Assignment 2: Runway Length Analysis

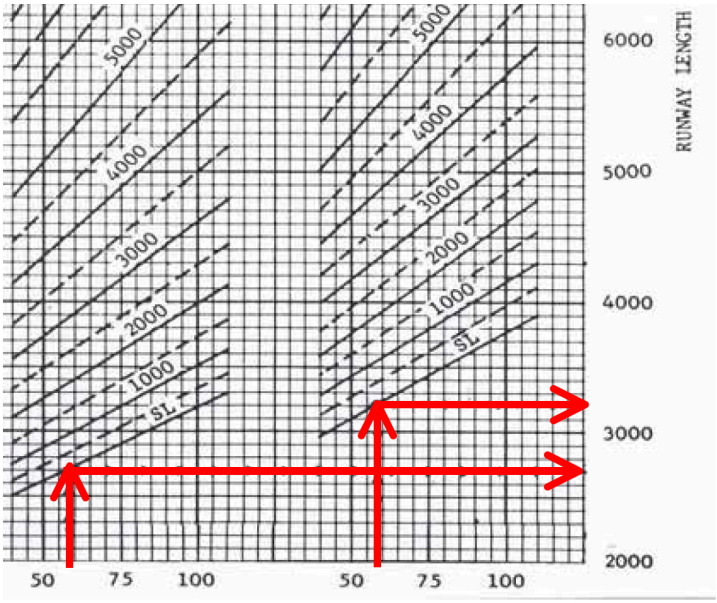
Solution Instructor: Trani

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 2,500 feet above sea level. Data from a temperature survey indicates a mean daily maximum temperature of the hottest month of the year is 80 degree F. The airport is expected to serve single, multi-engine piston aircraft, and turboprop aircraft with **less than 10 passenger seats**. All aircraft weigh less than 12,500 lbs. at maximum takeoff gross weight. Use 100% of the fleet below 12,500 lbs is expected to be served at the airport.

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



Mean Daily Maximum Temperature of the Hottest Month of Year
(Degrees F)

Using Figure 2-1 in the FAA AC 150/5325-4B, the airport needs a 4,500-foot long runway to serve 100% of the small aircraft fleet with fewer than 10 seats.

b) Revise the solution to part (a) if the runway is also expected to support turboprop aircraft with more than 10 passenger seats. An example of such aircraft is the Raytheon King Air **B300 which carries up to 12 passengers plus two pilots**.

I would accept two answers here:

1) New versions of the King Air B300 have a maximum takeoff gross weight above 12,500 lbs. Technically we should use the design charts in Chapter 3 of the FAA AC 150/5325-4B.

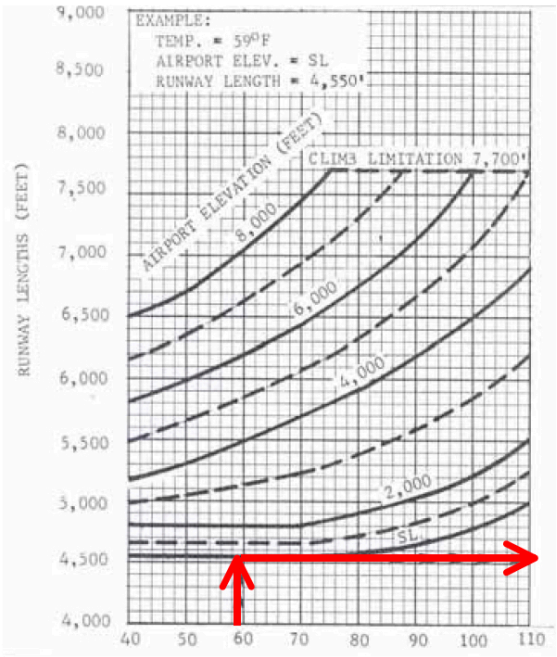
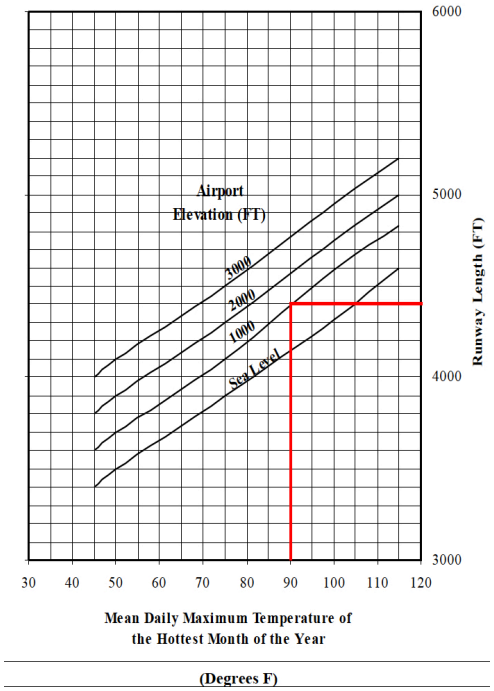


Figure 3-1 with 60% Useful Load.

