CEE 5614: Analysis of Air Transportation Systems Fall 2020

Assignment 9: Runway Capacity

Date Due: November 16, 2020 (via Canvas) Instructor: Trani

Problem 1

Review the runway configuration of LaGuardia Airport. Assume IMC conditions in the solution to the problem. Most of the time, the airport operates arrivals on runway 22 and departures using runway 13. The airport fleet mix is shown in Table 1. According to the departing aircraft acceleration is 2.1 m/s^2. The airport has a PRM radar at the facility. For this analysis we use the following technical parameters: a) in-trail delivery error of 16 seconds under IMC conditions, b) probability of violation is 5%. Arriving aircraft are "vectored" by ATC to FROGY - the initial approach fix located 12 miles from the runway threshold (see Figure 1). The minimum separation matrix for LGA is shown on page 43 of the Aircraft Classification handout (http://128.173.204.63/courses/cee4674/cee4674_pub/Aircraft%20Classifications_rfs.pdf). Considering the average ROT values at LGA the a minimum radar separation used is 2.5 nm. Operational observations at the airport show that **ATC controllers release (I.e., instruct pilots to takeoff) a departure on runway 13** if the arrival traffic is 2.6 nm or more from the threshold of runway 22. In your analysis assume that all arrivals to runway 22 touchdown prior to the intersection point with runway 13-31. The intersection point is located 2,120 feet from the threshold 22. Table 2 shows typical departure-departure separations at LGA.

Table 1. Runway Operational Parameters and Fleet Mix for LGA Airport. RECAT Groups. Source of Data: VT/FAA Landing Events Database.

Aircraft RECAT Group	Percent Mix (%)	Average Runway Occupancy Time (s)	Typical Approach Speed (knots) from Final Approach Fix
D	37	48.2	142
E	61	44.3	135
F	2	43.1	123
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 (including departure buffers).

Aircraft	D	E	F
D	70	70	70
E	70	70	70

Aircraft	D	E	F
F	70	70	70

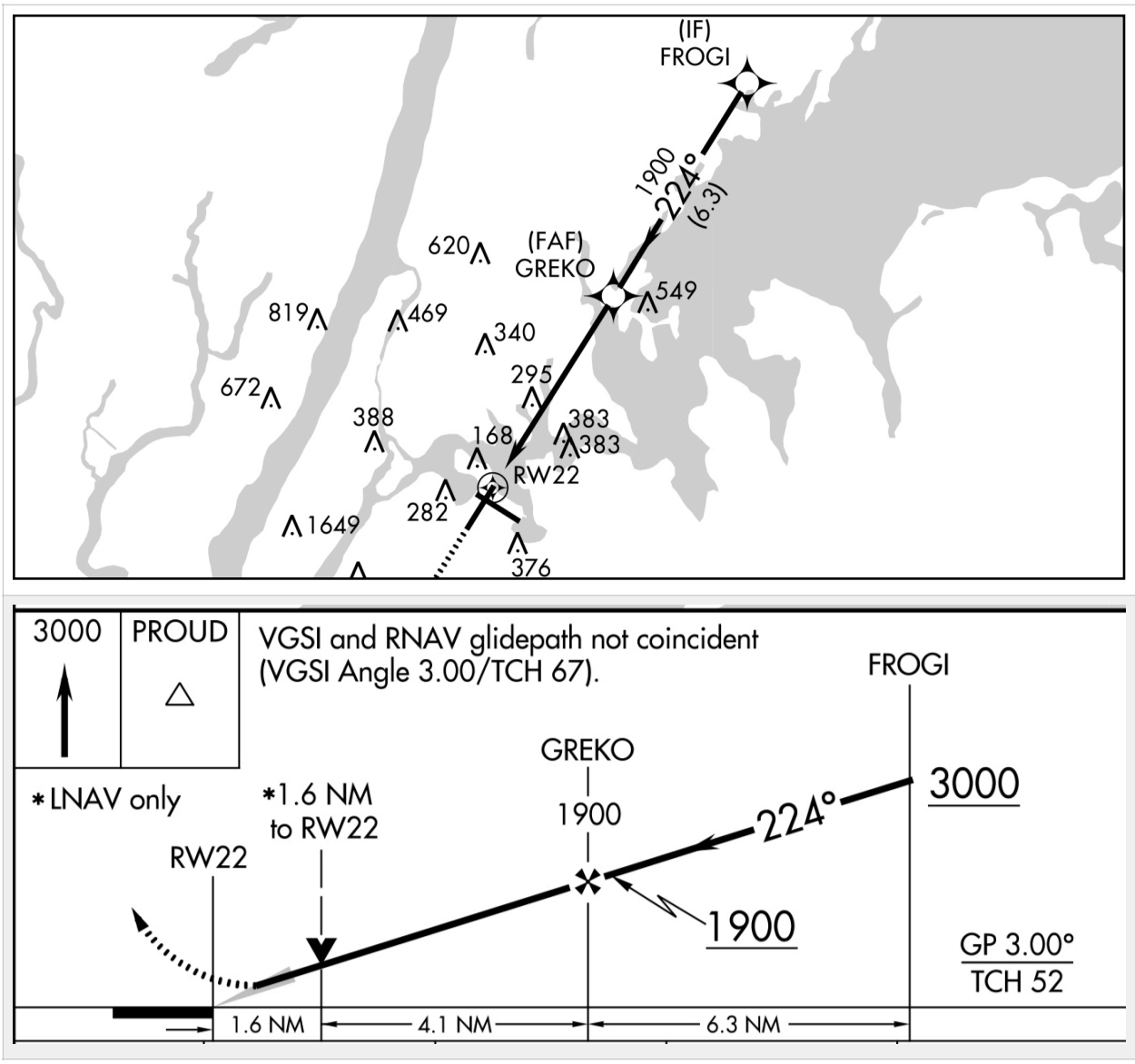


Figure 1. RNAV (GPS) LGA Approach Procedure to Runway 22 (Source: FAA).

a) For the runway configuration described above estimate the IMC **arrivals-only** runway capacity for LGA.

b) For the runway configuration described above estimate the IMC **departures-only** runway capacity for LGA.

c) Show the complete Pareto diagram (arrivals and departures) for LGA airport under IMC conditions for arrivals on runway 22 and departures on runway 13. Show sample calculations to estimate mixed operations at the airport.

