

## Assignment 3: Runway Length Analysis - Aircraft Evaluation

Solution

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### Problem 1

An airline is evaluating two aircraft to operate flights from Reagan National Airport (DCA). The following table shows two aircraft proposed by airline executives to operate from the airport. The critical stage lengths the airline would like to fly with the selected aircraft are: a) DCA-SEA and b) DCA-PHX.

Table 1. Aircraft Considered in the Airline Evaluation.

Aircraft Considered
Boeing 737-800 with CFM56-7B26 engines rated at 26,000 lb. engines at sea level static thrust condition. Aircraft maximum design taxi weight is 172,000 lb. with 160 seats in a two-class layout.
Boeing 737-700 (no winglets) powered by two CFM56-7B20 engines at 20,000 lb. sea level static thrust). Aircraft maximum takeoff weight is 154,500 lb. The aircraft has 128 seats in a two-class layout.

The airline would like to request your services to help them select among the two aircraft to start operations from DCA. The design airport temperature used should be the average of the maximum temperatures of the hottest month of the year. You can query these averages for any airport at:

<http://www.weather.com/weather/monthly//DCA:9:US>

More detailed information about the airport can be found at the AIRNAV database available on the web at: <http://www.airnav.com/airports/> or visit the airport site.

In your analysis use the latest version of the Boeing documents for airport design ([http://128.173.204.63/courses/cee5614/sites\\_ce\\_5614.html#Aircraft\\_Data](http://128.173.204.63/courses/cee5614/sites_ce_5614.html#Aircraft_Data)).

- a) Find the average stage length to be flown between each one of the critical OD airport pairs. In your analysis use the Great Circle Flight Path mapper link provided in our interesting web sites. For planning purposes, add 5% to the distances calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the optimal Great Circle flight path.

Route distance (DCA-SEA) = 1.05 (2024) = 2,125 nm

Route distance (DCA-PHX) = 1.05 (1719) = 1,805 nm

- b) Find the runway length needed for each one of the aircraft operating the two routes. Determine if DCA has enough runway length to support these flights in the critical day (i.e., average maximum temperature of the hottest month of the year).

89 deg. F design temperature. Elevation above sea level = 14 feet (sea level conditions)

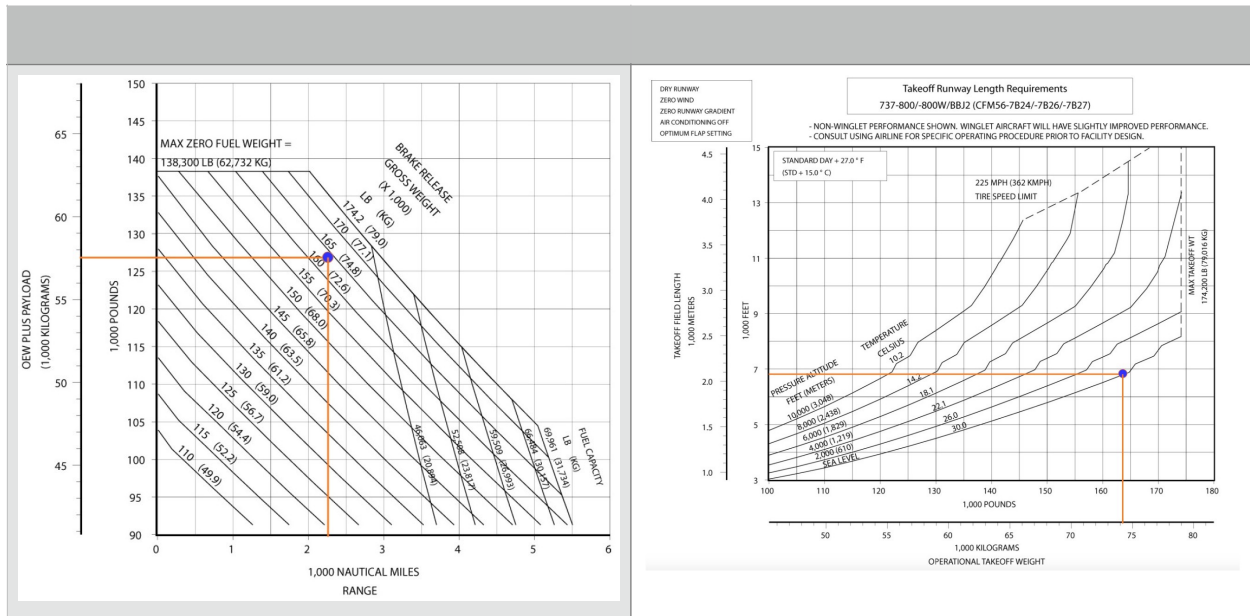
At sea Level ISA temperature is 59 deg. F. We need performance charts for ISA + 30 deg. F.