According to Figure 3-1, the airport needs a 5,300 foot long runway to serve aircraft with 10 seats or more and MTOW above 12,500 lbs.



2) Use the design chart in Chapter 2 (Figure 2-2 reproduced below). The chart applies to small aircraft with 10 seats or more.According to Figure 2-2, the airport needs a 4,500 foot long runway to serve small aircraft with 10 seats or more.

c) Comment on the change in runway length required with the King Air B300.

Using Chapter 2 figures, there is no change in the runway length for the King Air B300. However, some versions of the King Air weight more than 12,500 lbs and would require a 5,300 foot runway if we use the charts in Chapter 3 (applicable to aircraft with MTOW > 12,500 lbs). To solve this ambiguity, the use of SARLAT is recommended.

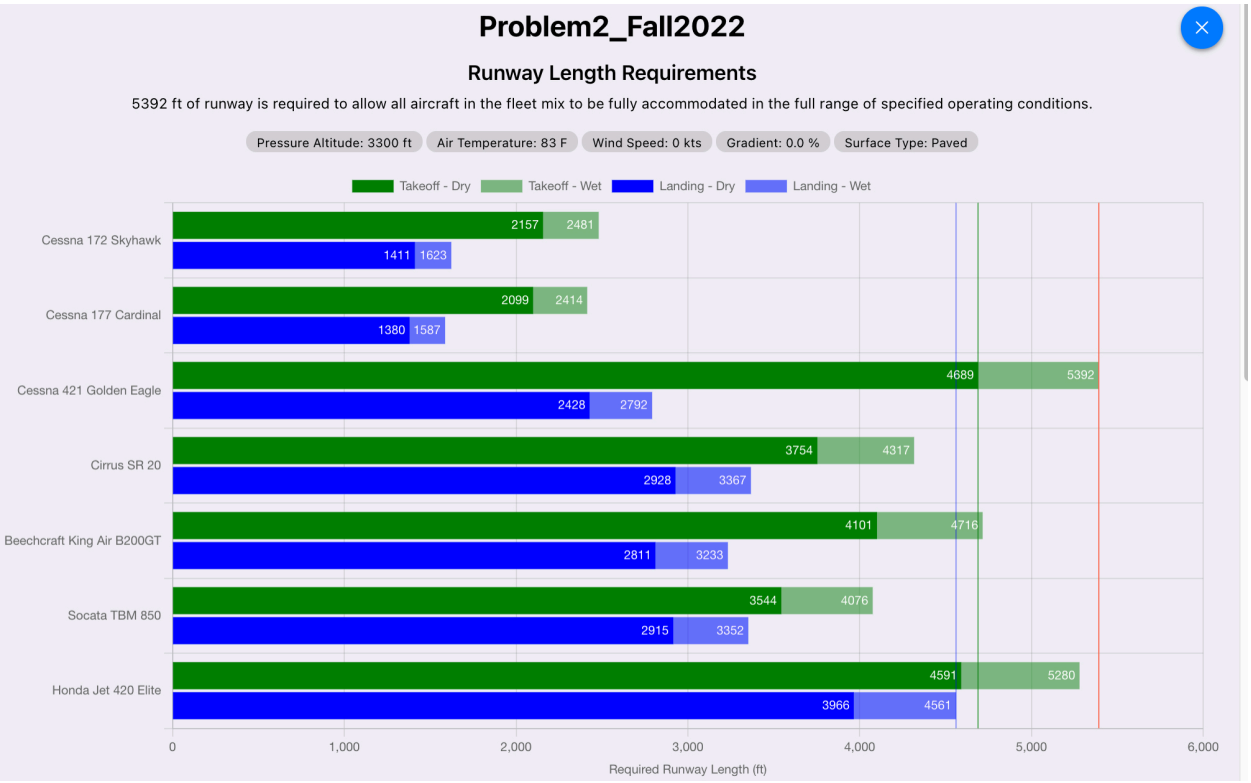
Problem 2

Use the recently developed Small Aircraft Runway Length Analysis Tool (SARLAT) to **design a new runway** to be constructed at a site located 3,300 feet above mean sea level conditions. The average of the maximum daily temperatures of the hottest month of the year is 83 degrees F. The airport is expected to serve single, multi-engine piston, turboprop and jet powered aircraft (see Table 1). In your analysis, consider all the aircraft listed in the second column (Typical aircraft).

