# Air Transportation Systems Field Exam: Air Transportation Systems
# January 2019

**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 1: AIRPORT DELAYS

Consider the situation shown in Figure 1. An airport's capacity during a particular day is shown in black. It is equal to 60 movements per hour, except for a decline to 40 per hour between t=3 and t=5 because of poor weather. The demand at the airport is shown in red (and is constant at 50 per hour throughout the day, except for a jump to 70 per hour between t=2 and t=4).

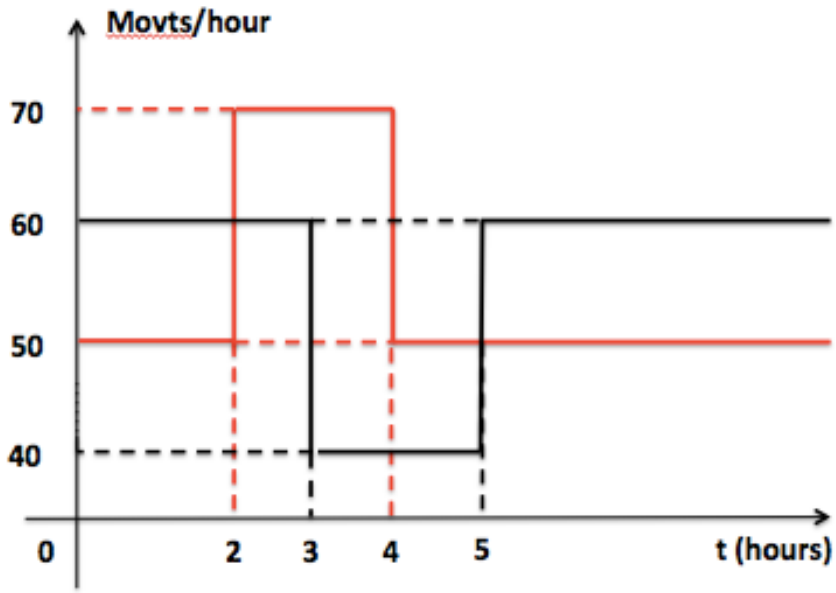


**FIGURE 1**

Assume service is provided in a first-come, first-served order. Under the usual assumptions associated with cumulative diagrams and deterministic queuing models (constant intervals between consecutive demands for any given demand rate, constant service times for any given capacity) please answer the following questions:

a) What is the total number of arrivals that will suffer non-zero delay during the day?

b) What is the maximum length of the queue of movements will reach during the day?

c) What is the longest delay that any arrival will experience during the day?

d) Assume that the demand shown in Figure 1 is fixed (i.e., it will be 50 throughout the day with a jump to 70 between t=2 and t=4. Assume also that the capacity will suffer a decline to 40 per hour for a continuous period of exactly 2 hours. However, the starting time of this 2-hour period of poor weather is uncertain and can be at any time $t \geq 0$ (for example, it could be at t=1, at t=2.6 or at any other time of the day).
   (i) What is the worst starting time of the 2-hour, poor-weather period? (This is the time that would maximize the total delay experienced during the day.)
   (ii) What is the best starting time of the 2-hour, poor weather period? (Minimize the total delay experienced during the day.

e) Assume now that al the movements are arrivals and that we have 3 different types of aircraft (for example, Heavy, Medium and Light in ICAO terminology) with different speeds on final approach. (Forget also the assumption about constant service times – in this part of the problem, the time interval between any pair of consecutive arrivals depends on the type of the leading and the trailing aircraft in the pair.) Suppose we compute the arrival capacity of a runway at this airport (with first-come, first-served order of service) for some given value, $n$, of the length of the final approach (e.g., $n$ = 5 n. miles). If we keep everything else the same and only increase $n$, the length of the final approach, will the (maximum throughput) capacity of the runway increase or decrease? Please explain your answer briefly.