**Using Boeing 737-800 in the DCA-SEA route as example:**

$DTW = OEW + FW + PAY = 41,413 \text{ kg} + FW + 16,000 \text{ kg} = 57,413 \text{ kg} + FW$

$DTW = 74,200 \text{ kg}$ ; therefore  $FW = 16,787 \text{ kg}$

Use the B737-800 performance chart for ISA + 27 deg. F. This is the closest to the design temperature at DCA. **Takeoff runway length = 6,800 feet (DCA longest runway is 7,170 feet).**



c) For the aircraft selected in part (c) estimate the maximum cargo load above the passenger load that the airline could carry if the aircraft seats are full.

The runway length available is 7,170 feet. Therefore we can add some cargo until the runway length available matches the required runway length. Using the Boeing design chart we see that a runway length of 7,170 feet is matched to a DTW of 75.2 metric tons.

The cargo that can be carried in the route is 1,000 kg.

d) Compare the fuel used per passenger-kilometer used by each aircraft in the longest route. Comment on the results.

For the DCA-SEA route the fuel used is 16,787 kg. The trip is 3,936 kilometers. The fuel used per passenger-km is 0.0267 kg/pax-km.

## Problem 2

a) An airline is evaluating the operation of services between Toluca International Airport (in Mexico) (IATA airport code is **TLC**, ICAO airport code is **MMTO**) and Tokyo Narita (Japan) using a long-range aircraft. Toluca is located on a high plateau at 8,466 feet above mean sea level conditions. The airline requires a minimum of 250 seats in a two-class cabin layout. The Boeing 777-200LR is one of the aircraft considered by the airline. The airline would like to carry an extra 6 metric tons of freight under the fuselage to generate additional revenue in the route. In your analysis, use the great circle mapper application and add 5% to the route distance to account for Air Traffic and weather detours. Also consider the runway length available at Toluca Airport (use the link provided in our web page to the World Airport data).

For the aircraft in question investigate the following:

a) Can the aircraft operate the route TLC-NRT with a full passenger load?

