CEE 5614 Analysis of Air Transportation Systems Spring 2026

# Assignment 6: Air Traffic, and Runway Operations

Date Due: April 2, 2026 Instructor: Trani

## Problem 1 Basic ATC and Runway Separations

Answer briefly the following ATC-related questions.

a) A Boeing 737-700 cruises at Mach 0.78 at FL 400 above Washington DC.Name the ATC service that oversees the flight.

ARTCC Washington Center

b) Find the true airspeed of aircraft in part (a).

Speed of sound = 295.07 m/s

True Airspace = 230.16 m/s

True Airspace = 446 knots

c) Indicate if the flight in part (a) is flying to the East or to the West. Comment on your answer.

The aircraft has a Westbound heading

d) Briefly explain why flights above FL 410 are separated by 2,000 feet.

At higher altitudes, aircraft travel at higher speeds. The safe separation is 2,000 feet.

e) Over the ocean, explain how pilots communicate with Air Traffic Control.

Data link (CPDLC)

f) Suggest the minimum separation distance (d) between two parallel runways to serve operations on parallel runways similar to Figure 1 allowing independent arrival and departure operations in IMC conditions.

Rule: Reduce 100 feet of separation for each 500 feet of stagger. The configuration would work if the distance (d) is 1,900 feet.

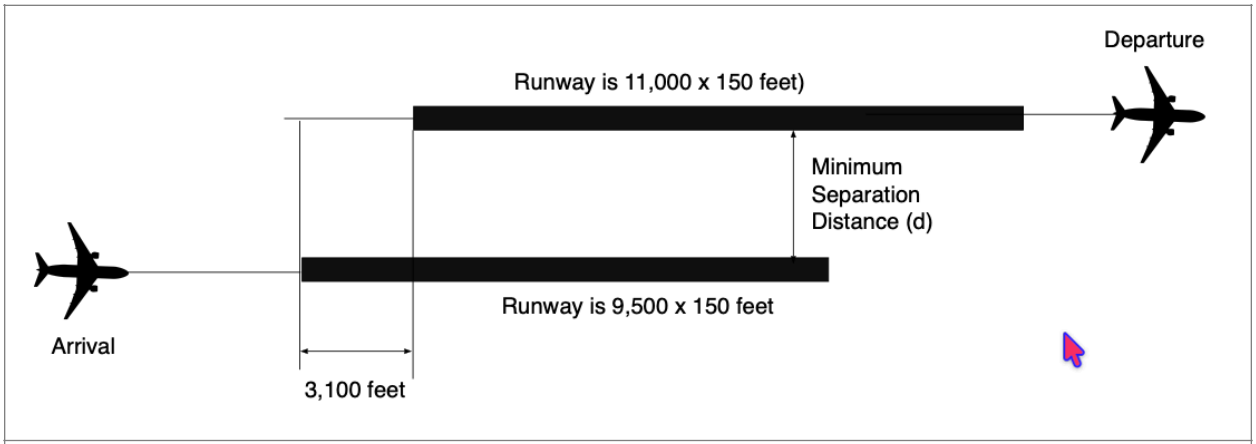



*Figure 1. Runway Configuration.*

g) If the airport in Figure 1 operates on a Westerly flow configuration (flights operating to the West), find the distance (d) needed to conduct independent arrival and departure operations in IMC conditions.

Rule: Increase 100 feet of separation for each 500 feet of stagger operating to the West. The configuration would have 4,600 feet. If the northern runway is used for departures and the southern runway is used for arrivals. The configuration would work if the distance (d) is 3,400 feet. 2500 feet + integer(4600/500)*100 feet.

h) Use Google Earth and the FAA airport diagram to familiarize yourself with the runway configuration at Phoenix International Airport. Can runways 25R and 26 be operated independently for simultaneous instrument departures? Comment on the rule used.

Yes, the two runways can be operated simultaneously. The distance between the runway centerlines is 3,600 feet.

i) Can the Dallas-Fort Worth airport operate three simultaneous arrivals in East flow and IMC conditions? Name the runways selected in such operations.

Runways 13L and 13R can provide simultaneous arrivals. Runways 35L, 35R, and 36L are separated by 5,000 feet or more. They would allow triple simultaneous operations to the North.

## Problem 2 Oceanic Operations

Read the paper “A Metaheuristic Optimization Algorithm for Flight Assignment to the North Atlantic Organized Track System” (https://doi-org.ezproxy.lib.vt.edu/10.2514/6.2021-2364). You can also watch the presentation associated with the paper at: https://arc-aiaa-org.ezproxy.lib.vt.edu/doi/10.2514/6.2021-2364.

