Assignment 3: Runway Length Analysis (Solution)

Date Due: February 11, 2015 Instructor: Trani

Problem 1

The San Diego International Airport would like to request your services to estimate if an airline can operate a new nonstop service San Diego to Shanghai Pudong International Airport (PVG) using Boeing 787-9 with General Electric engines and a maximum takeoff weight of 560,000 lb.

a) Find the route distance from San Diego (SAN) to Shanghai (PVG). Use a 5% detour factor above the Great Circle Distance (GCD).

Distance = 6,015 nautical miles (with detour factor included)

b) Find the runway length needed to operate this non-stop service from SAN. Assume the aircraft has a two class configuration.

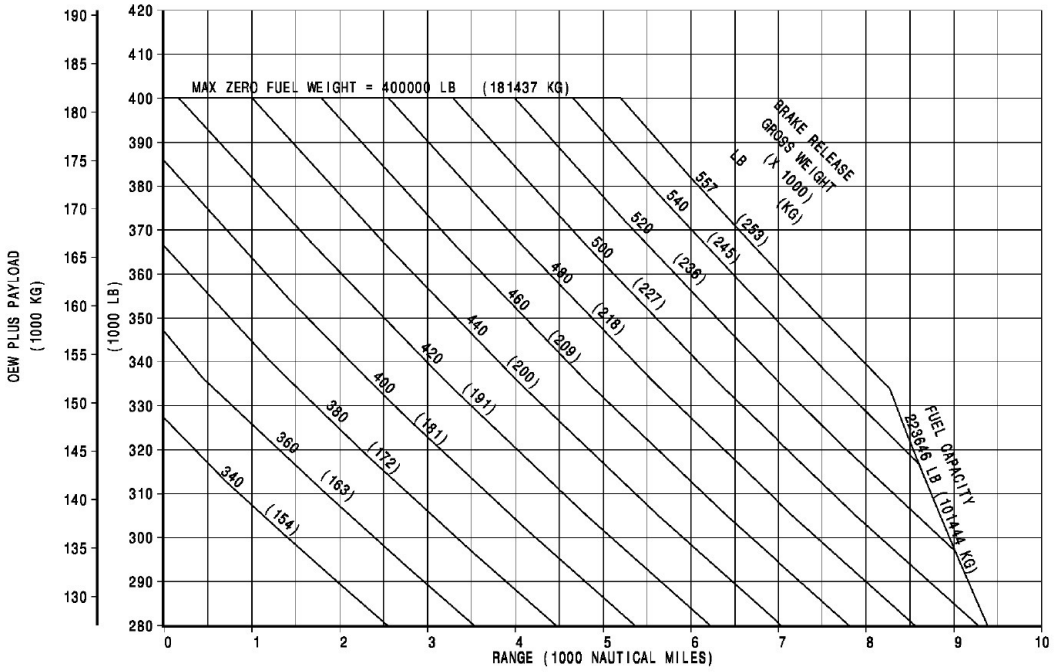
Design temperature is 77 degree F. ISA temperature is 59 deg. F. Hence use ISA + 20 deg. F (if available) or above curves in your design procedure. Boeing provides charts for ISA + 15 deg. C or ISA + 27 deg. F. I used these charts in the analysis.

OEW = 284,000 lb (128,850 kg)

