Assignment 2: Runway Length Analysis

Date Due: September 8, 2021 at 5:00 PM via Canvas. Instructor: Trani

Reading Assignment: Review Chapters 1 and 2 of the FAA Advisory Circular 150/5325-4b. Also review the course notes Aircraft Runway Length Estimation.

Problem 1

Design the runway length for a new General Aviation airport to be constructed at a site located 2,850 feet above sea level. Data from a temperature survey indicates a mean daily maximum temperature of the hottest month of 85 degree F. The aircraft fleet mix expected to operate at the airport is shown in Table 1. The airport is expected to serve single, multi-engine piston aircraft and single-engine turboprop aircraft like the Pilatus PC-12. All aircraft weigh less than 12,500 lbs at maximum takeoff gross weight.

Table 1. Expected Aircraft Fleet at Proposed General Aviation Airport. Aircraft in Boldface Text is shown in the Picture.

Aircraft Type	Typical Aircraft	Sample Picture
Single Engine Piston	**Cirrus SR-22 (4 seats),** Cessna 182 Cessna 172	
Multi-engine Piston	**Beechcraft Baron 58 (6 seats)**	
Turboprop Aircraft	**Pilatus PC-12 (9 seats)**	

a) Use the design charts in the FAA 150/5325-4b to find the recommended runway length required to serve the aircraft fleet listed in Table 1.

95 Percent of Fleet: 4,300ft (95% of fleet blue line)

100 Percent of Fleet: 4,800ft (100% of fleet blue line)

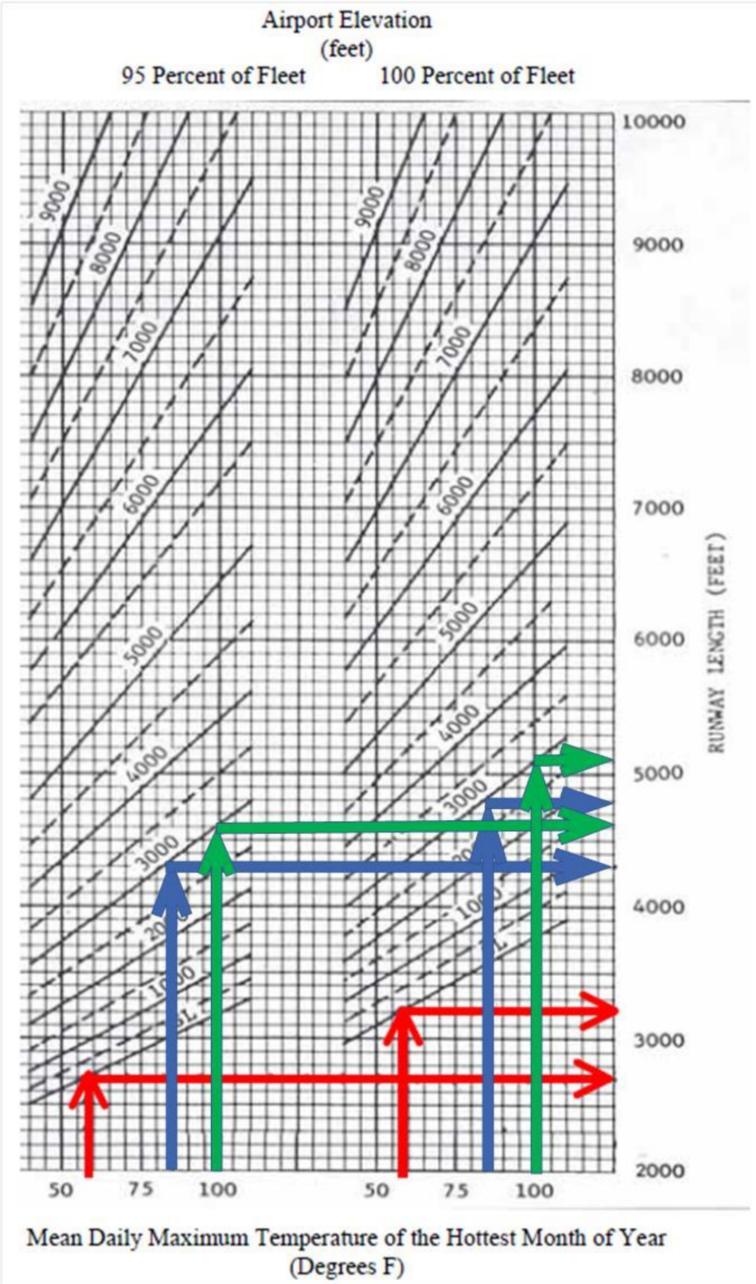
b) Find the sensitivity of the runway length required if the airport design temperature is 100 degrees F. State the additional runway length under the new design temperature.