A) Summarize the possible benefits of using the metaheuristic optimization approach described in the paper.
B) Explain some of the obstacles to adopting an optimization-based approach to assign traffic in the North Atlantic Organized Track System (OTS).
C) Explain the tools used to estimate fuel benefits in the Atlantic.
D) What aircraft performance model was used to support the analysis?

## Problem 3 Runway Capacity

Figure 2 illustrates the configuration of the runways at the airport. Runways 9L and 9R serve different aircraft fleet mix.

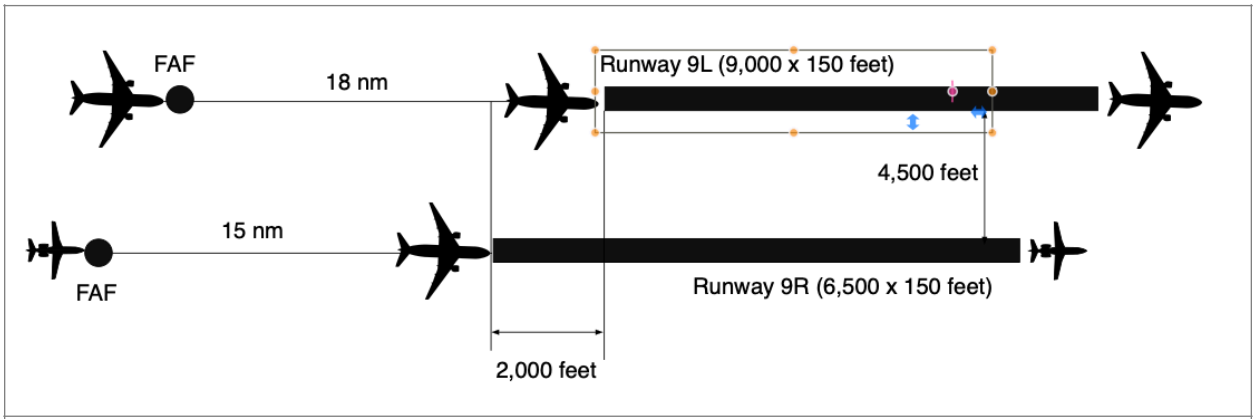



*Figure 2. Runway Configuration for Problem 2.*

Assume IMC conditions in the solution to the problem. The airport operates an East flow configuration with arrivals and departures using both runways. Tables 1 and 2 show the airport fleet mix for runways 9L and 9R, respectively. For this analysis we use the following technical parameters: a) in-trail delivery error of 21 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) 2.4 nautical miles minimum separation between an arrival and a departure. The 2.4 nm arrival-departure separation includes a small 0.4 nm buffer over the minimum value used in the US. Use the arrival-arrival separations for on-approach operations described in the consolidated wake vortex separation document (or notes). Table 3 shows the departure-departure separation matrix employed.

**Table 1.** Runway 9L Operational Parameters and Fleet Mix. CWT Groups.

| Aircraft CWT Group | Percent Mix (%) | Runway Occupancy Time (s) | Average Approach Speed (knots) from FAF |
|---|---|---|---|
| B | 6 | 59 | 155 |
| E | 18 | 57 | 152 |
| F | 76 | 55 | 136 |
| Totals | 100 | | |

**Table 2**. Runway 9R Operational Parameters and Fleet Mix . CWT Groups.

| Aircraft CWT Group | Percent Mix (%) | Runway Occupancy Time (s) | Average Approach Speed (knots) from FAF |
|---|---|---|---|
| F | 54 | 53 | 140 |
| H | 23 | 50 | 125 |
| I | 23 | 48 | 116 |
| Totals | 100 | | |

**Table 3.** Departure-Departure Separations with Buffers Included. Columns 2-6 are the Following Aircraft. First Column Presents the Lead Aircraft. Values in are seconds (includes 10-second departure buffers).

| | Following Aircraft | | | | |
|---|---|---|---|---|---|
| **Lead Aircraft (Below)** | **B** | **E** | **F** | **H** | **I** |
| B | 130 | 130 | 130 | 140 | 140 |
| E | 95 | 120 | 130 | 130 | 130 |
| F | 70 | 70 | 70 | 70 | 90 |
| H | 70 | 70 | 70 | 70 | 70 |
| I | 70 | 70 | 70 | 70 | 70 |

a) Estimate the IMC arrivals-only capacities for runways 9L and 9R at the airport.

