**CEE 5614: Analysis of Air Transportation Systems** **Spring 2023**

# Quiz 1 : Open Notes

Date Due: March 3, 2023 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 (50 Points)

**Task 1.** Read the Aviation Week and Space Technology article (https://aviationweek.com/air-transport/aircraft-propulsion/nasa-picks-boeings-transonic-truss-based-wing-sustainable-x-plane) to understand the context of the problem.

Use the new generation Transonic Truss-Braced Wing (TTBA) aircraft provided in class (http://128.173.204.63/courses/cee5614/cee5614_pub/SUGAR_class.m ) to answer the following questions.

Model a flight using the future TTBA aircraft traveling from Punta Cana, Dominican Republic (PUJ) to New York (JFK). The aircraft has the following parameters: OEW of 40,000 kg., carries 16,000 kg. of fuel, and 14,000 kg of payload (passengers and belly cargo).

**Task 2.** Use the default climb speed profile provided in the aircraft data file to calculate the fuel burn in climb and the time to climb to an initial altitude that provides at least 150 m/minute climb rate. Use ISA atmospheric conditions in your calculations.

a) Based on the data provided, estimate the fuel used to reach the Top of Climb Point (TOC) if the pilot wants to cruise at an altitude that provides a minimum climb rate of 152 m/minute. Airline dispatch suggest a cruise speed of Mach 0.75. For the selected altitude, estimate the mass of the aircraft at the Top of Climb (TOC) point. State the distance and travel time to reach the TOC point.

b) Estimate the fuel used by the aircraft in cruise (**TOC to TOD only**) assuming the standard 6% detour factor to account for ATC restrictions and weather deviations. Perform the analysis using two cruise scenarios:

1. One climb at mid point between TOC and TOD
2. Schedule multiple climbs throughout the flight so that a climb is requested and granted when the aircraft mass allows the aircraft to climb at a minimum of 152 m/min at the start of each climb point (see Figure 1). Since the flight is mostly over the Atlantic ocean, assume climbs can be granted at 1,000 foot intervals (with Reduced Vertical Separation Minima).

c) What is the fuel savings using the multi-climb profile for the TTBA?

d) Calculate the additional cost to the airline per flight (between the two profiles estimated in part (b)) if the fuel price today in large volumes is $2.70 per gallon of Jet-A fuel (http://www.iata.org/publications/economics/fuel-monitor/Pages/index.aspx). Comment if the cost differential would be significant if the airline has three daily flights between PUJ and JFK.

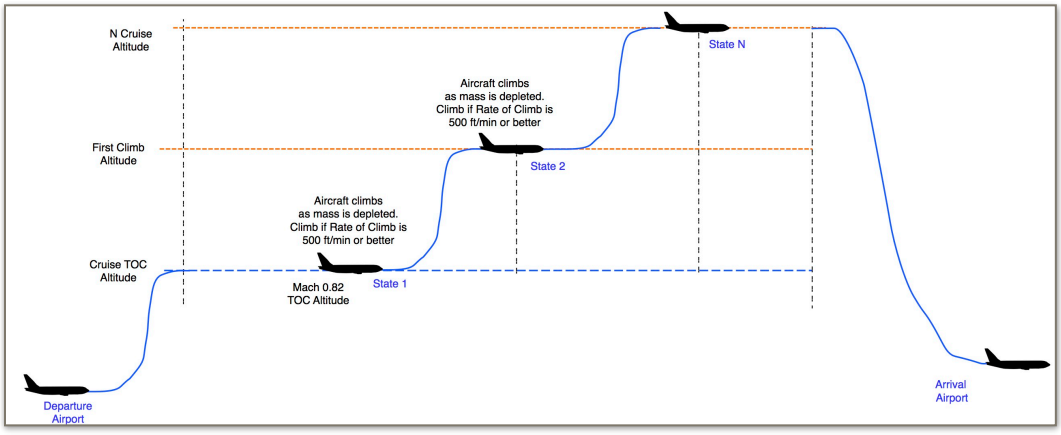


*Figure 1. Notional Flight Profile Showing Step Climbs.*

## Problem 2 (30 Points)

A low-cost airline started operations of Boeing 737-9 Max (with 194,700 lbs max. design takeoff weight and 193 seats) between Providence (PVD) and Dublin (DUB). The engine used is the CFM Leap 1B27 engine.

a) Evaluate the suitability of the aircraft for the route in question.

b) Find the runway length needed at Providence (PVD) that satisfies FAA/EASA requirements.

c) If the total operating cost of the aircraft is 3.3 times the cost of the fuel used in the route, estimate the average fare required to breakeven with a load factor of 85%. The cost of fuel is $2.7 per gallon at today's prices.

## Problem 3 (30 Points)

The Payload-Range diagram of an aircraft offers useful information about the efficiency of operations across a wide spectrum of routes ( stage length) and payload conditions. An important parameter to evaluate the efficiency of aviation operations is the Specific Air Range (SAR) which measures the distance traveled for every pound (or kilogram) of fuel used.

a) Using the TTBA aircraft explain the steps that you would follow to construct a basic payload-range diagram for the aircraft with three boundaries defined by the maximum zero fuel, the maximum takeoff, and the maximum fuel boundaries.

b) Provide a sample calculation to show me how would you construct the payload-range diagram for such aircraft.