95 Percent of Fleet: 4,600ft

The additional runway length under the new design temperature is 300ft (95% of fleet green line)

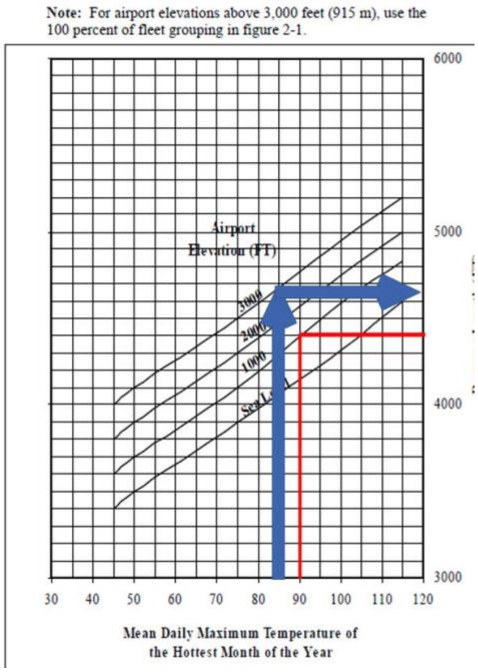
100 Percent of Fleet: 5,100ft

The additional runway length under the new design temperature is 300ft (100% of fleet green line)



c) Estimate the runway length to support turboprop aircraft such as the Raytheon King Air E90 (shown in Figure 1). **The King Air B200 carries up to 10 passengers plus two pilots**.

4,700ft (blue line)



d) Comment on the differences found in parts (a and c).

Assume this general aviation airport will be constructed to serve medium size population (95% of fleet). The runway length is not enough if they have a greater potential for increased aviation activities, such as adding Raytheon King Air E90 to the aircraft fleet mix.

Figure 1. Raytheon King Air B200 (A. Trani).