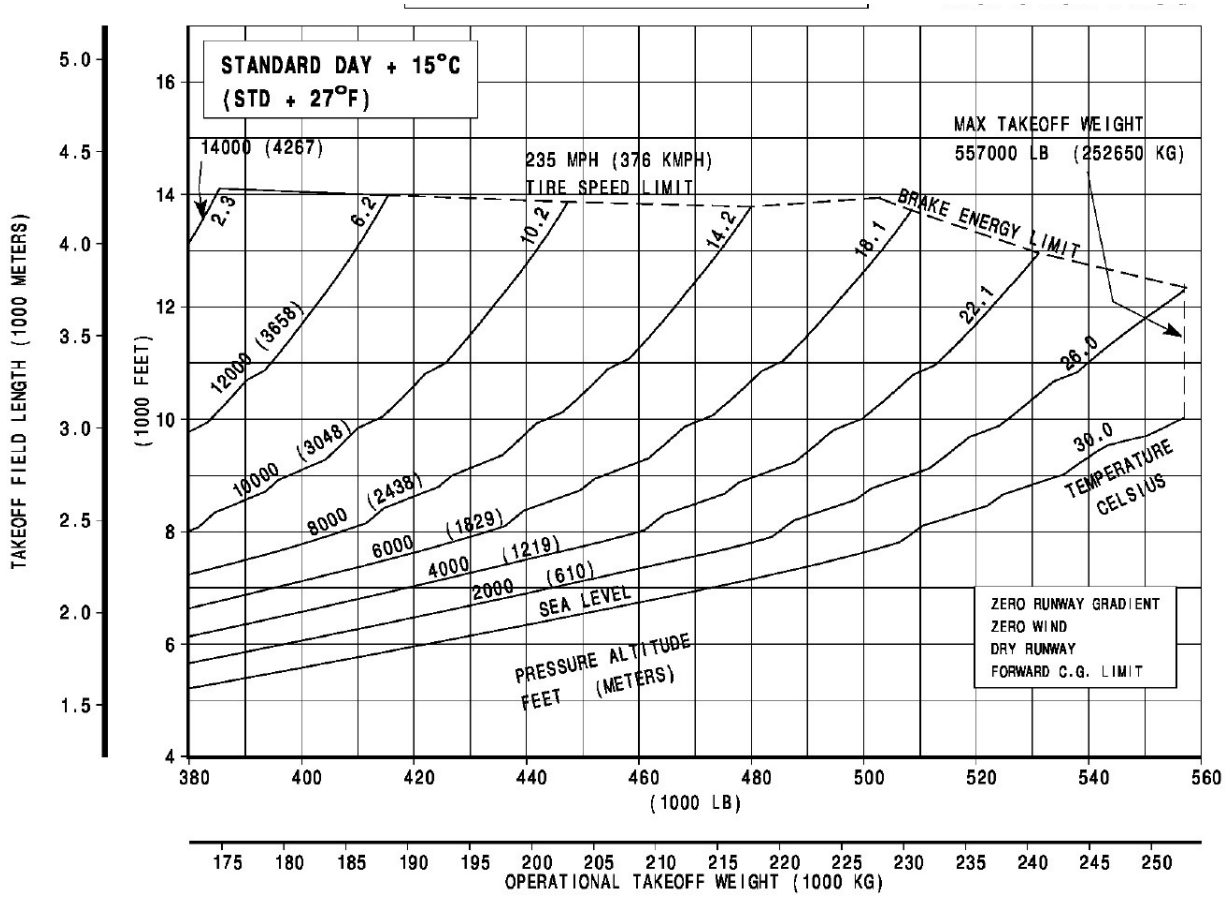
PYL = 63,800 lb (29,000 kg)

OEW + PYL = 347,800 (157,850 kg)

Use payload-range diagram with OEW + PYL given above and 6,015 nm in the range axis. Obtain a Desired Takeoff Weight (DTW) of 510,000 lb (231,820 kg).



Boeing 787-9 Payload Diagram. Source: Boeing.



Boeing 787-9 Runway Performance. Source: Boeing.

RL takeoff dominates = 8,000 feet with dry pavement (no correction)

RL takeoff (wet conditions) = 9,200 feet with wet pavement correction.

Grade correction = 0 (no slope given in airnav.com)

c) Look at the existing runway conditions at SAN. Do you need a runway extension? Comment.

No extension needed.

d) With the existing runway and full passengers estimate the maximum "belly cargo" load the Boeing 787-9 could carry departing from runway 27 at San Diego.

Work the problem backwards. With a 9400 foot runway corrected for wet pavement conditions equates to 8174 feet (uncorrected). Look at the runway length performance diagram above and read a maximum takeoff weight of 236,000 kg (520,000 lb). The maximum additional cargo is 10,000 lb.

Problem 2

A new international airport has been considered for San Diego. Estimate the runway length requirement for the same Boeing 787-9 departing San Diego but, in your new design, provide maximum flexibility for the airline to operate the aircraft at maximum takeoff weight. Use the Boeing 787-9 with General Electric engines and a maximum takeoff weight of 560,000 lb.

a) Find the runway length needed to operate the Boeing 787-9 from the proposed new airport. Assume the aircraft has a two class configuration.

The runway length needed at MTOW is 10,000 feet (see diagram above). This runway length is uncorrected for wet pavement. If a 15% correction fact is added, the runway length is 11,500 feet.

b) Compare the runway length requirements found in part (a) with those found in Problem 1(b). Compare your answers.

