300 knots IAS) and again for one minute at 8,000 feet (at 250 knots IAS). The rest of the profile is the same as part (a). Figure 3 shows typical descent profiles with one and two steps.

d) Comment on the value of continuous descent profiles in terms of travel time savings and fuel burn for this aircraft.

e) If there are 150 arrivals to the airport using the same type of aircraft, estimate the benefits of CDA arrivals per year (assume the price of jet fuel last year was $1.8 per gallon).