Assignment 2: Basic Performance Calculations

Date Due: February 6, 2023 Instructor: Trani

Problem 1

Use the Eurocontrol interactive BADA database (https://contentzone.eurocontrol.int/aircraftperformance/default.aspx?) to answer the following questions.

a) Examine the performance characteristics of the Airbus A350-900 (see Figure 1). Find the **typical cruise Mach number** for the aircraft according to the BADA database. The aircraft code name for the Airbus A350-900 in the BADA database is A359.

b) Estimate the true airspeed for the Airbus A350-900 in cruise. Assume the A359 typically flies at 39,000 feet. Assume ISA atmospheric conditions.

c) Use the graphical flight profile (called details) of the BADA database for the A359 to estimate the **True Airspeed (TAS)** of the aircraft during the climb procedure at 15000 feet (Flight Level 150). The BADA database provides Indicated Airspeed (IAS) information for various phases of flight. Assume International Standard Atmospheric conditions (ISA). Figure 2 shows a graphic profile for the Airbus A320 (A320).

d) Use the graphical flight profile of the BADA database for the A350 to estimate the **True Airspeed** and the **Mach Number** of the aircraft during the climb procedure at 20,000 feet (or FL 200 - called flight level). Assume International Standard Atmospheric conditions (ISA).

e) Use Flightaware to examine the flight track and altitude profile for Singapore Airlines flight 21 from Newark (EWR) to Singapore Changi airport (SIN) on January 28, 2023. This is one of the longest commercial flights today. State the number of flight level changes during the flight. Explain the reason for the low starting flight level.

f) Use the NOAA re-analysis wind data demonstrated in class to explain why Singapore Airlines flight 21 from Newark (EWR) to Singapore Changi airport (SIN) on January 28, 2023 took an Easterly route. Using the NOAA web tool, plot the wind vector data at 250 mBar level (35,000 feet) and estimate the maximum winds encountered by that flight.

Figure 1. Airbus A350-900 in tow at Atlanta Airport (A. Trani).

Note: For this problem, you can use the Matlab scripts provided in class. However, for one of the problems, I would like you to show me a sample calculation using the equation to convert IAS to true Mach and then True Airspeed (TAS).

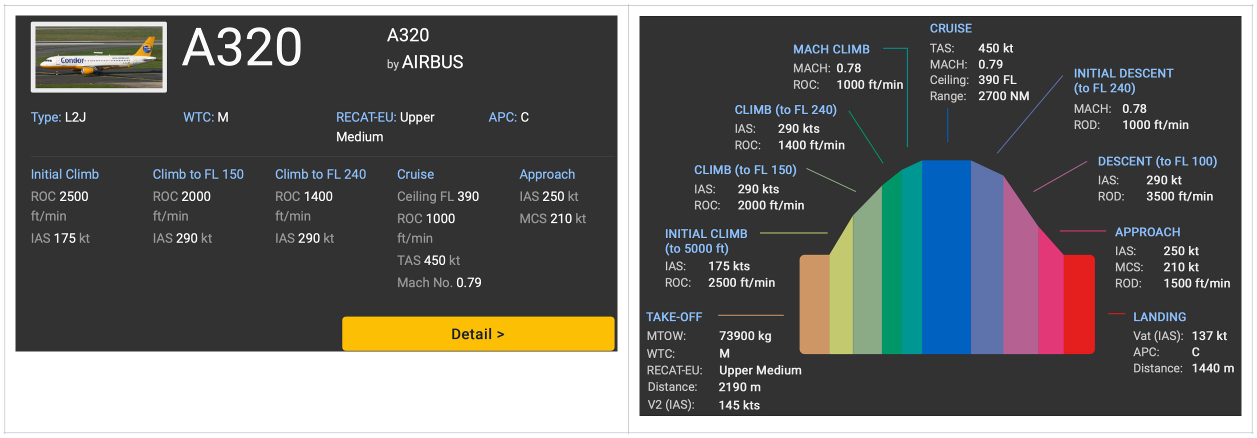

Figure 2. Airbus A320 Eurocontrol Database.

Problem 2

Use the Matlab computer programs such as **ISAM.m** (available in the Matlab files section of our web site - http://128.173.204.63/courses/cee5614/matlab_files_cee5614.html) to answer the following questions:

a) An Airbus A350-1000 (see Figure 3) flies at Mach 0.84 and at 39,000 feet. Assuming ISA atmospheric conditions, find the true airspeed (in knots) of the aircraft, the typical outside atmospheric temperature, and the density of air at Flight Level 390.

b) If the atmospheric temperature at FL 380 is 20 degrees Celsius above ISA, estimate the value of air density at FL 380 (you are allowed to use the **densityAltitudeOffISA Matlab** script supplied). Compare the density of air value obtained with that obtained in part (a) of the problem.

c) An aircraft flying near Phoenix and in contact with the Terminal Radar Approach Control (TRACON) facility reports an indicated airspeed of 275 knots while descending through 12,000 feet. Estimate the value of true airspeed (TAS) assuming ISA conditions at 12,000 feet.

Figure 3. Airbus A350-1000 Landing on Runway 27 at San Diego International Airport (A. Trani).

Problem 3

The minimum flight speed in steady-flight (called stalling speed V_{stall}) can be estimated using the fundamental lift equation (assuming Lift is equal to aircraft weight - mg):

$$V_{stall} = \sqrt{\frac{2mg}{\rho S C_{l\max}}}$$

where: m is the aircraft mass (in kilograms), g is the gravity constant (9.81 m/s-s), S is the aircraft wing area (square meters), ρ is the air density (kg/cubic meter) and $C_{l\max}$ (dimensionless) is the maximum lift coefficient (a parameter determined during flight testing).

According to Federal Aviation Regulations (FAR Part 25):

i) T**he approach speed (over the runway threshold) of a commercial aircraft should be 1.3 times the stalling speed (30% safety margin to protect against wind upsets on final approach) in the landing flap configuration.**

ii) The initial safe climb speed (after takeoff) is **1.2 times the stalling speed in the takeoff flap configuration.**

a) Estimate both, t**he stalling and the approach speeds** for a large twin-engine jet aircraft (similar to the Airbus A350-1000 - see Figure 3) with the following parameters: S= 464.3 square meters, $C_{l\max}$ = 2.70 (with flaps down 30 degrees in the **landing configuration - see Figure 3**), landing mass of 236,000 kg (the maximum allowable landing mass) and landing at sea level ISA atmospheric conditions. **Note that all speeds calculated using this method are true airspeeds (TAS).**

b) Repeat the analysis for a landing mass values of 190,000, 215,000, and 230,000 kilograms. Plot the trend of landing speeds asa function of landing mass. Comment on the different approach speeds asa function of aircraft mass.

c) Find the **approach speed** for the twin-engine aircraft when the aircraft lands at Mexico City International airport - Mexico - located at 7,320 feet above sea level conditions) at 236,000 kgs. Comment on the difference in the approach speeds at sea level and in Mexico City.

d) The large twin-engine jet aircraft (similar to the Airbus A350 - see Figure 4) has a maximum lift coefficient $C_{l\max}$ of 1.85 (with f**laps down 10 degrees** in the **takeoff configuration**. Find the **initial safe climb speed** (1.2 times the stall speed in the takeoff flap configuration) at the maximum takeoff mass of 236,000 kilograms.

e) Repeat for values of takeoff mass of 200,000 and 215,000 kilograms. Comment on the changes to takeoff speed with changing mass.