The new design provides more flexibility to operators. This at a cost.

Problem 3

Use Google Earth and refer to the Charleston, WV airport to answer the questions below. The airport has an EMAS installed on runway threshold 5. Check that out using Google Earth.

Figure 2. Lockheed C130 Hercules. source: https://en.wikipedia.org/wiki/Lockheed_C-130_Hercules#/media/File:Lockheed_C-130_Hercules.jpg

CRW had a 400 foot EMAS at runway 5 threshold (Google Earth). This is shown below. Note: The area around the EMAS suffered a slope stability failure in 2015 (article with engineering details: http://www.wvgazettemail.com/assets/PDF/CH6236321.pdf)

a) Find the approximate length of the EMAS installed at CRW on runway end 5. use the Google Earth measuring tool.

Before the geotechnical failure it was 400 feet.

b) Estimate the length of an EMAS system to stop an aircraft of the size of the Lockheed C130 - Hercules (Takeoff weight is 150,000 lbs.). Refer to FAA AC 150/5220-22A available on our home page. Use the recommended FAA design speed for the EMAS design.

Use figure A2-3 and the EMAS designed for a Boeing 737-400 (150 lbs of weight) is 400 feet.

c) Is the EMAS installed at CRW consistent with your design found in part (b)? Explain.

Yes they are the same length.

d) Estimate the accelerate and stop distance available (ASDA) for an aircraft departing runway 5 at CRW. In your analysis consider that the runway safety area on the departure end of the runway needs to be protected. The critical aircraft for the airport is the Lockheed C130 Hercules flown by the US National Guard at CRW.

The RSA for the critical aircraft is 1,000 feet. The ASDA is estimated to be **5,800 feet** (6,800 ft - 1,000 ft of RSA). RSA needed at the end of the runway is 600 feet for the critical aircraft.

e) What is the length of the RSA considered in part (d)?

1,000 feet needed at the departure end of the runway.

Problem 4

An airline is studying adding new regional jet services from Charleston, WV airport to Orlando International airport in Florida. The airline has Embraer 175 (standard version) with CF-34-8E5 engines (similar to the aircraft shown in Figure 1). The aircraft belonging to the airline have a maximum takeoff mass of 37,500 kg and seat 78 passengers. The airline flight planning department estimates 4500 kg of fuel for the trip to Orlando (using average fuel burn for planning purposes is 32 kg/minute plus fuel reserves).

Figure 1. Embraer 170 on Final Approach to Chicago O'Hare International Airport. source: A.A. Trani.

a) Estimate if the existing runway at CRW is long enough to support this operation in a hot summer day.

Use 85 deg. F as design temperature. This is 15 deg. C above ISA.

