CE 361 Introduction to Transportation Engineering

Homework 9 Solutions

AIRPORT FORECASTS, CAPACITY, AND DELAY

HW Posted: Wed. 17 November 2004, HW Due: Fri. 3 December 2004

Submit this HW as a member of a group of at least two and no more than four CE361 students.

1. (20 points) **Forecasting air travel using the FAA "Share Model".** Forecast the *total operations and total passenger traffic* at Rozelle Airport for the years 2005, 2010, 2015, 2020, and 2025. Use four digits after the decimal point for ROZ's stature. Choice of *Planning Factors* may differ, so you provide a brief explanation for each of the values you chose and show the values clearly.

Year	Total Operations	Enplanements
2005	18,033	139,859
2010	21,251	171,190
2015	24,780	207,060
2020	28,792	249,220
2025	33,029	295,800

The full Share Method spreadsheet can be seen by clicking on the link directly below the link for this document. The planning factors for Market Share (0.0170%) and Percent Interline (46%) were fairly obvious. The Planning Factors I chose for Departing Seats (+0.5/year for 20 years), Load Factor (80%), and Percent GA (70%) were judgments I made based on the last 5 years or so of data. Seats grew 0.6/year over the last 5 years, LF fluctuated above and below 80%, and GA grew steadily past 70%, but I did not think it would continue to grow faster than Commercial Operations.

2. **Airport capacity and delay.**
   A. Capacity with VFR. Use the format of Table 11.16. *Use VFR spacings called for in footnote to Table 11.13. See changes in "Sep. Std." in table below.*

Lead Aircraft Type	*Trail Aircraft Type*	*Case*	*Sep. Std. delta (n. mi.)*	*V(L) (knots)*	*V(T) (knots)*	*T(LT) Total (sec.)*	*Probab. of Lead Aircraft*	*Probab. of Trail Aircraft*	*Weighted Time (sec.)*
H	*H*	*1*	*2.7*	*150*	*150*	*64.8*	*0.10*	*0.10*	*0.65*
L	*L*	*1*	*1.9*	*120*	*120*	*57*	*0.70*	*0.70*	*27.93*
S	*S*	*1*	*1.9*	*100*	*100*	*68.4*	*0.20*	*0.20*	*2.74*
L	*H*	*2*	*1.9*	*120*	*150*	*45.6*	*0.70*	*0.10*	*3.19*
S	*H*	*2*	*1.9*	*100*	*150*	*45.6*	*0.20*	*0.10*	*0.91*
S	*L*	*2*	*1.9*	*100*	*120*	*57*	*0.20*	*0.70*	*7.98*
H	*L*	*3*	*3.6*	*150*	*120*	*138*	*0.10*	*0.70*	*9.66*
H	*S*	*3*	*4.5*	*150*	*100*	*222*	*0.10*	*0.20*	*4.44*
L	*S*	*3*	*2.7*	*120*	*100*	*127.2*	*0.70*	*0.20*	*17.81*
									75.31

Capacity = 3600 sec per hour/75.31 sec per landing = 47.80 landings per hour.

B. Mean delay if λ = 34/hr, μ = 50/hr, and σ = 20 sec. *Use (11.6) to get W_a = 0.88/0.64 = 1.37 minutes.* What is the maximum number of arriving aircraft that the airport can receive in an hour, while maintaining a mean delay of no more than 0.5 minutes? *Putting (11.6) into spreadsheet and using Solver, λ = 21.83 produces W_a = 0.5 minutes.*

3. **Airport capacity with a known sequence of operations.** Expected sequence of operations at ROZ beginning 5:30PM today: Ld, Sd, La, Sa, Ld, La, Sa, La, Sd, Ld, La, Hd
   A. (12 points) Create a table just like Table 11.18 that summarizes the time between operations for each pair of consecutive aircraft. What is the total elapsed time between the first and last operations listed above? *See Table 3A below. Use IFR with $\gamma = 5$ nm.*