The runways are separated allowing independent operations. Use the Excel spreadsheet model provided to solve each runway independently.

b) Estimate the IMC departures-only capacities for the airport

d) Show the complete Pareto diagram (arrivals and departures on both runways) for the airport under IMC conditions.

e) Comment on the differences in runway capacity between runways 9L and 9R.

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

## Problem 4 Runway Capacity

Figure 3 shows the runway configuration for Problem 3. Use the technical separation parameters similar to those of Problem 3. Table 4 shows the fleet mix and ROT parameters of the airport. Use the departure-departure separations of Table 3 which include the departure-departure buffers.

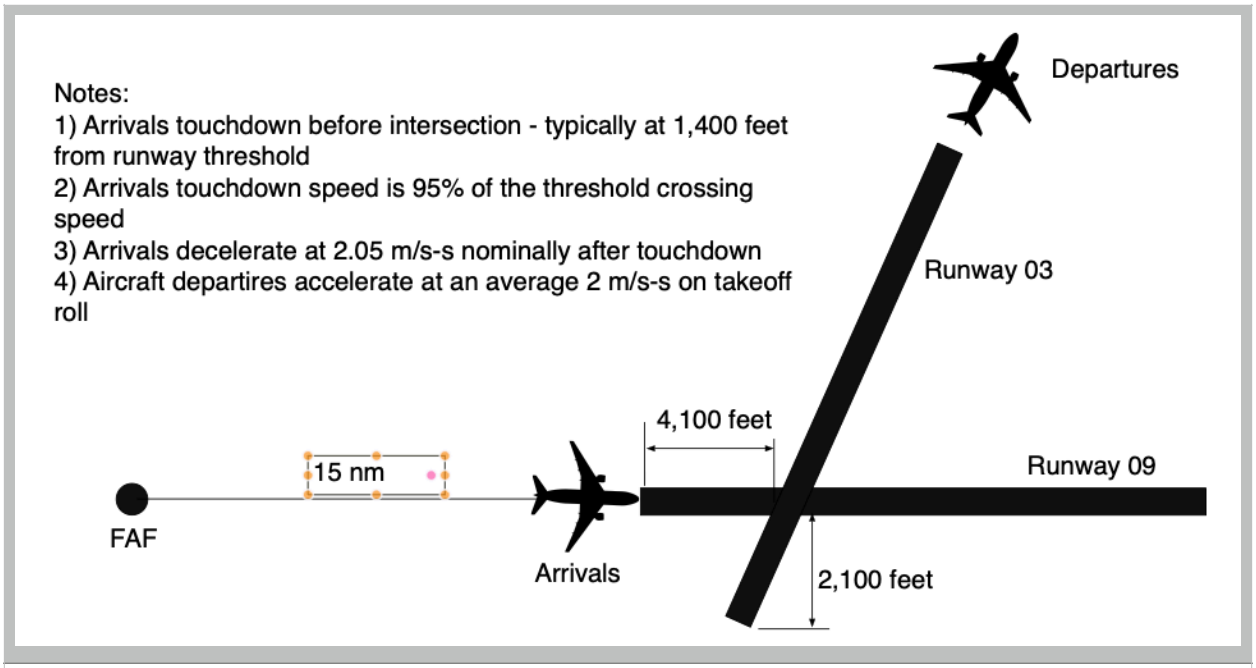



*Figure 3. Runway Configuration for Problem 3.*

**Table 4.** Operational Parameters and Fleet Mix for Problem 3.

| Aircraft CWT Group | Percent Mix (%) | Runway Occupancy Time (s) | Average Approach Speed (knots) from FAF to Runway Threshold |
|---|---|---|---|
| F | 59 | 59 | 140 |
| G | 20 | 57 | 131 |
| H | 21 | 53 | 125 |
| Totals | 100 | | |

a) Estimate the IMC arrival and departure capacities for the two-runway system. Show me the procedure to estimate departures on runway 03.

**Single runway arrival analysis**

Arrival capacity = 29 arrivals per hour (using $\gamma = 18$ nm)

## Intersecting runway calculations

The table below shows the estimated times to cross the runway intersection point for arrivals. The expected value of time to cross the intersection for arrivals is 19.9 seconds.

| Aircraft CWT Group | % Mix | Touchdown Speed (knots) | Touchdown Speed (knots) | Time to Reach Intersection (s) |
|---|---|---|---|---|
| F | 59 | 140 | 133 | 18.3 |
| G | 20 | 131 | 124 | 20.8 |
| H | 21 | 125 | 119 | 23.5 |
| Expected Value | | | | 19.9 |

The estimated times to cross the runway intersection point for departures is 25.3 seconds assuming an acceleration rate is 2m/s-s.

