FUEL AND CO2 MODELING – BASIC CALCULATIONS

A. Background Information

kgCO2/kg_fu 3.16 (Note that this figure is determined by the combustion of fuel on-board the aircraft. It does not include any consideration of CO2 that might have been produced in obtaining or transporting the fuel to the aircraft.)

B. Total Fuel (kg) Used by the Aircraft as Function of Great-circle Trip Distance (nmi)

	125	250	500	750	1000	1500	2000
AT7	352	567	999	1430	1861	2722	3581
CR7	929	1324	2022	2737	3483	5063	6682
CR9	1023	1444	2206	3008	3824	5486	7201

C. Nominal Seat Capacity

AT7	70
CR7	70
CR9	90

D. Number of Engines, Fuel Consumption Rates (kg/sec), and NOx Emission Indices (g/kg_fuel)

	Number of Engines	Fuel (kg/s) 100% thrust	Fuel (kg/s) 85% thrust	Fuel (kg/s) 30% thrust	Fuel (kg/s) 7% thrust	EI NOx 100% thrust	EI NOx 85% thrust	EI NOx 30% thrust	EI NOx 7% thrust
AT7	2	0.1546	0.1377	0.0817	0.0503	16.8	15	9.4	6.6
CR7	2	0.6080	0.4790	0.1702	0.0703	13.82	12.00	9.85	4.03
CR9	2	0.648	0.530	0.179	0.064	14.69	12.60	10.75	4.60

E. Questions

1. If fuel efficiency is defined as fuel expended per unit distance, how do these three aircraft compare, as a function of trip distance?

a. Calculate the ratio of the fuel used to the distance traveled.

	125	**250**	**500**	**750**	**1000**	**1500**	**2000**
AT7	2.81	2.27	2.00	1.91	1.86	1.81	1.79
CR7	7.43	5.29	4.04	3.65	3.48	3.38	3.34
CR9	8.18	5.78	4.41	4.01	3.82	3.66	3.60

Units above are kg/nmi.

2. If fuel efficiency is defined as fuel expended per unit seat distance, how do these three aircraft compare, as a function of trip distance?

a. Calculate the ratio of the fuel used to the product of the number of seats and the distance traveled.

	125	**250**	**500**	**750**	**1000**	**1500**	**2000**
AT7	0.0402	0.0324	0.0285	0.0272	0.0266	0.0259	0.0256
CR7	0.1062	0.0756	0.0578	0.0521	0.0498	0.0482	0.0477
CR9	0.0909	0.0642	0.0490	0.0446	0.0425	0.0406	0.0400

Units above are kg/(seats*nmi).

3. What is the total CO2 and the CO2 emitted per passenger for these aircraft, as a function of trip distance?

a. Calculate the CO2 produced from a given quantity of fuel using the production rate given in section A.

	125	250	500	750	1000	1500	2000
AT7	1111	1793	3156	4518	5880	8601	11317
CR7	2936	4183	6389	8647	11005	15999	21115
CR9	3232	4564	6972	9505	12084	17335	22756

Units for total CO2 above are kg.

b. Assuming that the aircraft is fully occupied, divide the total CO2 by the number of seats.

	125	250	500	750	1000	1500	2000
AT7	15.87	25.61	45.08	64.54	84.00	122.87	161.67
CR7	41.94	59.75	91.27	123.53	157.22	228.56	301.64
CR9	35.92	50.71	77.47	105.61	134.27	192.61	252.84

Units for total CO2 per passenger above are kg/person (asssuming all seats occupied).

4. What is the total NOx and the NOx emitted per passenger for these aircraft, as a function of trip distance?

Assume that the aircraft spends 16 minutes in taxi-out mode (7% thrust), 0.7 minutes in takeoff mode (100% thrust),

2.2 minutes in climbing to 3000 feet (85% thrust), 4 minutes in descending from 3000 feet, and 10 minutes in taxi-in mode (7% thrust). For simplicity, assume the remainder of the flight has an average thrust of 30%.

Note that the descent thrust above was not specified clearly. It is normally set to 30%, but either 30% or 7% is acceptable for our purposes here. The answers below use 30%. If you used 7%, your answers will differ somewhat, but the overall method remains the same.

a. Calculate the fuel and NOx used in the portion of the flight below 3000 feet.

	Fuel (kg)	NOx (kg)
AT7	245.49	2.17
CR7	478.56	3.91
CR9	479.95	4.40

b. Determine the fuel used above 3000 feet by subtracting the below-3000 fuel from the total fuel.
Then calculate the NOx (kg) generated above 3000 feet, by trip distance, using the 30%-thrust NOx emission rate per kg of fuel.

	125	250	500	750	1000	1500	2000
AT7	1.00	3.03	7.08	11.13	15.18	23.28	31.36
CR7	4.44	8.32	15.20	22.24	29.59	45.16	61.10
CR9	5.84	10.37	18.56	27.17	35.95	53.81	72.25

c. Add the below-3000 and above-3000 portions to obtain the total NOx (kg) generated, by trip distance.