Table 1. Aircraft Fleet Mix for Problem 2.

Aircraft Type	Typical Aircraft
Single Engine Piston	**Cessna 177** Cessna 172 Cirrus SR 20
Multi-engine Piston	**Cessna 421C**
Turboprop Aircraft	**Socata TBM 850** Beechcraft King Air B200GT
Jet Aircraft	**Honda Jet 420**

a) Find the required runway length needed to satisfy the runway performance requirements of the fleet mix in Table 1. For the critical aircraft, list the following runway lengths: 1) dry runway takeoff distance, 2) wet runway takeoff distance, 3) dry landing distance, and 4) wet landing distance.



Critical aircraft for takeoff (wet and dry runway) is the Cessna 421C. Critical aircraft for landing (wet and dry) is the Honda Jet 420.

Note: The FAA Airport Improvement Program (AIP) pays for a **dry takeoff runway** and a **wet landing runway**. Find the runway length that could be supported through the FAA AIP Program. State the critical aircraft.

FAA will pay for a 4,700 foot runway (4,689 ft obtained in SARLAT) rounding to the nearest 100 ft for takeoff (dry pavement) and 4,600 feet (4,561 feet in SARLAT) rounding for wet landing conditions. The runway length required is 4,700 feet.

b) If the airport client wants to pay additionally for a runway that satisfies wet takeoff and landing conditions , estimate the runway length needed. State the critical aircraft.

The runway that satisfies the wet pavement takeoff design conditions for the critical aircraft (Cessna 421C) is 5,400 feet. The airport authority will have to pay for an additional 700 feet of runway.

c) Show the SARLAT bar chart of runway length requirements for each individual aircraft for your solution. (done above)

d) Name the single-engine, piston-powered aircraft of the fleet mix that requires the longest runway length.

The Cirrus SR-20 is the most critical single-engine piston aircraft in the fleet mix.

Problem 3

Use the Small Aircraft Runway Length Analysis Tool (SARLAT) to **evaluate a runway extension** for an airport to serve large turboprop and business jet aircraft. The existing airport has a 4,550 foot runway and an airfield elevation of 2,200 feet above mean sea level conditions. The runway has a grade of 0.3%. The average of the maximum daily temperature of the hottest month of the year is 80 degrees Fahrenheit. Table 2 shows the existing aircraft fleet mix operating at the airport.

Table 2. Existing Aircraft Fleet Mix for Problem 3.

Aircraft Type	Aircraft	Percent of Fleet Mix (%)
Piston	Cessna 172	60
Piston	Beechcraft Baron 58	20
Turboprop	Socata TBM 850	20
Total		100

The airport manager would like to improve the airport business by attracting business jets (Cessna Citation 560 XL) and large turboprops (King Air B350ER). **Your job is to estimate the benefit of increasing the runway length by 1,000 feet to accommodate the larger aircraft.** Table 3 illustrates the future fleet mix for the airport once business jets and the turboprops are added to the mix.

The current situation is that all the aircraft can operate at a useful load of 100%. The 4,550 foot runway is adequate for the existing fleet mix.