Route distance (TLC-NRT) = 1.05 (6,070) = 6,374 nm

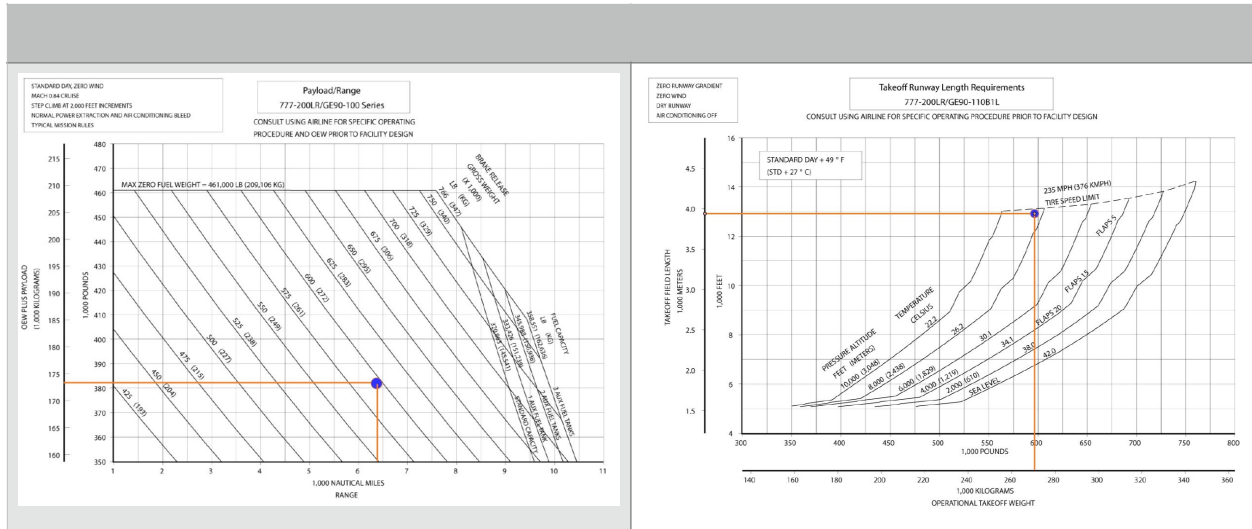
80 deg. F design temperature. Elevation above sea level = 8,466 feet; Temperature (ISA) = -1.6 deg. C. or 29 deg. F. Use the performance charts of ISA + 51 deg. F.

**Using Boeing 777-200LR (with 279 seats):**

$DTW = OEW + FW + PAY = 145,150 \text{ kg} + FW + 27,900 \text{ kg} = 173,050 \text{ kg} + FW$

$DTW = 597,00 \text{ lb} (271,360 \text{ kg}) ; \text{ therefore } FW = 98,310 \text{ kg}$

Use the B777-200LR performance chart for ISA + 51 deg. F. This is the closest to the design temperature at TLC. **Takeoff runway length = 12,900 feet. The Toluca airport has a single runway that is 13,780 feet. The flight can be done.**



b) Estimate the fuel load needed to operate the route.

$FW = 98,310 \text{ kg}$

c) Find the average fuel consumption per passenger-kilometer. Compare to the values obtained in Problem 1.

$Fuel/pax-km = 0.0298 \text{ kg/pax-km.}$

d) Find the maximum freight capacity each aircraft is able to carry in the TLC-NRT route above the full passenger load. State all your assumptions.

**Due to tire speed limits, no more cargo can be carried.**

### Problem 3

A Middle East airline would like to operate Airbus A380-800 from Washington Dulles International Airport to Dubai. The airline has several A380s in the fleet all powered by Power Alliance GP 7200 engines. If the airline has a version of the A380 (version WV005 in the Airbus Document for airport compatibility) with 520 seats and the aircraft has a maximum ramp weight of 562 000 kg, find:

- a) The maximum departure weight from ORD (limited by runway length). State the runway length needed at ORD using ISA+15 deg. conditions.
- b) If the aircraft departs ORD at ISA+15 deg. conditions, what is the maximum range the aircraft can fly while carrying 520 passengers and no extra cargo. State the takeoff weight used.

- c) If the aircraft departs ORD at ISA+15 deg conditions, what is the maximum cargo capacity the aircraft can carry above the 520 passengers. State the takeoff weight used.
- d) For condition (b) estimate the fuel consumption per passenger per kilometer for the trip. Also estimate the specific air range (SAR) expressed as the number of miles flown for each kilogram of fuel used.
- e) Find the CO<sub>2</sub> contribution per passenger during the trip in part (d). For each gallon of fuel burn, aircraft produce 9.6 kilograms of CO<sub>2</sub> (ref. [http://www.eia.gov/environment/emissions/co2\\_vol\\_mass.cfm](http://www.eia.gov/environment/emissions/co2_vol_mass.cfm)). Jet fuel specific weight is 0.785 kg/liter.