Assignment 4: Air Transportation Systems Analysis

Due: February 21, 2023 Instructor: Trani

Problem 1

Use the new generation Transonic Truss-braced Wing Aircraft (TTBW) file to answer this question (http://128.173.204.63/cee5614/cee5614_pub/TBTA_class.m). The TTBW is a NASA proposed aircraft concept reduce fuel burn using a high-aspect ratio wing (see Figure 1).

a) Estimate the **aircraft rate of climb** after departing Eagle County Regional Airport (EGE) while the aircraft **flies at 250 meters above the airport ground level and 180 knots indicated**. Assume atmospheric conditions are ISA. Assume the wing **flaps are fully retracted** and use the regular table lookup function to estimate *Cdo* provided in the aircraft file. The aircraft departs Denver with a mass of 68,000 kilograms.

b) Repeat part(a) if the aircraft suffers an engine failure at 250 meters while traveling at 180 knots indicated airspeed.

c) Can the aircraft fly the MEEKER Standard Instrument Departure (see page 60 of the course notes for Meeker One Departure) and meet the climb gradient required? Current departure is MEEKER three.

d) Compare the rates of climb obtained in parts (a-b). Comment on the implications of an engine out condition at 250 meters.

e) Use the Unrestricted climb rate Matlab script to estimate the Top of Climb (TOC) for the TTBW aircraft concept if the pilot would like to maintain a 500 feet per minute climb potential at the TOC.

f) Find the fuel burn near the TOC if the pilot starts the cruise phase at Mach 0.73.