The following parameters estimate the time between the arrival at threshold and the departure crossing the intersecting runway. Note that I used a single 10-second buffer in the estimation.

| Parameter | Time (seconds) |
|---|---|
| Expected Value X Arrivals | 19.9 |
| Expected Value X Departure | 25.3 |
| Buffer for Departure Crossing | 0 |
| Buffer for Arrival Crossing | 10.0 |
| Total Time Between Arrival and Departure on X Runway | 65.2 |

Assume the minimum distance between an arrival and a departure that crossed the intersection is 2 nm.

| Time Separation when departure on crossing runway crosses the intersection | | | | |
|---|---|---|---|---|
| | | Trailing Aircraft (Header Columns) | | |
| Lead (column 1) | H | G | F | E |
| H | 65.86 | 61.90 | 56.60 | |
| G | 85.64 | 61.90 | 56.60 | |
| F | 112.14 | 88.40 | 56.60 | |

Time Separation Between Second Arrival and Departure as it Crosses the Intersection.

| Distance Separation when departure crosses intersection | | | |
|---|---|---|---|
| | Trailing Aircraft (Header Columns) | | |
| Lead (column 1) | H | G | F |
| H | 2.29 | 2.25 | 2.20 |
| G | 2.97 | 2.25 | 2.20 |
| F | 3.89 | 3.22 | 2.20 |

Distance Separation Between Second Arrival and Departure as it Crosses the Intersection.

| | Trailing Aircraft (Header Columns) | | |
|---|---|---|---|
| Lead (column 1) | H | G | F |
| H | 1.00 | 1.00 | 1.00 |
| G | 1.00 | 1.00 | 1.00 |
| F | 1.00 | 1.00 | 1.00 |

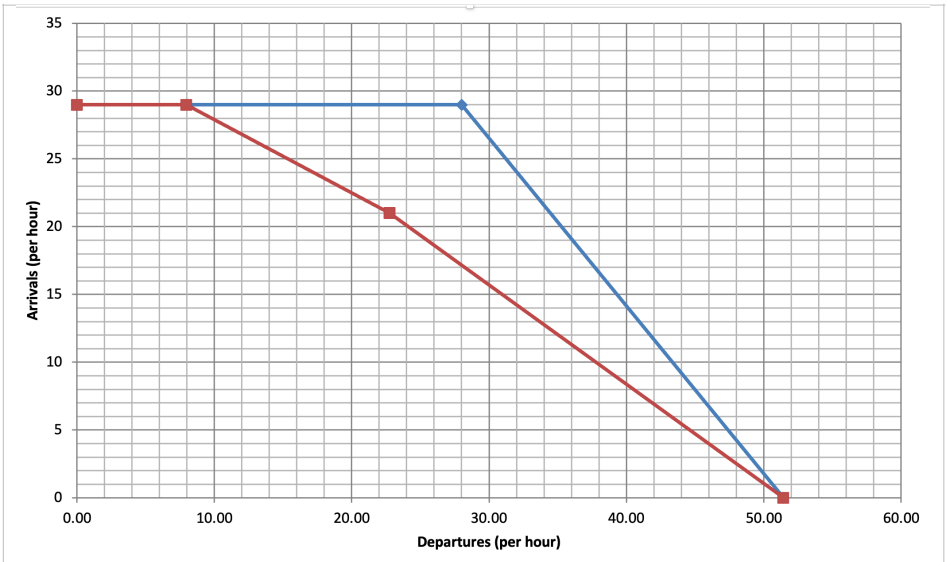
Distance Separation Between Second Arrival and Departure as it Crosses the Intersection.

| | Trailing Aircraft (Header Columns) | | |
|---|---|---|---|
| Lead (column 1) | H | G | F |
| H | 1.23 | 1.18 | 3.47 |
| G | 1.18 | 1.12 | 3.30 |
| F | 3.47 | 3.30 | 9.75 |

Expected Value of Departures per Arrival Gap.

The number of departures on crossing runway with 100% arrivals is 28 departures.

b) Draw the IMC Arrival-Departure diagram for the configuration shown below.



Pareto Frontier for Intersecting Runway Configuration.

c) If the airport ATC decided to operate additional departures on runway 09, estimate the new departure capacity with 100% arrival priority on runway 09 and 100% departures on runway 03.

The operation of departures on the arrival runway while the departure runway is in use would yield heavy workload conditions for the ATC and yield negligible additional departures.