Air Transportation Systems Field Exam
January 2009

Note: You have 60 minutes to prepare for this examination. The preparation is closed book, but you can bring any notes that you generate during the preparation period to use in the oral exam. The oral examination will be 45 minutes long.

GOOD LUCK!

1. Let us consider an airport with an arrival capacity of 60 aircraft/hour and an arrival demand of 45 aircraft/hour. We will begin by modeling this as a simple queuing system, as shown in Figure 1.

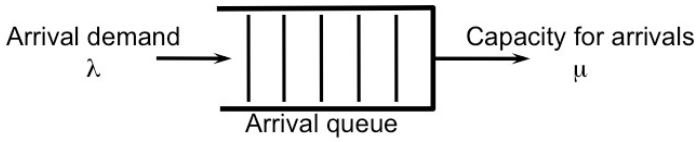

Figure 1. Simplified model of arrival queue at an airport.

   A. Suppose the arrivals are timed (through metering, for example) to arrive exactly 80 seconds apart, and the airport can land one flight a minute (exactly). What would the expected delay per aircraft be?

   B. We know that in reality, aircraft will not arrive exactly as scheduled.

      a. Could you describe a few of the reasons why this may happen?

      b. How would you modify the model from Part (A) to account for this? Briefly discuss what the advantages/disadvantages of your model are.

      c. Intuitively, would you expect the delay to increase, decrease or remain the same, when compared to Part (A)? What would the expected delay be for each flight under your modified model?

      d. This delay corresponds to airborne delay. Let us suppose that the arrival queue is a holding stack – could you estimate the average number of aircraft in (i.e., the expected size of) the holding stack?

   C. Suppose the weather forecast predicts that the arrival capacity will be reduced to 50 aircraft/hour.

      a. If the arrival demand remains unchanged, what will be the expected arrival delay and size of the arrival queue?

      b. Could you describe a few of the ways in which Traffic Flow Management might respond to the reduction in arrival capacity at an airport, especially when the reduction is severe, compared to the demand level?

c. With arrival demand still at 45 per hour, suppose, instead, that due to weather uncertainty, we obtain a probabilistic forecast with two capacity scenarios: the arrival capacity is predicted to either be reduced to 50 aircraft/hour with probability 2/3, or to remain unchanged (i.e., 60 aircraft/hour) with probability 1/3. What will be the effect on the expected arrival delays and size of the arrival queue?

D. Discuss the incremental costs to airlines of flight delays caused by airport and ATC congestion. What specific categories of airline operating costs are affected by such flight delays? Explain the reasons for and likely impacts on each affected cost category.

E. What schedule planning strategies might an airline implement in an effort to reduce the impacts on its operations of persistent flight delays due to congestion at a particular airport? What are the trade-offs involved in implementing such strategies?

2. Assume that an economic mechanism to reduce congestion-related flight delays (e.g., slot auction, peak-period pricing) is implemented at a particular airport susceptible to excessive delays.
If such a mechanism were indeed effective, what would be the expected impacts on the following performance metrics on affected flights for an airline that is already operating to/from that airport? Please give a brief explanation for your answers.

A. Average aircraft size; departure frequency; stage length; unit operating costs.

B. Total passengers; revenues; yields; average load factor.

You may find the following formulae from queuing theory useful in your calculations:

Average number of customers in the queue, L_q:

M/M/1 queue: $L_q = \rho^2/(1 - \rho)$

M/G/1 queue: $L_q = \{\rho^2(1+\sigma_s^2\mu^2)\}/\{2(1 - \rho)\}$

where ρ is the utilization rate, μ is the service rate, and σ_s^2 is the variance of the service time distribution.

If there are any other specific formulae from queuing theory that you need but do not remember, your committee will be happy to provide them to you during the exam, without any loss of credit to you.