Assignment 7: Runway Capacity and Delays

Solution Instructor: Trani

Problem 1

Estimate the runway capacity for an airport without an ATC tower. The airport approach geometry is shown in Figure 1. The operational procedure is for ATC TRACON controllers to hold aircraft at the FAF point until the lead arrival is out of the runway. Similarly, departures can only be released if the inbound arrival is at least 10 nm from the runway. Successive departures can be released if the lead departure reaches 4000 feet AGL which normally occurs at a point 7.5 nm from the departure end of the runway. Table 1 shows the parameters of the problem. Assume the in trail delivery error for this application is 25 seconds at the FAF fix.

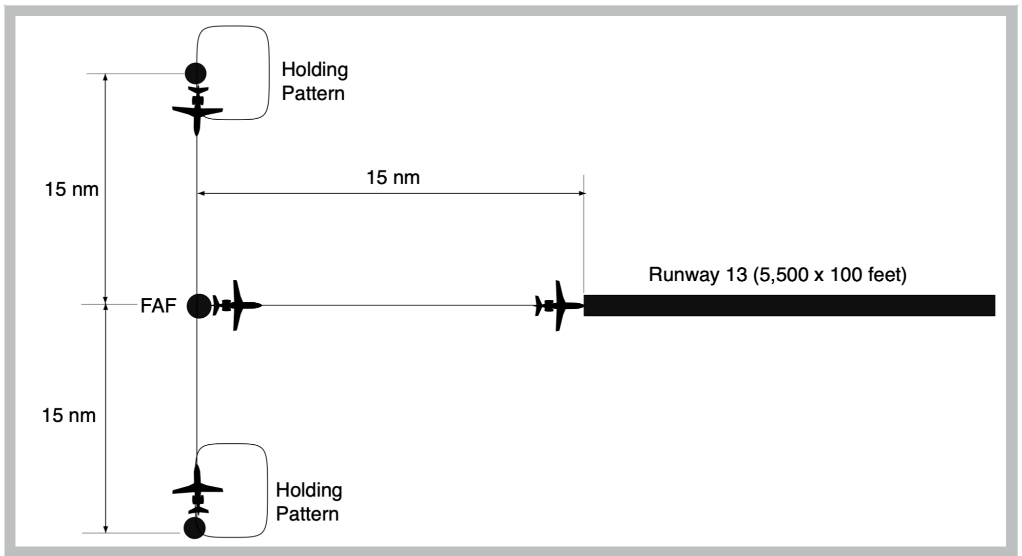


Figure 1. Runway and Airspace Configuration for Problem 1.

Table 1. Parameters for Problem 1.

Aircraft CWT Group	H	I
ROT (s)	53	56
Percent Mix (%)	65	35
Average Approach Speed (knots)	105	130
Average Departure Speed (knots)	110	165

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 6 nm 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. Comment on the differences between the baseline and the advanced ADS-B technology scenario.

Problem 2

Figure 2 shows the capacity diagram for a single runway airport in the West Coast.

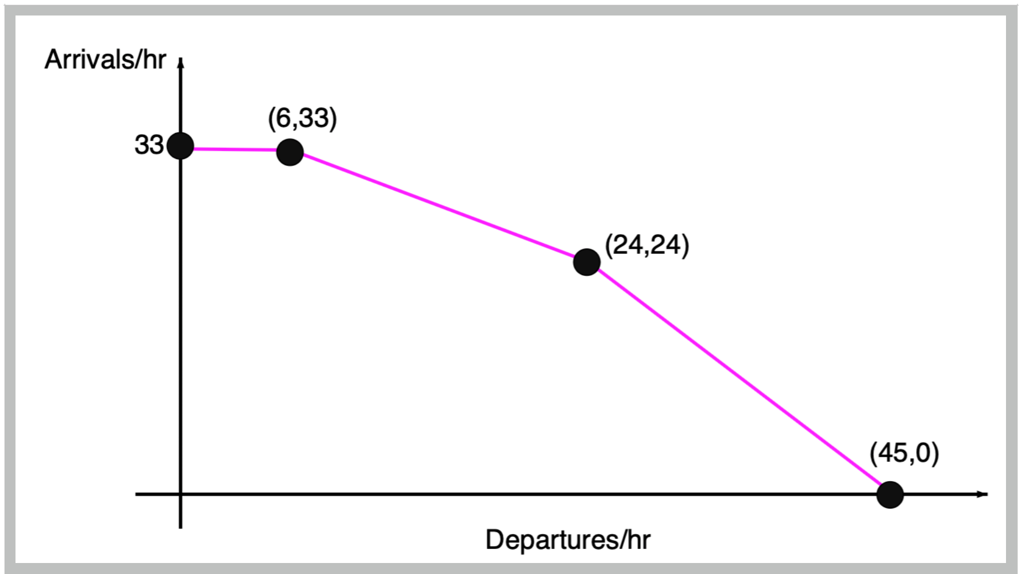


Figure 2. Arrival-Departure Diagram for Problem 2.