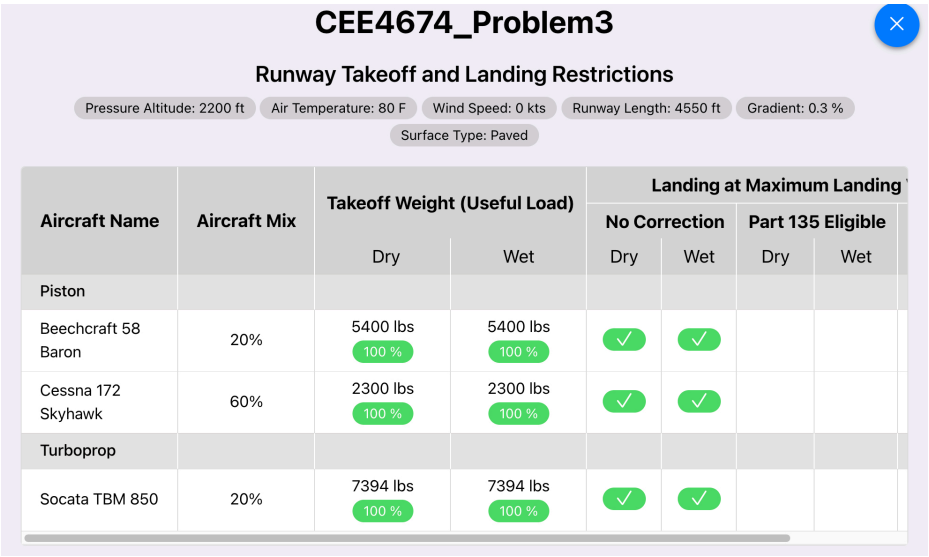


Table 3. Future Aircraft Fleet Mix for Problem 3.

Aircraft Type	Aircraft	Percent of Fleet Mix (%)
Piston	Cessna 172	40
Piston	Beechcraft Baron 58	15
Turboprop	Beechcraft B200GT	15
Turboprop	Beechcraft B350ER	10
Turboprop	Socata TBM 850	10
Jet	Cessna 560 560 XL	10
Total		100

Yellow rows indicate new aircraft to be attracted to the airport after runway extension.

a) For dry runway conditions, find the takeoff weight and useful load for the Beechcraft King Air B350ER and the Cessna 560XL operating from the existing runway (i.e., 4,550 feet).

CEE4674_Problem3_EnhancedFleet_Mix

Runway Takeoff and Landing Restrictions

Pressure Altitude: 2200 ft | Air Temperature: 80 F | Wind Speed: 0 kts | Runway Length: 4550 ft | Gradient: 0.3 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	Takeoff Weight (Useful Load)		Landing at Maximum Landing Weight					
				No Correction		Part 135 Eligible		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston									
Beechcraft 58 Baron	15%	5400 lbs 100 %	5400 lbs 100 %	✓	✓				
Cessna 172 Skyhawk	40%	2300 lbs 100 %	2300 lbs 100 %	✓	✓				
Turboprop									
Beechcraft King Air 350ER	10%	12856 lbs 40 %	10883 lbs 8 %	✓	✓			✓	✗
Beechcraft King Air B200GT	15%	12500 lbs 100 %	12500 lbs 100 %	✓	✓			✓	✓
Socata TBM 850	10%	7394 lbs 100 %	7394 lbs 100 %	✓	✓			✓	✗
Jet									
Cessna 560 XL	10%	20020 lbs 98 %	18518 lbs 77 %	✓	✓	✓	✗	✗	✗

SARLAT Tool Results for the Existing Airport Conditions (4,550 feet runway).

The table shows that the King Air B350ER is limited to 40% useful load with a dry runway and 8% useful load with a wet runway. Takeoff weights are 12,856 and 10,883 lbs., respectively. The Cessna 560XL is able to operate at 98% useful load on a dry runway and 77% from a wet runway.

b) If the runway is extended to 5,550 feet, find the improved useful load parameters for the Beechcraft King Air B350ER and the Cessna 560XL.

CEE4674_Problem3_EnhancedFleet_Mix_5550ft

Runway Takeoff and Landing Restrictions

Pressure Altitude: 2200 ft | Air Temperature: 80 F | Wind Speed: 0 kts | Runway Length: 5550 ft | Gradient: 0.3 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	Takeoff Weight (Useful Load)		Landing at Maximum Landing Weight					
				No Correction		Part 135 Eligible		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston									
Beechcraft 58 Baron	15%	5400 lbs 100 %	5400 lbs 100 %	✓	✓				
Cessna 172 Skyhawk	40%	2300 lbs 100 %	2300 lbs 100 %	✓	✓				
Turboprop									
Beechcraft King Air 350ER	10%	15706 lbs 87 %	13731 lbs 55 %	✓	✓			✓	✓
Beechcraft King Air B200GT	15%	12500 lbs 100 %	12500 lbs 100 %	✓	✓			✓	✓
Socata TBM 850	10%	7394 lbs 100 %	7394 lbs 100 %	✓	✓			✓	✓
Jet									
Cessna 560 XL	10%	20200 lbs 100 %	20200 lbs 100 %	✓	✓	✓	✓	✗	✗

SARLAT Tool Results for Extended Runway (5,550 feet runway).

The King Air B350ER can operate at 87% and 55% useful load from dry and wet pavement conditions if the runway is extended to 5,500 feet.

c) Comment on the significance of adding 1,000 feet to the existing runway. Use the table below that applies to the Beechcraft King Air B350ER. More specifically, estimate the additional aircraft range that can be flown in the King Air B350ER after the runway extension.