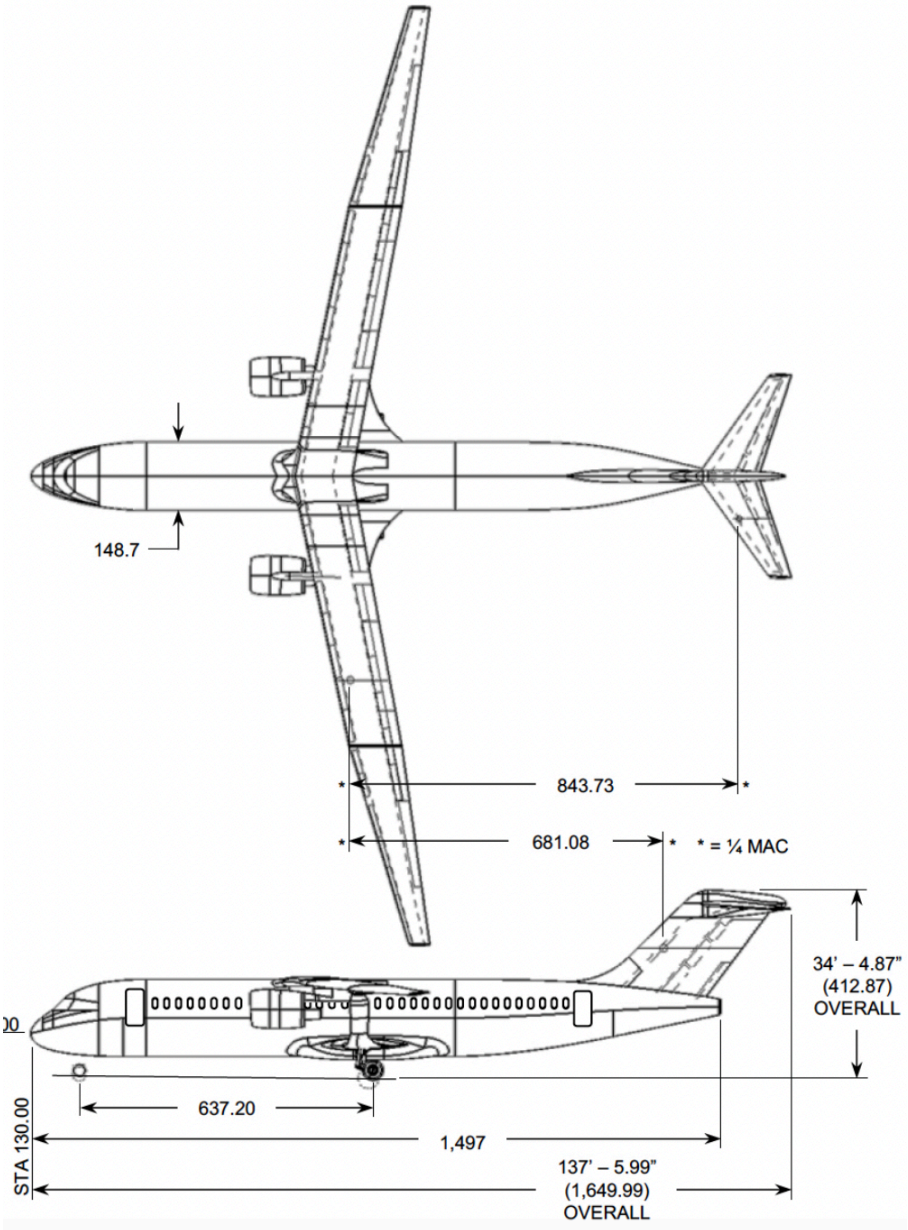

Figure 1. Early Version of the NASA TTBW Aircraft Concept.

Problem 2

Use the new generation TTBW file provided to answer this question. The TTBW aircraft now operates out of Dubai with a mass of 69,000 kilograms at at ISA + 20 deg. C.

a) Run the **unrestricted climb Matlab code** demonstrated in class for the aircraft in question. Simulate the climb profile for 3600 seconds (one hour) and estimate the **time to climb** and distance traveled to reach FL 370 (37,000 feet).

b) Using the results obtained in part (a), estimate the fuel burned during the climb to reach FL 370.

c) Estimate the L/D ratio at the Top of Climb (TOC) as the aircraft starts its cruise phase at Mach 0.73.

d) On a hot summer day, the aircraft departs Dubai at ISA+30 deg. C. Run the computer simulation (similar to part a) using the same initial takeoff mass of 69,000 kilograms and estimate the time to climb, distance traveled, and fuel used to reach FL370. Compare the results obtained in parts (a-c) and comment on the effect of temperature on rate of climb and time to climb.

Problem 3

Use the Boeing 787 class file (http://128.173.204.63/cee5614/cee5614_pub/B787_class.m) to answer the following questions

a) Estimate the value of Specific Air Range (SAR) for the aircraft while in cruise at Mach 0.84 and 36,000 feet. The mass is 200,000 kilograms.

b) Repeat the process in part(a) after a long flight if the mass is now 175,000 kgs. Comment on the effect of aircraft mass on SAR.

c) Use the Range equation, to estimate the maximum range for the aircraft if the aircraft reaches the TOC point (36,000 feet) at 200,000 kilograms. The aircraft cruises at Mach 0.84. The pilot estimates the aircraft carries 85,000 kilograms of fuel remaining at the TOC point. In the range calculation, assume the range is calculated using the aircraft mass at the mid-point between TOC and TOD. Also, assume that 6300 kilograms of fuel are needed in the descent plus a possible diversion to an alternate airport.

d) Solve the problem in part (c) using a piecewise numerical analysis method (as explained class). Use the range value obtained in part (b) and refine the answer obtained by dividing the range into six segments in the numerical solution. Comment on the obtained in parts (c) and (d).

Problem 4

Read the paper entitled: Development of an Efficient Mach=0.80 Transonic Truss- Braced Wing Aircraft article by Harrison et al. (AIAA year 2020) to get familiarized with the latest design procedures of the TTBW aircraft.

A) Explain the aerodynamic refinements made to the original SUGAR Phase III aircraft in order to improve the cruise speed of the TTBW.

B) What kind of L/D ratios are predicted for the Mach 0.8 TTBW and how they compare to the original SUGAR Phase III aircraft?

C) Wing flutter is a concern in high aspect ration wings. Does the paper addresses flutter margins?