Problem 2

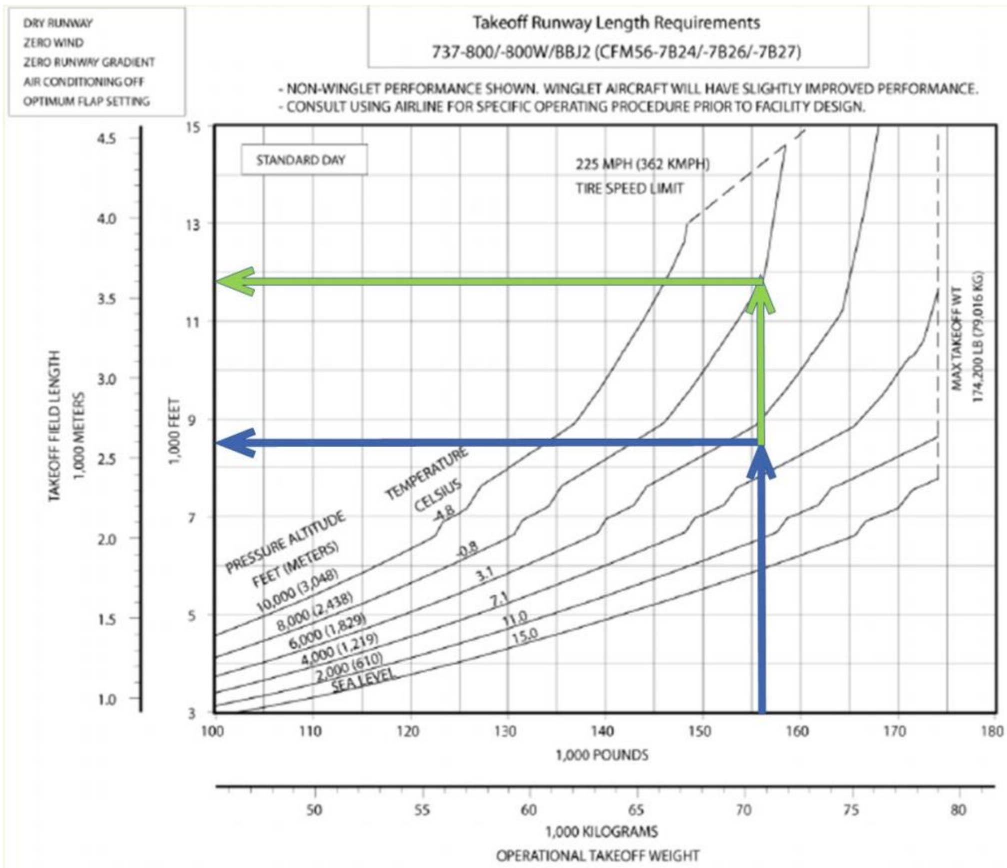
Refer to the figure on page 28 of the "Aircraft Runway length Estimation" notes to answer the questions. the figure contains takeoff field length (takeoff runway length) for a Boeing 737-800 (see Figure 2).

a) For a flight from Denver International (DEN) to San Diego (SAN), with a takeoff weight of 156,000 lbs, find the takeoff field length required. Assume the pressure altitude of Denver is 5,200 feet.

8,500ft (blue line)

b) If an airline operates the same aircraft from Toluca International Airport (in México), find the takeoff field length required. Toluca has a pressure altitude of 8,000 feet and the airline expects a takeoff weight of 156,000 lbs.

11,800ft (green line)



c) Compare the results obtained in parts (a-b) with the same aircraft departing Boston (BOS) at 156,000 lbs. Comment on the effect of airfield elevation (or pressure altitude) on the takeoff distance required.

As the airfield elevation increases, the density of atmosphere decreases. Based on the following equation, thrust will diminish and so does aircraft acceleration. The aircraft requires a longer runway to accelerate to the same decision speed at higher airfield elevation. However, at higher airfield elevation, the takeoff speed increases due to less lift generated at lower density, hence the runway length increases non-linearly with airport elevation.

Figure 2. Boeing 737-800 (A. Trani).

Problem 3

a) Explain in your own words, the causality (e.g., X causes Y) between runway length and airfield elevation. To help you explain use the fundamental equation of motion explained in class - (see equation 2.10 in handout).

Same with problem 2 (part c)

As the airfield elevation increases, the atmospheric density decreases. Based on the following equation, thrust will diminish and so does acceleration. So, aircraft requires a longer runway to accelerate to the same decision speed. The takeoff speed increases at higher elevation. Here we see the same double penalty effect.

$$a_x = \frac{1}{m}\left(T(V,\rho) + \frac{1}{2}\rho V^2 S\left(C_L f_{roll} - C_D\right) - mg f_{roll}\right) \quad (2.10)$$

b) Use the results obtained in Problem 2(part c) to explain the causality between runway length and aircraft takeoff weight. Support your explanation using equation 2.10 in the course notes.

As the aircraft takeoff weight increases, the numerator decreases (mgf_{roll}) and the denominator increases. This means that the acceleration will be diminished. So, aircraft requires a longer runway to accelerate to the same decision speed.