With a dry runway and 4,550 feet, the King Air B350ER could carry 40% useful load. The table below shows the limited payload and range with 40% useful load (less than 100 nm with 10 passengers). Increasing the runway length to 5,550 feet, allows the King Air B350ER to carry 10 passengers over 1,000 nautical miles. The added runway provides a substantial operational capability to the aircraft.

Table assumes a full load of passengers except when mission range requires off loading passengers to carry more fuel.

For example: a mission range of 300 nm carrying 10 passengers is equivalent to 61.5% useful load for this aircraft.

Mission Range (nm)	Maximum Number of Passengers	Useful Load (%)
100	10	50.4
150	10	53.5
200	10	56.4
300	10	61.5
600	10	73.7
1000	10	87.0
1316	10	97.4
1400	10	100.0
1500	9	100.0
1600	8	100.0
1700	7	100.0
1800	6	100.0
1900	5	100.0
2223	3	100.0

All values in the table assume two pilots and 30 lbs of luggage for each pilot

Problem 4

Refer to the figure on page 69 of the " Aircraft Runway length Estimation" notes to answer the following questions. The figure contains the takeoff field length (takeoff runway length) for a Boeing 777-300ER (see Figure 2) operating under hot airport temperature conditions (ISA + 27 deg. Celsius).

a) For a flight from Dubai to Paris, with a takeoff weight of 650,000 lbs, find the takeoff field length required. Dubai is at sea level conditions

8,500 feet of runway needed..

b) One day the airline operates the same flight from Dubai to Paris but carries additional belly cargo (commercial aircraft can carry cargo in special containers) that increase the takeoff weight to 725,000 lbs. Estimate the takeoff field length required.

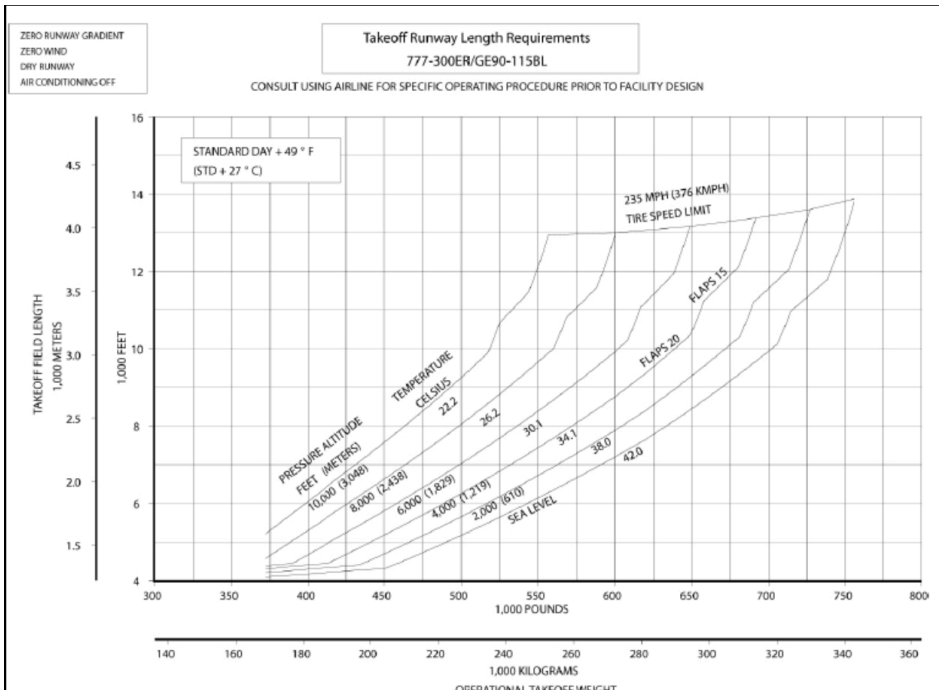
11,200 feet needed.

c) Comment on the results obtained in parts (a) and (b).

Adding 75,000 lbs of belly cargo increases the FAR takeoff field length by 32%.

d) Find the maximum operational takeoff weight departing Salt Lake City (~4,230 feet) on a hot summer day using the same chart.

Takeoff weight limited to 660,000 from Salt Lake City with 13,300 ft of runway needed.



e) For part (d) find the runway length needed departing Salt Lake City on a hot summer day.

Runway length needed = 13,300 feet limited by tire speed limits.