Quiz 1 - Take Home

Open Notes and Internet

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Instructions

Create a solution file using the word processor of your choice. Convert to PDF and submit to Canvas. Include all screen captures of all your work including aircraft manufacturer's tables and figures, FAA nomographs and others.

Honor Code Pledge

The information provided in this exam is my own work. I have not received information from another person while doing this exam.

_____ (your signature/name)

Problem #1 (40 points)

An airline is evaluating flying from Sacramento (SMF) to several Asian destinations including Seoul Incheon Airport (South Korea) and Tokyo Narita Airport (in Japan). The airline is exploring using Boeing 787-10 aircraft with characteristics provided in Table 1.

In your analysis use the latest version of the Boeing documents for airport design. Add 6% to the distance calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the shortest flight path.

Table 1. Critical Aircraft Used in the Re-design of LAX Runway 24R.

Airport Design Aircraft
Boeing 787-10 with Rolls-Royce engines.
Rolls-Royce engines with **typical thrust rating**.
Aircraft maximum design takeoff weight is 560,000 lb.
Aircraft has a **mixed class seating configuration**.

a) Estimate the Operating Empty Weight (OEW) from the Payload-Range diagram for this aircraft. Consult homework 2 solution if needed.

OEW = 300,000 lbs (136,078 kg) using the bottom of the Y-axis of the payload-range diagram of the Boeing 787-10.

b) Find if a runway extension is needed at Sacramento to allow the airline to fly the longest of the two proposed routes. The airline would like to carry 100% of passengers and an additional 30,000 kilograms of cargo in the form of belly cargo (State the airport design temperature, airport elevation and other environmental conditions and assumptions used in your calculations. State the figure(s) used in the aircraft manufacturer documents (a screen capture would be useful).

SMF-ICN is the critical stage length (4902 nm) using the Global Great Circle Mapper application

Design range is then 5,196 nm (just round to 5,200 nm).

DTW = PYL + OEW + Fuel

Design temperature (using Climate Explorer) = 93.4 deg. F. (34 deg. C)

Sacramento is located 26.9 feet above mean sea level.

At sea level the ISA temperature is 15 deg. C or 59 deg. F

Hence the temperature profile to be used in the analysis is ISA + 19 deg. C

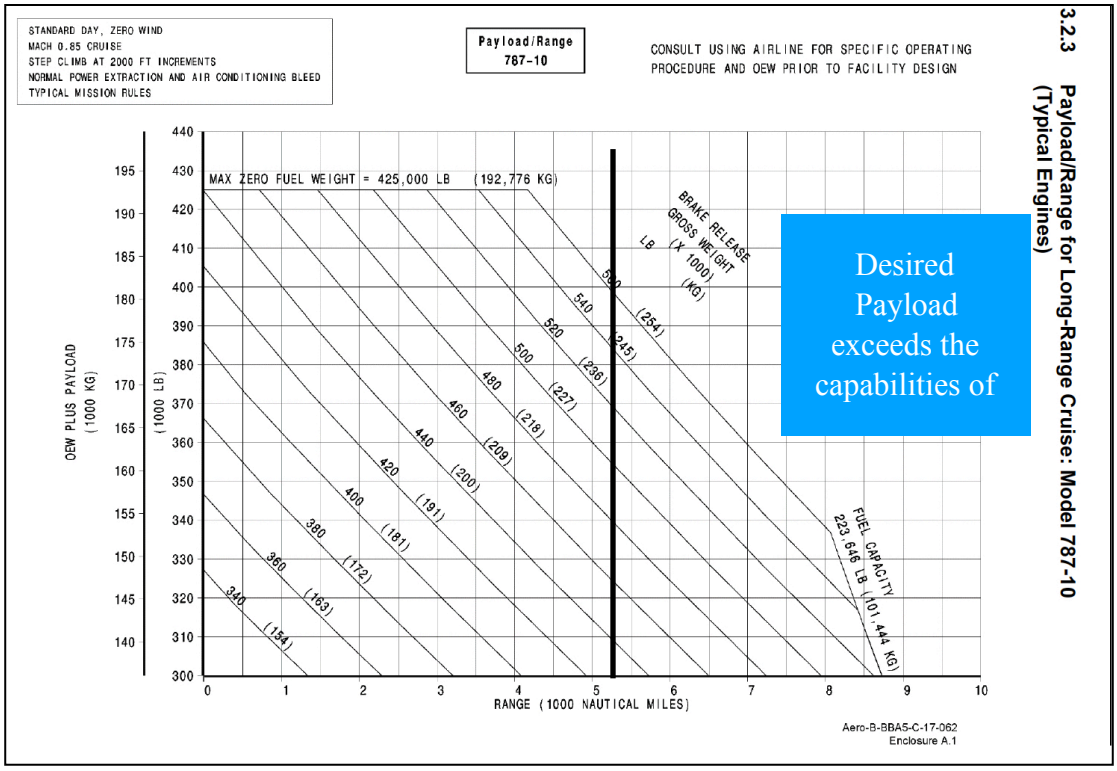
The closest performance charts from Boeing are ISA + 25 deg. C (note that ISA + 15 deg. C is not acceptable because is not within 1.7 deg. C of the desired design temperature).