Table 3A Summary of operations times for Problem 3

Op Nr	Op	approach speed (kt)	Item in Table 11.17 or equation used	Time for op (sec.)	Comments
1	Ld		Rules 3 and 4	5+45	to enter runway and take off
2	Sd		Rule 7	60	After Ld takes off
3	La	120	Rule 5 eqn, R6	60-45=15	After Sd takes off
4	Sa	100	(11.5)	174	After La touches down
5	Ld		R2,R3,R4	45+5+45	After Sa touches down
6	La	120	Rule 5 eqn, R6	60-45=15	After Ld takes off
7	Sa	100	(11.5)	174	After La touches down
8	La	120	(11.4)	90	After Sa touches down
9	Sd		R2,R3,R4	45+5+45	After La touches down
10	Ld		Rule 7	60	After Sd takes off
11	La	120	Rule 5 eqn, R6	60-45=15	After Ld takes off
12	Hd		R2,R3,R4	45+5+45	After La touches down
				938	15.63 minutes total
				78.17	average time per op

B. (8 points) What is the capacity (ops/hr) of ROZ during the period studied? *3600 sec/78.17 sec/op = 46.05 ops/hr*

4. **Runway configurations and capacity.** ROZ's operations are expected to be 42% Class A, 8% Class B, 32% Class C, and 18% Class D aircraft.
   A. (10 points) Calculate the Mix Index. *MI = 32 + (3*18) = 86.* Runway configuration is No. 1. What will ROZ's Hourly Capacity be under VFR and IFR conditions? *In Figure 11.23, MI=86 → 56 ops/hr under VFR and 53 ops/hr under IFR.* What will ROZ's ASV be? *MI=86 → ASV=210,000 ops/year.*
   B. (10 points) If 157,000 operations in that year, calculate ROZ's Delay Factor for that year. *(11.9) DF = 157,000/210,000 = 0.748.* Use Fig 11.24 to estimate average aircraft delay. *Read up from ratio = 0.748 to dotted line in figure, then to left scale. Average delay approx. 0.8 minutes.*

5. **Runway length and takeoff weight.** Elevation 2000 ft, temperature 90°F. 7000-foot runway with one end of the runway 23 ft higher than the other.
   A. (2 points) What is MATOW at 2000 ft and 90°F? *In top third of Table 11.23, MATOW = 188,700 lbs.* What is the Ref Factor at 2000 ft and 90°F? *In middle third of Table 11.23, R = 74.7.*
   B. (4 points) How long must the runway be for the MATOW found in Part A? *MATOW = 188,700 lbs and R = 74.7 → 10,670 ft. <u>effective</u> length by interpolation in bottom third of Table 11.23.*

Interpolation table:

Table 11.23C	68	74.70 (R)	78
185	9.25	10.23	10.71
188.70		10.67	
190	9.78	10.83	11.35

What is the MATOW for the current runway at ROZ? *FTE p. 607: Effective length = 7000 – (23*10) = 6770 ft. In bottom third of Table 11.23, interpolate to find MATOW = 151.960 lbs., given this effective length:*

Interpolation table:

Table 11.23C	68	74.70 (R)	78
150	6.02	6.59	6.87
151.96		6.77	
155	6.44	7.05	7.35

C. (14 points) How many passengers can be carried to an airport 400 miles away, given the current runway? Show the steps in your analysis.

Step	*lbs.*	
A	*151,960*	*min MATOW*
B	*109,210*	*OEM + reserve fuel*
C	*42,750*	
D	*8,800*	*fuel use*
E	*33,950*	*left for pax*
F	*169.75*	*passengers*
G	*162*	*passengers*

Steps explained:

A. MATOW from Part B of this problem
B. OEM + reserve fuel from Table 11.24
C. Subtraction, A – B = C
D. 400 mi at 22 lb/mi = 8,800 mi
E. Subtraction, C – D = E
F. 33,950 lbs at 200 lbs/pax = 169.75 pax
G. Aircraft holds max 162 pax.