

Assignment 4: Air Transportation Systems Analysis

Due: September 22, 2014

Instructor: Trani

Problem 1

The National Airspace System is a complex system with more than thirty thousand commercial flights each day. The file `nasOperations_2011.xls` contains a sample of the flights that were filed one day in the NAS. The header and a few flights are illustrated in Table 1. The Excel file contains a tab that explains each one of the columns of data (see Data Dictionary Tab).

Table 1. Sample NAS Flights File.

Flight ID	Aircraft Type	Type of Aircraft	Origin Airport	Destination Airport	Cruise Flight Level (feet/100)	Cruise Speed (knots)	Departure Time (hrs)	Arrival Time (hrs)	Distance Flown (nm)
BSK841	B738	J	MUHA	MIA	230	346	1.70	3.40	235.17
CSDKC	GLF5	J	OMA	DAL	190	337	13.83	16.15	586.62
EJA931	C750	J	FLL	APF	60	249	23.50	0.12	100.82
TSU132	CVLT	T	MDSO	BQN	150	279	23.63	0.40	166.49
ABX2217	B762	J	MIA	SPIM	340	471	22.78	4.55	2621.49
ABX2250	DC86	J	NGU	MUGM	320	450	12.13	15.20	1178.55
ABX2251	DC86	J	MUGM	NGU	380	453	17.18	20.77	1178.55
ABX38	B762	J	ZBAA	ANC	390	462	19.28	3.25	3950.40
AIP511	B190	T	HNL	MUE	130	219	11.30	12.32	171.82
AIP512	B190	T	MUE	HNL	120	219	12.63	13.65	171.82

- Examine operations in the NAS performed by Airbus A320 family aircraft (labeled as A318, A319, A320 and A321 in the aircraft type column). Make a plot of cruise flight levels assigned to the aircraft stated above vs. the distance flown. Explain the trends observed. What is the average cruise altitude used by these aircraft in all routes?
- For the aircraft fund in Part (a), create a histogram representing the stage length flown by the aircraft vs. frequency of operations. What is the average stage length flown by A320 family aircraft?
- Compare daily operations of Jetblue Airlines (flight ID starts with JBU) Airbus A320 and those of USAirways (flight ID starts with AWE) in the NAS. Contrast the distribution of the stage lengths flown (i.e., distance flown) and the cruise flight levels and filed cruise speeds used.
- Explain any difference observed in the stage lengths flown by each type of Airbus aircraft in part (a). For example, are A321s operated differently than A319 and A320 aircraft? Comment.

Problem 2

- For the large twin-engine, long-range transport aircraft provided in the class web site (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing777_class_2006.m), estimate climb profile (distance vs. altitude) using the `unrestrictedClimbAnalysis.m` Matlab script. Run the program at different takeoff weights ranging from 280,000 to 340,000 kg (steps of 20 metric tons). Assume ISA conditions. Comment about the changes observed in distance and time to climb to cruise flights levels where the aircraft is still able to climb at a slow pace (i.e., 400 feet/min).
- How many metric tons of fuel does the aircraft burn in the climb profile departing San Diego International Airport at ISA + 20, DTW of 310,000 kg? The pilot files 350 as the initial cruise flight level at TOC.
- What is the climb rate of the aircraft at flight level 350 (35,000 feet)?
- Find the distance traveled in the climb to 35,000 feet.
- Perform a manual calculation to estimate the climb rate for this aircraft as it passes 3,000 meters at 230 knots Indicated Airspeed (IAS). Assume ISA conditions in this calculation.

Problem 3

- a) For the large twin-engine, long-range transport aircraft provided in the class web site (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing777_class_2006.m), estimate the **fuel used in cruise** from the TOC point found in Problem 2 until the aircraft starts its descent to Narita (RJAA) airport in Tokyo (a point located 140 nm from the Narita airport). Here are some assumptions for this flight.
- DTW = 310,000 kg (per Problem 2)
 - Fuel onboard = 120,000 kg
 - Passenger Load = 30,000 kg
 - Cargo load in LD3 containers = 20,000 kg
 - OEW = 140,000 kg
 - Planned route distance = 5,100 nm (includes possible ATC and weather detours)
 - Cruise altitude = 35,000 feet (ISA conditions in cruise)
 - Cruise speed is Mach 0.82

In this analysis consider a minimum of 5 segments to calculate the fuel burned in the cruise profile.

- Is the amount of fuel carried sufficient to fly the route SAN-RJAA? Comment.
- Find the distance traveled to the TOD (Top of descent point) and also the travel time from takeoff to TOD.
- Compare the fuel burn estimated in part (a) with a more optimal profile where the aircraft climbs to 37,000 feet after flying 3 hours at 35,000 feet. How much fuel is saved?
- Using the Breguet range equation and using 135 metric tons of usable fuel, estimate the maximum range the aircraft can fly in cruise mode at Mach 0.82 and 36,000 feet.