Assignment 2: Air Transportation

Date Due: September 9, 2013   Instructor: Trani

Problem 1

Suppose we are conducting an analysis of flight operations for Charlotte International Airport (CLT). We would like to use the FAA Aviation System Performance Metrics database (ASPM). A link to ASPM can be found on our web site (http://aspm.faa.gov/eurl.axd/215b24959b3b0343923e2ce188ab5d03/).

Before doing this problem please read the presentation entitled "Aviation System Performance Metrics (ASPM) Overview" posted at the ASPM Complete web site (see Figure 1).

Figure 1. Aviation System Performance Metrics (ASPM) Presentations Window.

For two days: July 5 and July 7, 2013 do the following:

- a) Extract the hourly and quarterly hour operations at the airport considering all types of operations.
- b) Plot the flight demand at CLT against time and comment on the pattern observed.
- c) Estimate the delays at the airport using the ASPM data.
- d) Find the taxi-in and taxi-out times at CLT in the two-day period.
- e) Repeat steps (a-d) for Atlanta International Airport. Comment on the differences observed at these two airports.
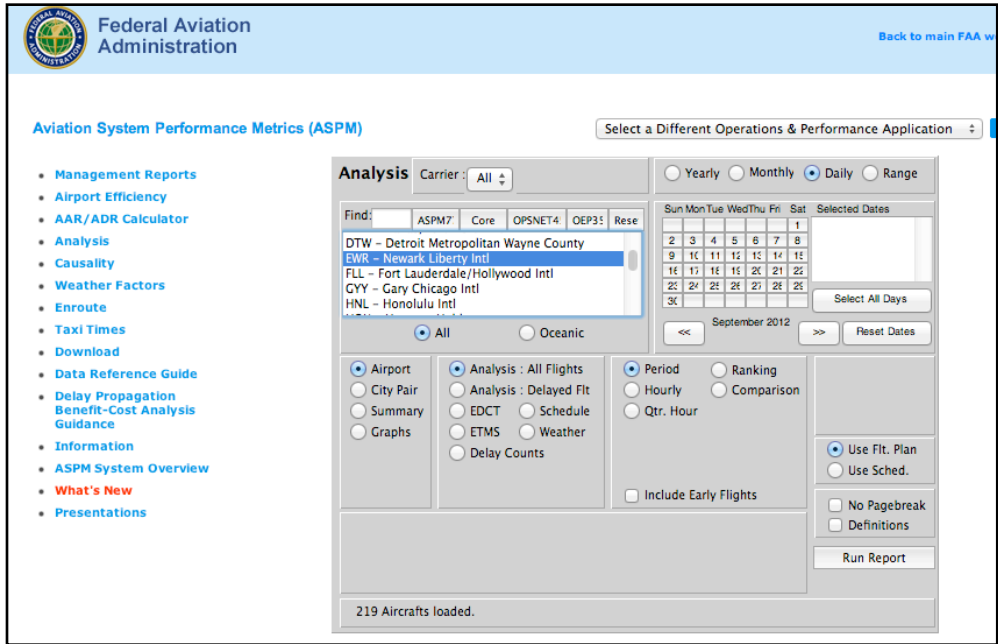
Figure 2. ASPM Analysis Java Interface.

Problem 2

The minimum flight speed of an aircraft 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 $C_{l\,max}$ i(dimensionless) s 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.

Create a simple Matlab function to estimate the stalling and approach speeds of an aircraft. The function should take 4 parameters (aircraft mass, maximum lift coefficient, wing area and air density) and should output two parameters: stalling speed, and approach speed. Suggested names of variables for the function are shown below:

function [approachSpeed, stallSpeed] = speedCalculator(mass,clMax,wingArea,density)

a) Run the function for an aircraft with the following parameters: S= 325 square meters, $C_{l\,max}$ = 1.3 (clean wing - no flaps) , m = 200,000 kg and g = 9.81 m/s-s and sea level atmospheric conditions. Find the values of atmospheric density on pages 14 and 15 of the aircraft performance notes 1 (http://128.173.204.63/courses/cee5614/cee5614_pub/ Aircraft_perf_notes1.pdf)

b) Repeat the analysis for altitudes ranging from sea level to 10,000 meters (every 2000 meters).

c) Plot the stall speed vs altitude and comment on the trends observed.

d) What is the stalling speed if the aircraft flies at 40,000 feet above mean sea level?

e) Suppose that for the aircraft described in part (a), the maximum lift coefficient is 2.4 with full flaps down (I.e., landing configuration) . Find the approach speed require to land the aircraft at 85 metric tons at an airport located at sea level conditions.

Problem 3

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) A Boeing 787-800 of United Airlines climbs out of Houston enroute to Tokyo Narita airport. The pilot reports to Air Traffic Control an indicated airspeed of 300 knots while climbing through 26,000 feet. Find the true airspeed (in knots) of the aircraft and the typical outside temperature in the standard day (ISA conditions).

b) For the aircraft in part (a) the Flight Management Computer (FMS) reports a 30 knot tailwind when the aircraft passes 26,000 feet. Find the ground speed of the vehicle.

c) A Boeing 749-400 cruises at Mach 0.85 at Flight Level 370 (or 37000 feet above sea level) over the North Atlantic track system. The atmosphere is similar to the ISA conditions. Find the true airspeed of this aircraft. What is the value of the atmospheric density and the speed of sound at Flight Level 370?

Problem 4 - Questions from Whitford's Book (Chapter 3) - Short answers

a) Explain in simple terms the physics behind the formation of wake vortices behind a wing that produces lift.

b) Explain the benefits of wing flaps in aircraft operations. Contrast a basic wing section with one with split, plain, slotted and Fowler flaps.

c) Examine the bottom figure on page 50 of the text. Modern technology commercial aircraft such as the Boeing 777 can reach L/D ratios of 19 in cruise. Explain, using the equations presented on page 40 and those in your course notes, how L/D contributes to the aerodynamic efficiency of the vehicle.

d) Explain the aerodynamic efficiency of the Douglas DC-3 design compared to modern transport aircraft. The Boeing 737-700 achieves an L/D of 18 in cruise.