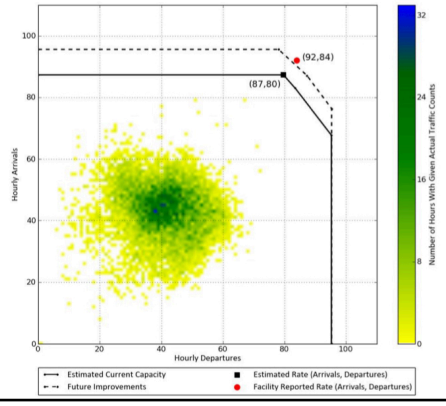
d) Comment on the average required arrival separation needed to allow allow the airport operate at the 50% arrivals and 50% departures point in the arrivals-departures diagram.

Problem 2 (all students)

The FAA and MITRE Corporation have studied runway capacity at airports. Airport capacity profiles are found at: https://www.faa.gov/airports/planning_capacity/profiles/. Figure 2 shows the runway capacity at Los Angeles International Airport when visual operations are in place (VMC). More information is found at: https://www.faa.gov/airports/planning_capacity/profiles/media/LAX-Airport-Capacity-Profile-2014.pdf.

LAX Scenario	Arrival Runways	Departure Runways	Procedures	Hourly Rate	
				ATC Facility Reported	Model-Estimated
CURRENT OPERATIONS	24R, 24L, 25R, 25L	24R, 24L, 25R, 25L	Visual Approaches, Visual Separation	176	167
FUTURE IMPROVEMENTS Improved Runway Delivery Accuracy	24R, 24L, 25R, 25L	24R, 24L, 25R, 25L		N/A	174

VISUAL WEATHER CONDITIONS



- The capacity rate range in Visual conditions is currently 167-176 operations per hour.
- This is LAX's dominant configuration. The airport operates in variations of this configuration approximately 96% of the time in Visual weather conditions (totaling 76% annually).
- The majority of LAX's arrivals occur on Runways 24R and 25L. However, in times of heavy arrival demand, some arrivals may be offloaded onto Runway 24L or 25R.
- The majority of LAX's departures occur on Runways 24L and 25R. However, in times of heavy departure demand, some departures may be offloaded onto Runway 24R or 25L.

Figure 2. Visual Runway Capacity at LAX International Airport (Source: FAA).

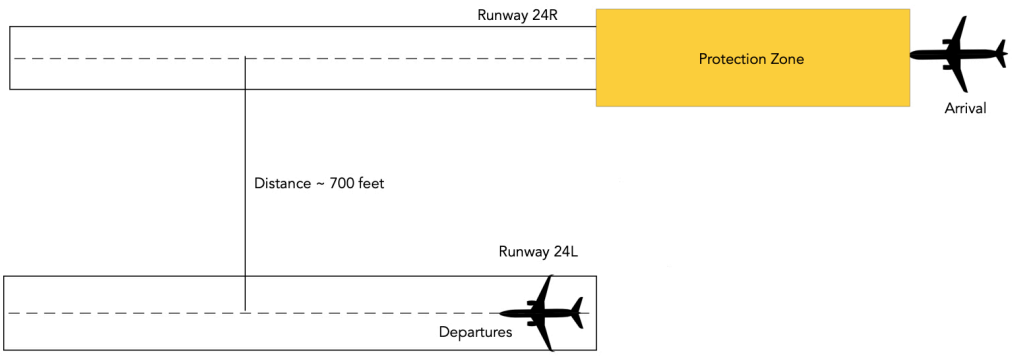


Figure 3. Possible Interaction Between Arrivals and Departures at LAX Northside.

a) Explain in a paragraph the reason fore the the tradeoff region (i.e., diagonal region in the arrival-departure diagram) observed in both diagrams.

b) Estimate the level of dependence between arrivals and departures in VMC conditions on the North side of the airport (runways 24R and 24L). Use Figure 3 to **estimate the length of the so-called protection zone** for runway 24R at LAX in order to avoid two aircraft in the air spectated by 700 feet in case the arrival on runway 24R makes a go-around maneuver. Assume the typical arrivals at LAX fly at 145 knots in the last 3 nm prior to landing at 24R. Write all calculations to support your answers.

c) Compare the VMC and IMC Pareto diagrams at LAX and comment on the runway capacity loss in IMC conditions. Comment on the technical parameters that changes between VMC and IMC.

Problem 3 (only for CEE 5614 students)

Solve Problem 1 when the airport operates IMC arrivals on runway 31 and IMC departures on runway 4 (Northeast departures). Assume that, in the new runway configuration, most departures become airborne at the point of intersection or shortly after and wake vortex effects need to be considered in the analysis. In other words, when a departure on runway 4 crosses the intersection point, ATC is required to enforce wake vortex separation standards because the descending wake of a climbing aircraft can affect a go-around on runway 31 or even if the arrival rolls past the intersection point.

a) Show the complete Pareto diagram (arrivals and departures) for LGA airport under IMC conditions for arrivals on runway 31 and departures on runway 04. Show sample calculations to estimate mixed operations at the airport.

b) Compare the capacity estimates of this problem with Problem 1.