a) Table 2 shows the daily demand function for arrival and departures at the airport. Use the **deterministic queueing model** to estimate the **average delays per flight delayed** to both arrivals and departures at the airport. Consider that air traffic controllers organize the traffic from an initial far-away fix to the FAF (final approach fix) to control the arrival separation and hence regulate the operational point along boundary the Pareto diagram (arrival-departure diagram). In a given day, no more than four distinct points on the Pareto boundary can be scheduled because it takes time to reconfigure the separations between successive arrivals. In your calculations, tell me the operating point selected on the Pareto frontier of the arrival-departure diagram.

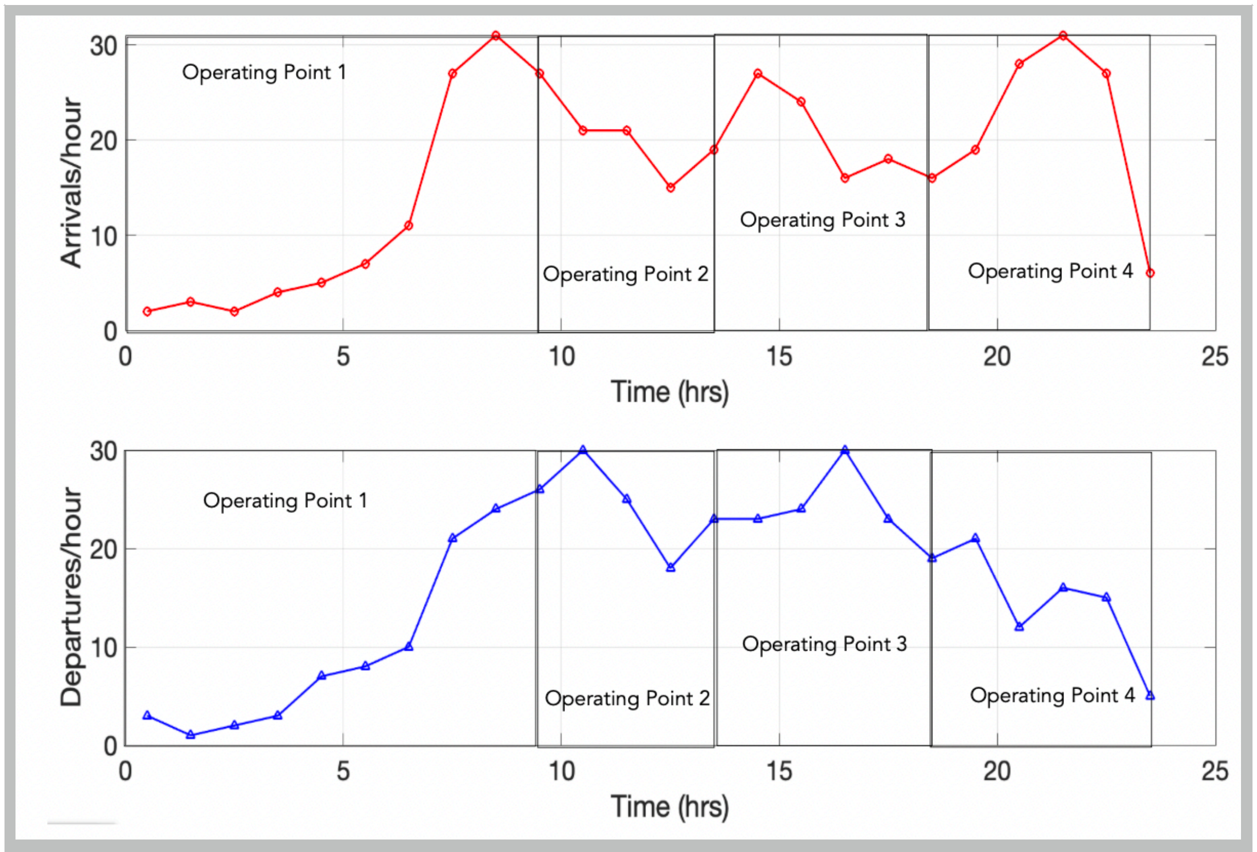
b) Estimate the annual cost of delay to airlines if the hourly cost of for an arrival is $7,100/hr and the hourly cost of departures is $4,800/hr. Assume the airport has daily operations similar to Table 2 for 365 days a year.

c) Estimate the annual cost of delay to passengers if the value of time for a passenger is $40/hr. The average passengers per flight at the airport is 153 passengers (typical in the United States).

d) How would you recommend a second runway at the airport? Assume adding a new runway costs $560 million dollars.

Table 2. Flight Demand for Problem 2. Demand Values are Per Hour.