OEW = BOW = 21,500 kg

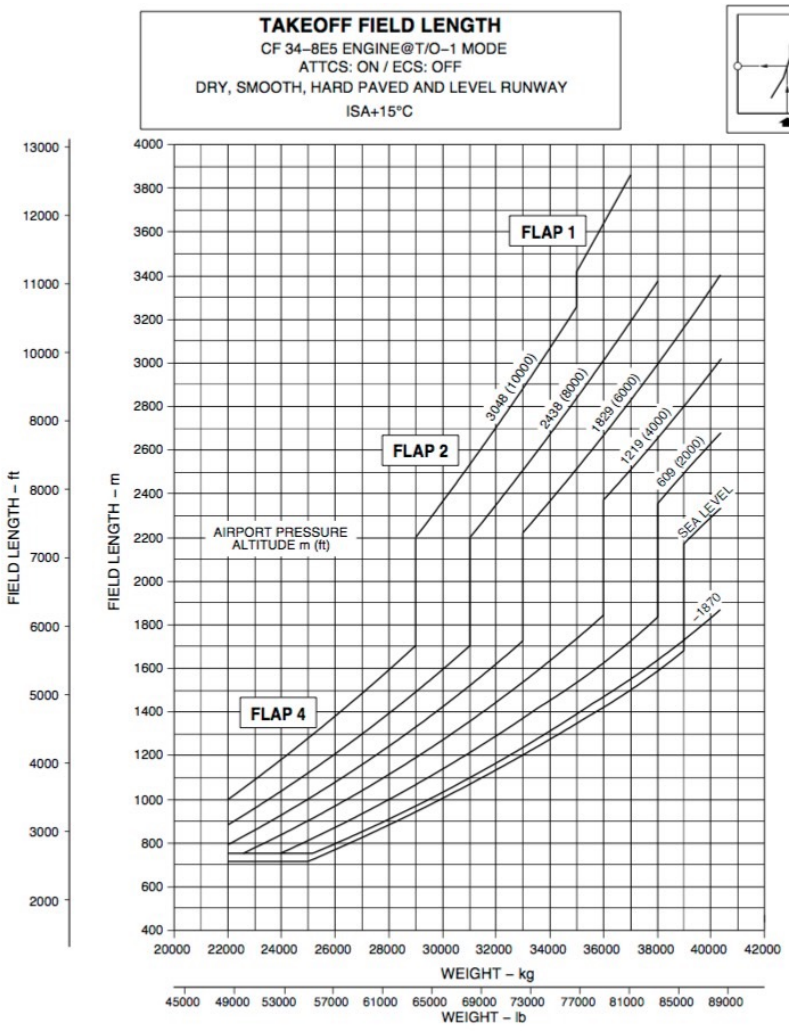
PYL =7,800 kg

FW = 4,500 kg (given)

DTW = OEW + PYL + FW = 33,800 kg

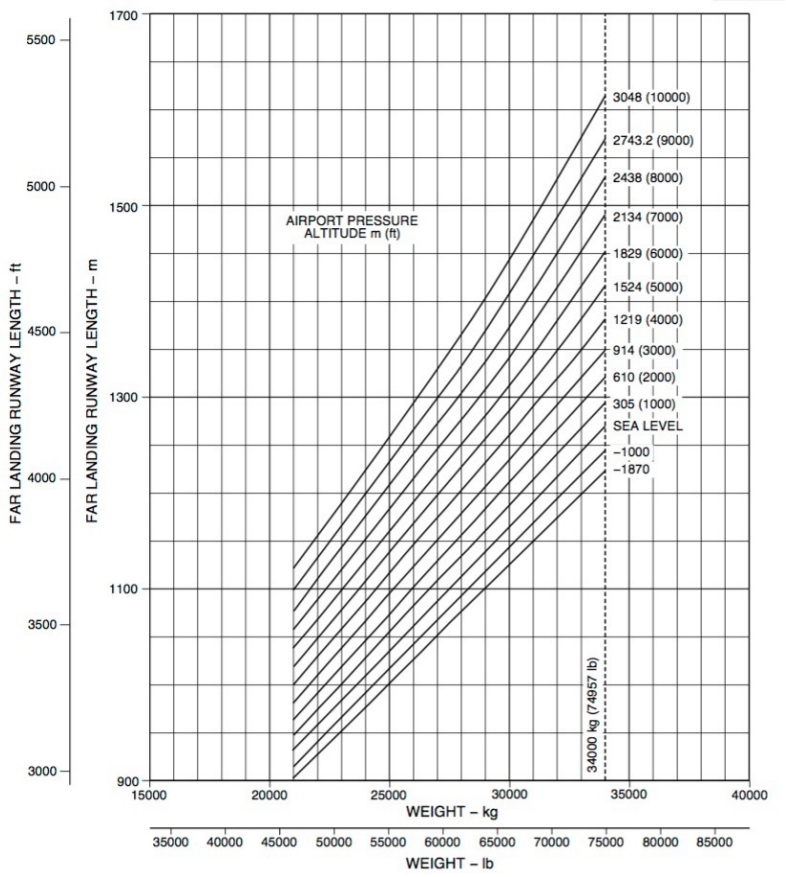
Runway length (takeoff) - 1400 meters (dry conditions) or 1,610 meters (wet pavement) (5,280 feet).

Runway length (landing) ~ 1,300 meters (dry conditions) or 1495 meters (wet pavement).



Takeoff Field Lengths - ISA + 15 °C Conditions
Figure 3.6

Embraer 175 Takeoff Runway Length Chart.



Embraer 175 Takeoff Runway Length Chart.

The aircraft is able to operate from CRW for the give stage length using both wet and dry design conditions.

b) How much extra payload can the airline carry before the runway length at CRW is reached?

Using dry conditions, the maximum takeoff runway length will be DTW ~ 38,000 kg. This means the aircraft could carry around 4,000 kg of extra cargo.