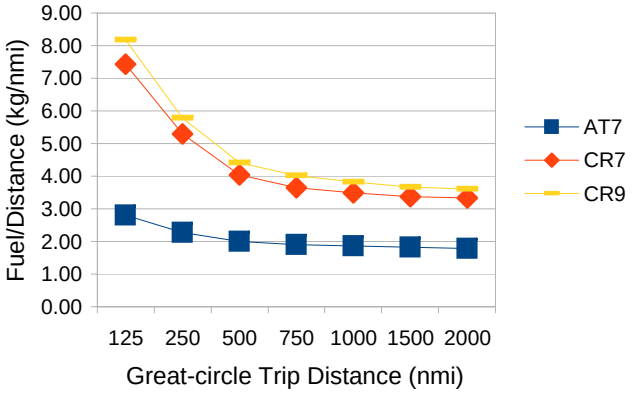
	125	250	500	750	1000	1500	2000
AT7	3.17	5.19	9.25	13.30	17.35	25.45	33.52
CR7	8.35	12.24	19.11	26.15	33.50	49.07	65.01
CR9	10.24	14.77	22.96	31.58	40.36	58.22	76.66

d. Assuming all seats are filled, use the number of seats to calculate the total NOx per passenger (kg/seat), by trip distance.

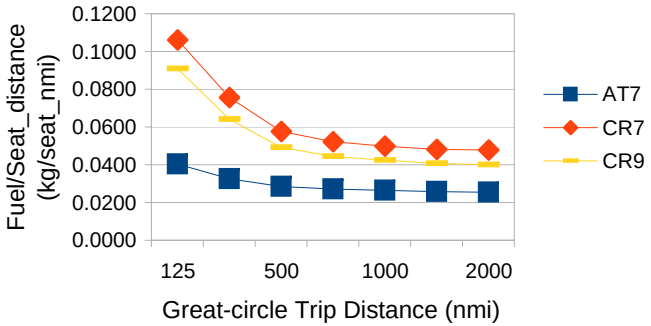
	125	250	500	750	1000	1500	2000

AT7	0.0452	0.0742	0.1321	0.1900	0.2479	0.3635	0.4789
CR7	0.1193	0.1748	0.2730	0.3736	0.4786	0.7010	0.9288
CR9	0.1138	0.1641	0.2551	0.3509	0.4484	0.6469	0.8518

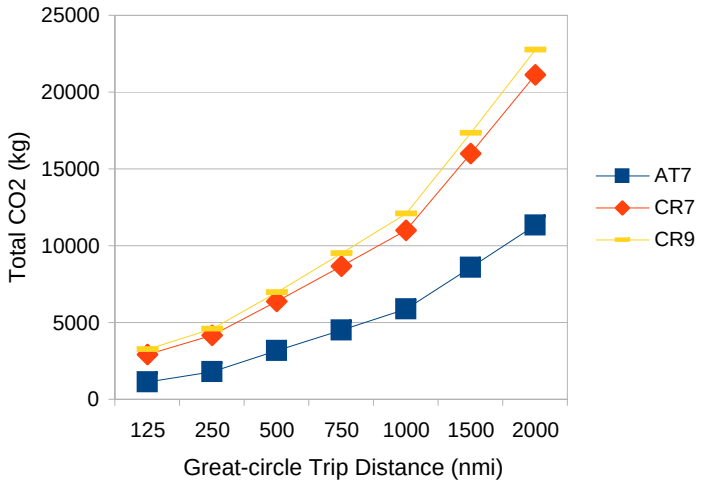
Fuel Efficiency I: Fuel/distance for Selected Aircraft



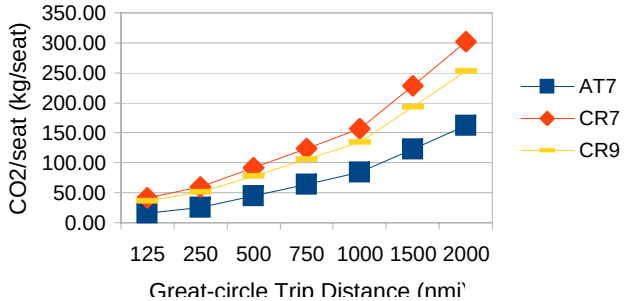
Fuel Efficiency II: Fuel/seat_distance for Selected Aircraft

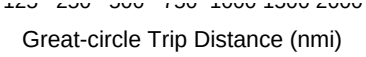


Total CO2 as Function of Trip Distance
for Selected Aircraft

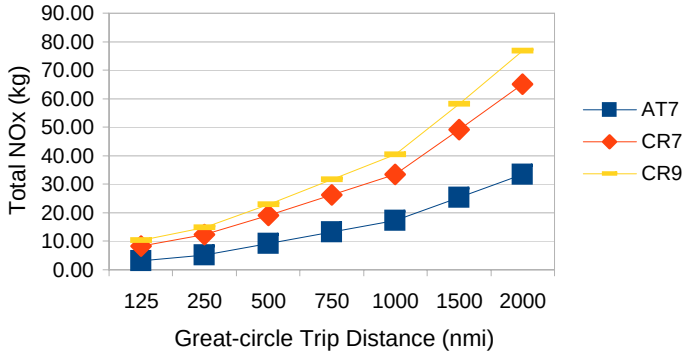


CO2/seat as Function of Trip
Distance
for Selected Aircraft





Total NOx as Function of Trip Distance for Selected Aircraft



NOx/seat as Function of Trip Distance for Selected Aircraft