## PART 2: LOW COST CARRIER COMPETITION

1. Low Cost Carriers (LCCs) and, more recently, Ultra Low Cost Carriers (ULCCs) offer air travel services at much lower fares than Network Legacy Carriers (NLCs), due to their substantially lower unit costs of operation. Based on your knowledge of these different airline business models, describe and explain 2 different reasons why LCCs/ULCCs are able to achieve each of the following.

   (a) Higher aircraft utilization (block hours/day) than NLCs

   (b) Lower airport fees per passenger enplaned than NLCs

   (c) Higher levels of labor productivity (ASM/employee) than NLCs

2. Now, consider a specific market in which Legacy Airlines currently operates two daily non-stop flights on a route dominated by local O-D passengers flying for leisure/vacation purposes. Legacy has been using 140-seat aircraft in a single-cabin configuration, operating at an average load factor of 80% on this route, with an average fare of $250 each way.

Ultra Low Cost (ULC) Airlines plans to enter this market with 1 daily non-stop flight in each direction, using the same aircraft type but configured for 158 seats, with 30% lower average fares. Legacy is expected to match these lower fares.

The following table provides relevant data before and after the planned entry of ULC.

| **BEFORE ENTRY:** | | | **AFTER ENTRY:** | | | |
|---|---|---|---|---|---|---|
| AIRLINE | LEGACY | | AIRLINE | LEGACY | ULC | TOTAL |
| DAILY FLIGHTS (each way) | 2 | | DAILY FLIGHTS (each way) | 2 | 1 | 3 |
| AIRCRAFT CAPACITY | 140 | | AIRCRAFT CAPACITY | 140 | 158 | |
| AVERAGE OW FARE | $ 250 | | AVERAGE OW FARE | $ 175 | $ 175 | |
| PASSENGERS (PDEW) | 224 | | PASSENGERS (PDEW) | | | 358 |
| MARKET SHARE | 100% | | MARKET SHARE | | | |

(a) We expect O-D demand in this market to be stimulated by ULC's 30% lower average fares, and given that Legacy is expected to match the lower fare levels. ULC claims that total O-D PDEW will increase from 224 to 358 after its entry. Is this a reasonable estimate of the increase in total demand, given the information provided? Explain.

(b) Legacy Airlines will see its market share of total O-D demand in this market to change, irrespective of the amount of demand stimulation. Describe qualitatively your expectations of this change in market share, with reference to the S-curve market share model and the information provided to you above. What alpha exponent for the S-curve model would be appropriate in this situation?

3. The table below summarizes average operating statistics for the same type of aircraft used by the two airlines to compete in a variety of leisure markets. Describe the variables and steps required to calculate each of the following metrics, given the data provide below (<u>you do not need to perform the actual calculations</u>):

| | | | **LEGACY** | **ULC** |
|---|---|---|---|---|
| **Aircraft Operating Costs (AOC)** | | | | |
| **per Block Hour** | | | **$4,200** | **$3,600** |
| | | | | |
| AVERAGE STAGE LENGTH | | | 1000 | 1000 |
| SEATS PER DEPARTURE | | | 140 | 158 |
| DEPARTURES PER DAY | | | 3.3 | 4.0 |
| UTILIZATION (BLK HR/DAY) | | | 9.9 | 12.0 |

(a) Aircraft productivity (in ASMs per aircraft per day)

(b) Aircraft Operating Costs per ASM

4. Facing increasing competitive pressures from ULC Airlines in an increasing number of leisure markets, Legacy Airlines is considering the re-configuration of its aircraft fleet to reduce seat pitch and increase seating capacity by 18 seats, to the same 158-seat capacity as ULC. Legacy Airlines estimates that the mean demand per flight departure across the relevant markets will be 130 with a standard deviation of 28.

(a) Describe how the principles of probability can be used to estimate impacts on average passenger loads of increasing the capacity of each flight from 140 to 158. Use a sketch graph of the given demand density to illustrate conceptually the required calculations.

(b) Based on your answer in (a), what are the expected changes in the following metrics due to this capacity increase? In each case, explain intuitively the reasons for your answer.

- Proportion of fully booked flights over a 1-month period of operations

- Average load factor of flight operated over the same period