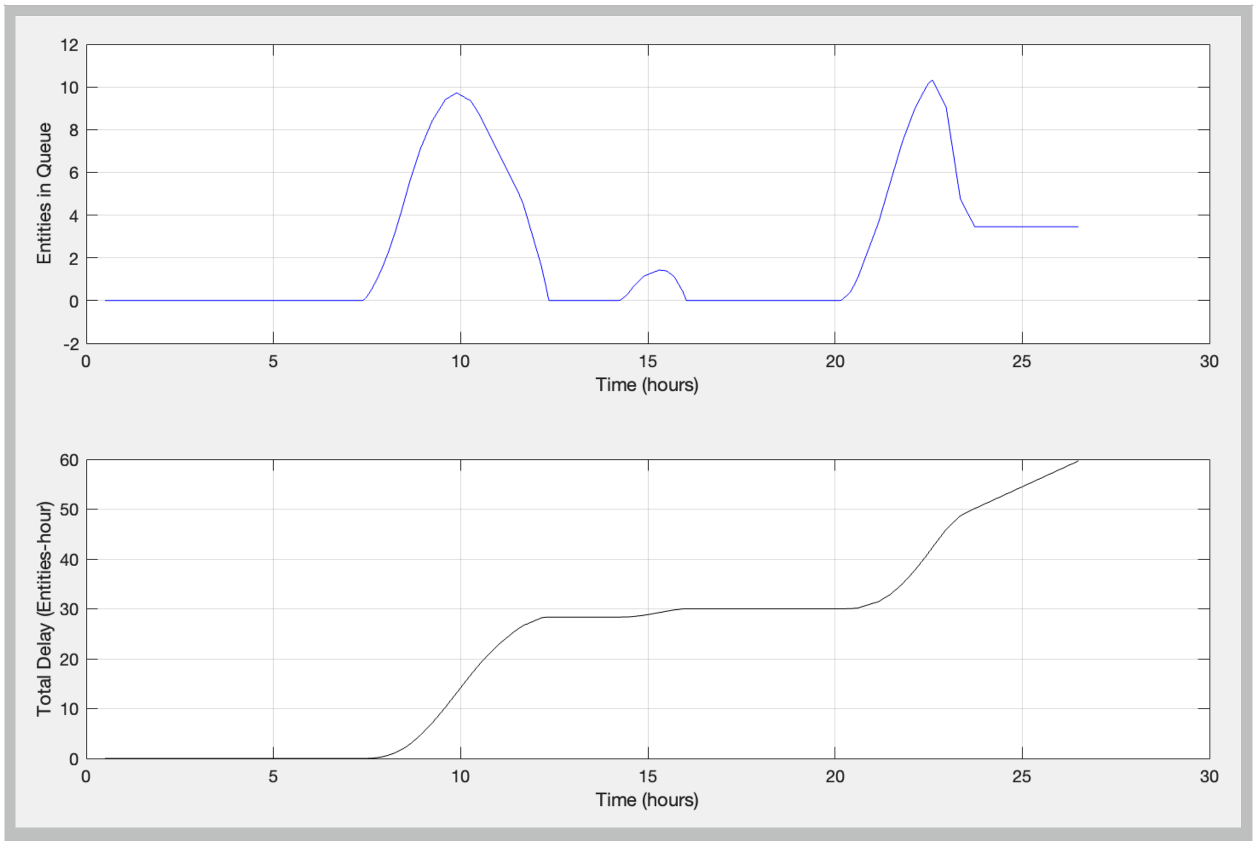
Time Period (Bin Center)	Arrivals/hr	Departures /hr	Total Operations/hr
0.5	2	3	5
1.5	3	1	4
2.5	2	2	4
3.5	4	3	7
4.5	5	7	12
5.5	7	8	15
6.5	11	10	21
7.5	27	21	48
8.5	31	24	55
9.5	27	26	53
10.5	21	30	51
11.5	21	25	46
12.5	15	18	33
13.5	19	23	42
14.5	27	23	50
15.5	24	24	48
16.5	16	30	46
17.5	18	23	41
18.5	16	19	35
19.5	19	21	40
20.5	28	12	40
21.5	31	16	47
22.5	27	15	42
23.5	6	5	11
Totals	407	389	796



Arrival and Departure Rates at the Airport. Possible Operating Points Shown.

The following solution uses a single operating point in the Pareto Frontier with an arrival capacity of 24.5 per hour and a departure capacity of 23 per hour. Better solutions are possible and your solution may vary depending upon where you decided to switch the operating points.

The solutions shown below assume that we prefer to build more delays on the departures because the cost of delays are less (fuel-wise). Note that according to the numbers obtained, the total arrival delays are 59.7 aircraft-hours and the total departure delays are 110.7 aircraft-hour.



Arrival delays operating at a constant arrival capacity of 24.5 operations per hour. Total Delay is 59.67 aircraft-hours.