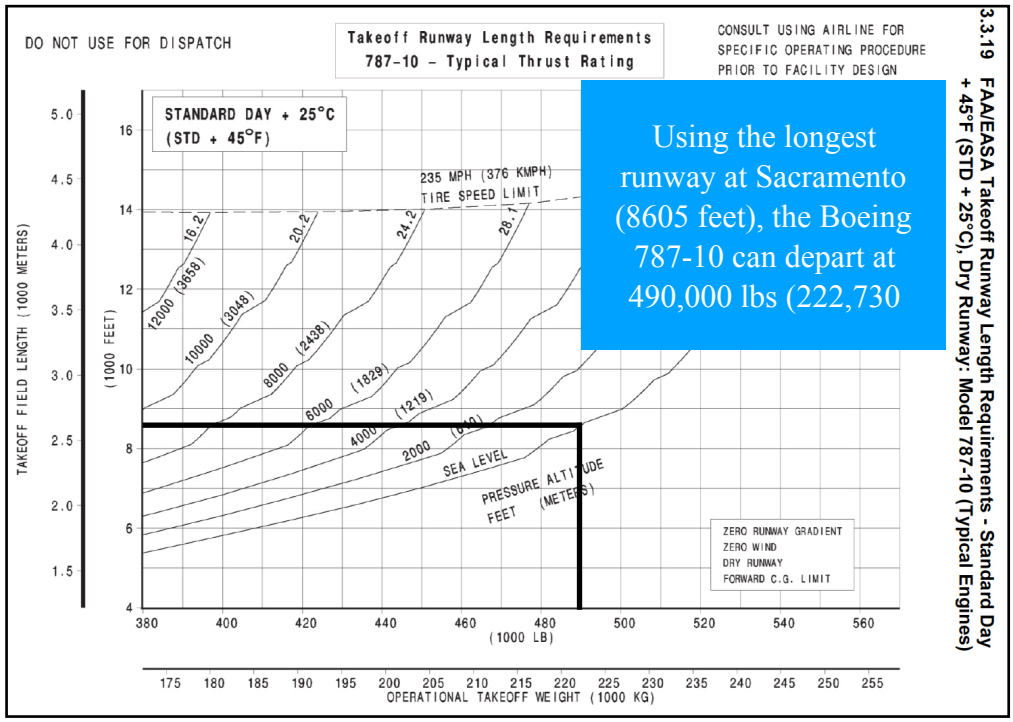
DTW = 136,078 + (337 seats) x 100 kg/passenger + 30,000 kgs (cargo) + Fuel = 199,778 kilograms (439,511 lbs) + Fuel

