Assignment 2: Air Transportation

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Problem 1

Read two articles about the ADS-B system (http://en.wikipedia.org/wiki/Automatic_dependent_surveillance-broadcast) and http://www.boeing.com/commercial/aeromagazine/articles/qtr_02_10/pdfs/AERO_Q2-10_article02.pdf. Answer the following questions:

a) State the advantages of the ADS-B system for surveillance (i.e. to determine aircraft positions for air traffic control and management)

b) What are the FAA implementation plans for ADS-B?

2020 mandate. All aircraft flying in the NAS will be required to have ADS-B out capability.

c) In the wake of the loss of Malaysian Airlines flight 370, explain what are the possible benefits of using ADS-B technology implemented using satellites over the ocean.

Satellite-based ADS-B is a feasible technology to track aircraft over oceanic airspace. several vendors (Aireon, Rockwell, etc) have offered solutions to address this gap.

d) How could ADS-B technology improve airspace capacity? Explain briefly.

ADS-B update rate of the aircraft position (1 second) would allow ATC to know with more accuracy the position of the aircraft. Today, airport surveillance radars provide updates every 5 seconds (4.8 seconds for ASR-9 radars). In the enroute airspace, radars provide updates every 12 seconds (ARSR-4).

Problem 2

Use the Matlab computer program 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 from Qatar Airways cruises at Mach 0.845 and at 38,000 feet over the Gulf of Oman. Assuming ISA conditions in the atmosphere, find the true airspeed (in knots) of the aircraft and the typical outside temperature at the cruise altitude (Flight Level 380).

   485 knots (true airspeed)

b) For the same A350 flight, find the air density and temperature at 38,000 feet according to ISA conditions.

   0.3326 kg/cu.meter

c) A Frontier Airlines pilot flying an Airbus A320 reports to Air Traffic controllers an indicated airspeed of 240 knots while climbing at 8,000 feet out of Charlotte Douglas airport. Estimate the true airspeed of the aircraft if the atmosphere comforts to ISA conditions.

   Mach = 0.41, TAS = 262 knots

d) For the exceptional flight mentioned in class, the British Airways Boeing 777-200 pilot reported to Gander Oceanic Center flying the Organized Track System at Mach 0.83 and cruise altitude of 36,000 feet. If the tailwind was 170 knots, find the ground speed of the aircraft. Assume ISA conditions.

   TAS = 476 knots and Ground Speed = 646 knots

e) A Boeing 787-9 of Air New Zealand cruises at Mach 0.84 at Flight Level 370 (or 37000 feet above sea level) over the South Pacific. Assume the atmosphere is similar to ISA conditions. Find the true airspeed (in knots) for this flight. What is the value of the atmospheric density and the speed of sound at the cruise conditions?

   TAS = 482 knots, density = 0.3492 kg/cu.meter, speed of sound = 295 m/s

Problem 3

An American Airlines Boeing 757-200 departs La Paz airport (in Bolivia) and the pilot follows the following indicated speed profile:

Table 1. Indicated Speed Profile for Boeing 757-200 Climbing out of La Paz (Bolivia) Airport.

Altitude (meters)	Indicated Airspeed (knots)
4,000	200
5500	260
7000	305
10,000	315

a) Estimate the true airspeed and true Mach Number for each point in the climb profile. Assume ISA atmospheric conditions and zero wind in your calculations.

Table 2. Indicated Speed Profile for Boeing 757-200 Climbing out of La Paz (Bolivia) Airport.

Altitude (meters)	Indicated Airspeed (knots)	True Airspeed (knots)	Mach Number
4,000	200	232	0.37
5500	260	318	0.51
7000	305	394	0.65
10,000	315	456	0.78

Problem 4

The minimum flight speed achievable in steady-flight is called the stalling speed (V_{stall}) and is given by the formula:

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

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 by the aerodynamic capability of the aircraft). According to Federal Aviation Regulations (FAR Part 121), the approach speed of an aircraft should be 1.3 times the stalling speed.

a) Estimate the stalling and approach speeds during the landing phase for a short-range, twin-engine aircraft with the following parameters: S= 125 square meters, $C_{l\max}$ = 2.8 (with 40 degree flaps) , m = 68,000 kg and g = 9.81 m/s-s and sea level atmospheric conditions.

Vapproach = 141 knots, Vstall = 108 knots

If necessary, consult the values of atmospheric density aircraft performance notes 1 (http://128.173.204.63/courses/cee5614/cee5614_pub/Aircraft_perf_notes1.pdf) or use the ISAM function provided in class.

b) Repeat the analysis for altitudes ranging from sea level to 4,000 meters (every 1000 meters). All speeds calculated using this method are true airspeeds.

At 4000 meters; Vapproach = 172 knots, Vstall = 133 knots

c) Plot the stalling speed (in knots) vs. altitude and comment on the trends observed.

d) What is the stalling speed when the aircraft approaches La Paz Bolivia at 4,000 meters above sea level?

At 4000 meters; Vapproach = 172 knots, Vstall = 133 knots

e) During the climb phase the aircraft takeoff off with a mass of 78,000 kgs.. At 1000 meters above sea level, the pilot retracts the flaps. In that configuration this aircraft has a maximum lift coefficient $C_{l\max}$ = 1.4 (with no flaps - clean wing), estimate the stalling speed in the new flight condition. How does this newly calculated stalling speed compares to that estimated for the landing at the same airport elevation (part a)?

At 1000 meters; density = 1.11 kg/cu.meters and Vstall = 173 knots

The stalling speed increases with aircraft mass. Stalling speed also increases with airport elevation.