Air Transportation Systems Field Exam
January 2017

Note: You have 75 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 60 minutes long.

Make any assumptions that you believe are reasonable, but be sure to state them while answering the questions.

GOOD LUCK!

Part A: Airport Delays

Consider an airport A where, like London Heathrow or LaGuardia, the number of scheduled ATMs (arrivals and departures) per hour is essentially constant throughout the day, because of limits on the number of flights that can be scheduled per hour. These limits are typically set to a value lower than the capacity of the airport's runway system. Assume then that at A, the runway system's hourly capacity is 72 movements per hour and the demand is equal to 60 ATMs per hour from 6 am until 11 pm. (The airport has a curfew between 11 pm and 6 am.)

We know, however, that because of poor weather conditions on a particular day, the capacity fell to 40 per hour between 8 am and 11 am, a period of 3 hours. The capacity then went back up again after 10 am, to 72 per hour.

Assume that the queuing discipline at airport A is "first-come, first-served".

(1) Assume for now that we have a perfectly "deterministic" queuing process. In other words, demands for use of the runway system occur at perfectly spaced intervals (every 60 seconds in this case) and service times for all movements are exactly the same (e.g., when the capacity is 72 per hour, each service time lasts exactly 50 seconds). Find the number of ATMs that will suffer non-zero delay on that day and the average delay experienced by these ATMs (the ones that suffer non-zero delay).

(2) Assign a number to each ATM according to the order in which they demand service. For example, the first demand of the day that occurs at 6:01 am is no.1, the one that shows up at 7 am is no. 60, the one at 7:30 am is no. 90, etc. Which ATM (identify it by its number) will suffer the longest delay of the day? How long will this delay be?

(3) According to deterministic queuing models, there will be no delays on days when the capacity remains at 72 per hour throughout the day, because "demand is lower than capacity". Given what you know about the characteristics of demand and of service times at airports, please explain why this is not so.

(4) Assume now that we use a "probabilistic" model that captures some of the uncertainty associated with queuing at a runway system. We are interested in the average delay on "normal" days when the expected capacity stays at 72 per hour throughout the day. Assume that the airport's operator decides to increase the limit on the number of ATMs that can be scheduled per hour from 60 to 66 (on the theory that the airport is "underutilized" when only 60 ATMs per hour are scheduled. By roughly how much would you expect the average delay to increase (compared to delays when demand was limited to 60 per hour)? Approximately by 10%? Approximately by 33%? 50%? Other? Please explain briefly your answer.

By how much will the **standard deviation of the delay** (i.e., the variability of delay from day to day) increase?

(5) Suppose that at an airport, such as the one described above, the queuing discipline was changed from "first-come, first-served" to "service in random order" (SIRO). SIRO means that, whenever there is a queue of movements waiting to be served (land or take off), the next movement to be served is selected randomly from the queue. Everything else being the same, will the SIRO discipline increase, decrease or not affect the average delay at the airport? What about the standard deviation of the delay?

Part B: Airline Fleet Assignment

Delta Airlines flight DL1901 operates non-stop daily from Boston (BOS) to Delta's large connecting hub at Atlanta (ATL), departing at 8:00am. During last summer's peak months (June-August), this flight was operated with an Airbus A319 aircraft, configured with 132 total seats. Delta observed the following distribution of loads over 90 operations of DL1901 during the schedule period June-August 2016:

	Total
Number of departures	90
Seating Capacity	132
Average Load (passengers)	114.8
Standard Deviation of Loads	24.1
Average Load Factor (LF)	87.0%
Departures with 100% LF	14

(A) Describe how the airline can use the single flight leg spill model to estimate the following measures, based on an assumption of Gaussian demand. For each of these measures, explain its meaning and relevance to spill modeling, explain how it can be estimated, and provide an indication of its expected magnitude, given the information provided above. Use diagrams and/or mathematical notation as appropriate.

1. Standard deviation of unconstrained demand
2. Mean unconstrained demand
3. Expected spill per departure

(B) Looking ahead to the peak June-August schedule period for 2017, Delta would like to determine whether it makes sense to assign a larger aircraft type to DL1901, given the relatively high observed load factor last summer. Under the assumption that the demand levels and distributions of summer 2016 will once again be valid for summer 2017, Delta estimates that assigning a larger A320 aircraft with a 160-seat capacity will reduce expected spill per departure by 9.1 passengers. Use the data provided below to calculate the change in contribution of this flight.

AIRCRAFT OPERATING COST (AOC) AND REVENUE DATA

TYPE	TOTAL SEATS	AOC($/HR)	NET REV PER PAX*
A319	132	$3700	$200
A320	160	$4200	

	MILES	BLOCK TIME
BOS-ATL	950	3.00 hours

*NET REVENUE is the average-one way fare prorated to this flight leg, net of all variable carrying costs (traffic and passenger servicing, promotion, sales and distribution)

(C) Describe briefly the limitations of the use of net prorated revenue per passenger in the above analysis. Specifically, what aspects of revenue management and hub network revenues does this simple analysis ignore? Conceptually, describe how Delta could adjust this revenue estimate to better incorporate the effects of its Revenue Management (RM) system and hub network connections into its spill estimates for DL1901. What would be the impacts on the change in contribution calculated in (B)?

(D) In the real world, Delta would have to take many additional operational and network considerations into account before it could commit to assigning the larger A320 aircraft type to this BOS-ATL flight. Discuss briefly the most important considerations, including aircraft rotation considerations, crew requirements and any potential airport constraints. Be as specific as possible with respect to the context of this DL1901 example.