Assignment 5: Air Transportation Systems Analysis

Date Due: September 30, 2013 Instructor: Trani

Problem 1

For the new generation long-range transport aircraft provided in the class web site (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing787_class.m) to answer the following questions.

a) Use the **unrestrictedClimbAnalysis.m Matlab script** to estimate the mass of the aircraft at the Top of Climb (TOC) point. The aircraft takeoff weight is 225,000 kg. with OEW of 117,700 kg., 71,300 kg. of fuel and 36,000 kg of payload (passengers and belly cargo). The pilot climbs to 35,000 feet restricted by Air Traffic Control. Use the default climb speed profile provided in the aircraft data file. Use ISA atmospheric conditions in your calculations. The departure airport is located at sea level conditions.

b) Use the **unrestrictedDescendAnalysis.m Matlab script** to estimate the fuel used from the Top of Descent (TOD) point (at 35,000 feet) to the destination airport. The destination airport is located at sea level conditions (assume ISA conditions in the decent as well). In this calculation assume the mass at the TOD point is 158,000 kg. This provides a 4,000 kg. of fuel reserve allowance at the end of the long flight.

c) Using the Breguet range equation, find the still-air (no wind) range of the aircraft with the parameters provided in parts (a) and (b) with the aircraft flying at 36,000 feet and Mach 0.82. To calculate the range parameter use the mass of the aircraft at a mid-point between TOC and TOD points.

Problem 2

An airline wants to fly the route CLT-FRA with a new advanced twin engine aircraft (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing787_class.m). The route of this flight is one of the many routes optimized daily for North Atlantic operations using the North Atlantic Organized Track System - NAT OTS (see Figure 1). Read about the NAT at**: http://en.wikipedia.org/wiki/North_Atlantic_Tracks.** On the day of the flight there are 6 tracks designated by letters from U to Z as shown in Figure 1. You can check the daily tracks at: http://www.turbulenceforecast.com/atlantic_eastbound_tracks.php.

The flight plan for this aircraft indicates a takeoff weight of 217,700 kg. with OEW of 117,700 kg., 60,000 kg. of fuel and 40,000 kg of payload (passengers and belly cargo). The aircraft is expected to climb to FL 360 directly after departing CLT and fly the first leg (CLT to NAT Track W) at Mach 0.82 (assume ISA conditions). The aircraft reaches the entry point of the North Atlantic Organized Track System (NAT OTS) near St. Pierre, Canada (see Figure 1). Just before entering the NAT the pilot requests FL 380 and Mach 0.83 for the North Atlantic leg crossing. Canadian controllers accept the request for both speed and cruise altitude. The final leg of the flight (NAT TRack W to FRA) is also expected to be flown at 38,000 feet as shown in Figure 1.

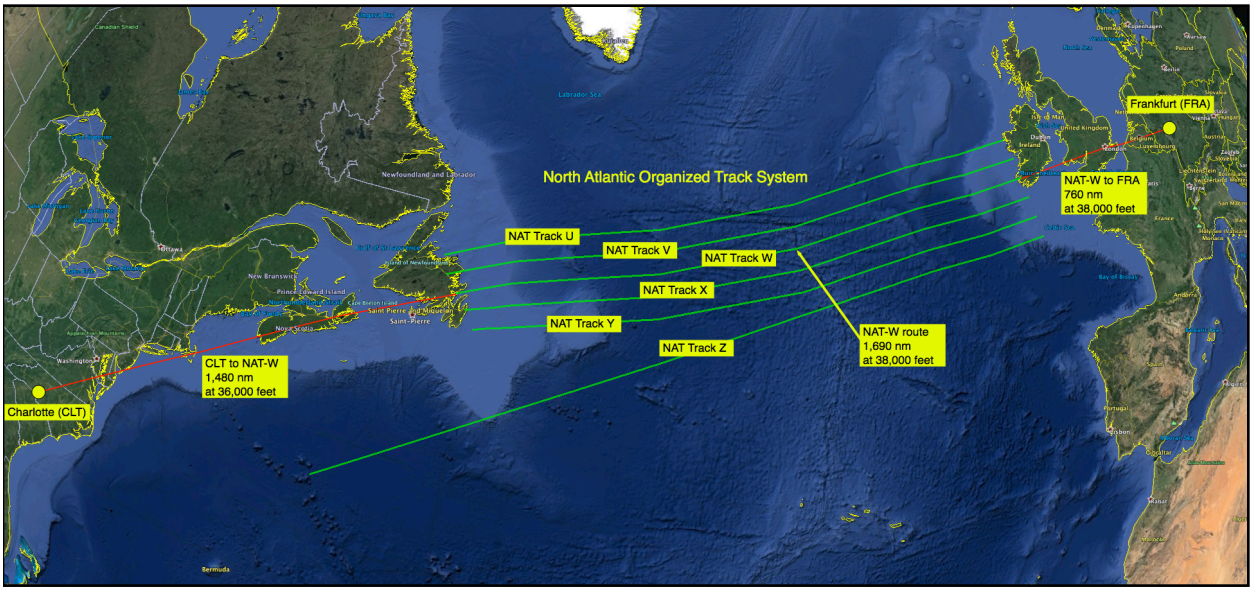

Figure 1. CLT-FRA Flight Using the Organized North Atlantic System (OTS).

a) Calculate the total fuel used in the flight given the parameters shown in Figure 1. In your calculations make sure to also include the fuel consumed in the climb phase from FL 360 to 380 before the aircraft enters the NAT OTS system. Assume the pilot performs the climb at Mach 0.82 and uses maximum continuous thrust.

For the cruise portion of the flight, approximate the fuel burn using the mid-point mass of every leg flown. Recall that fuel consumption in cruise is the product of drag and TFSC as shown below.

$$\frac{dW}{dt} = -TSFC(D)$$

where:

$\frac{dW}{dt}$ = is the fuel burn (N/s)

$TSFC$ = Thrust speficic fuel consumption (N/N/s)

D = total drag (N)

b) Based on the calculations performed, what is the fuel reserved carried? (fuel left after the flight is completed).

c) Calculate the fuel penalty to the airline if the aircraft receives an ATC clearance to fly the NAT OTS system at 36,000 feet instead (assume FL 360 for the NAT to FRA leg).

d) Calculate the additional cost to the airline per flight if the lower altitude is used. The fuel price today in large volumes is $3.15 per gallon of Jet-A fuel. Comment if the cost differential would be significant if the airline makes 600 crossings per year in that route.

e) What is the minimum longitudinal separation today in the OTS for aircraft with ADS-B and Datalink equipped aircraft?