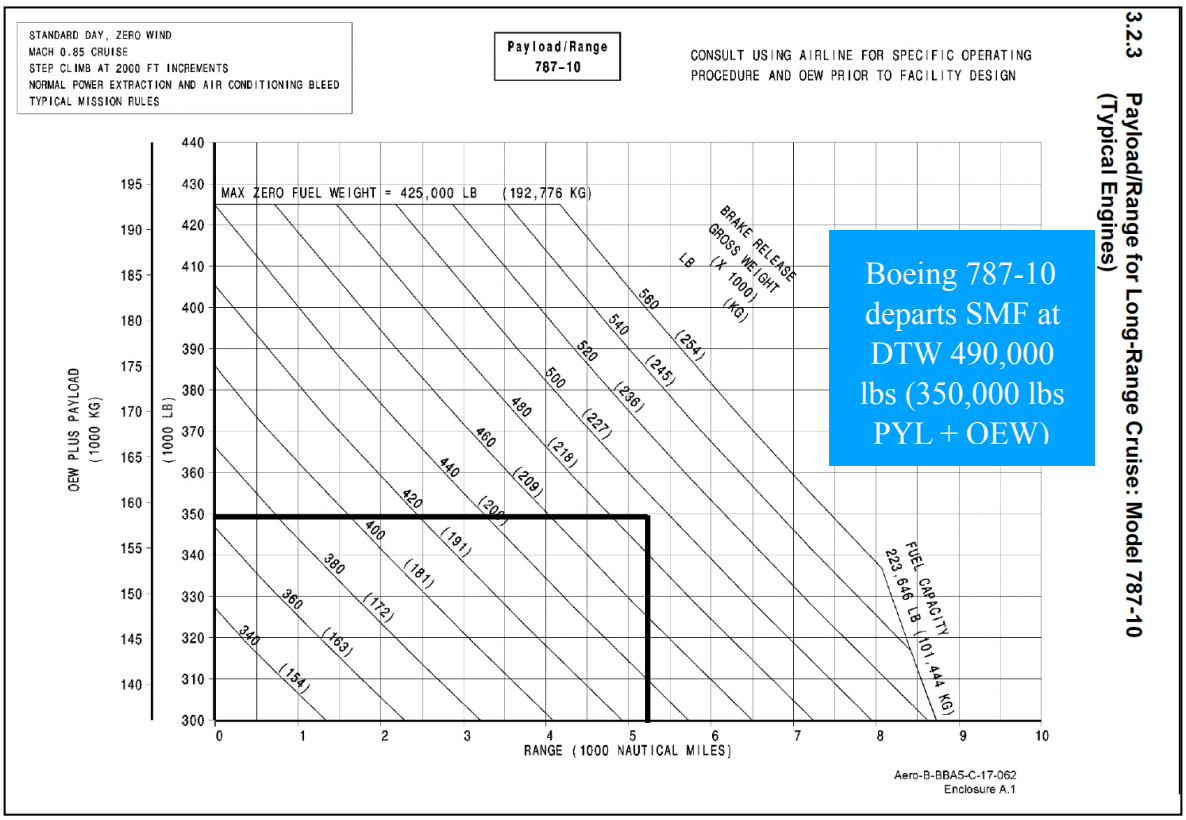
The airline wants to carry PYL = 63,700 kilograms (140,140 lbs).

Look at the payload-range diagram and the desired payload exceeds the capabilities of the aircraft. **The aircraft Cannot carry 30,000 kilograms of belly cargo.**

Look at the takeoff performance chart for the Boeing 787-10 at ISA+25 deg. C. The aircraft can depart Sacramento's longest runway (8,605 feet) at DTW 490,000 lbs (222,730 kgs).







SMF runway length (8,605 feet) restricts the aircraft departure weight to 490,000 lbs (350,000 lbs PYL+OEW).

Recall: OEW = 300,000 lbs

Hence the aircraft can only carry 50,000 lbs (227 passengers) using the existing runway. This is a severe limitation. A runway extension is needed.

c) Estimate the fuel per passenger to fly a full load of passengers in the critical route.

You can obtain the fuel per passenger by dividing the Fuel weight by the number of passengers.

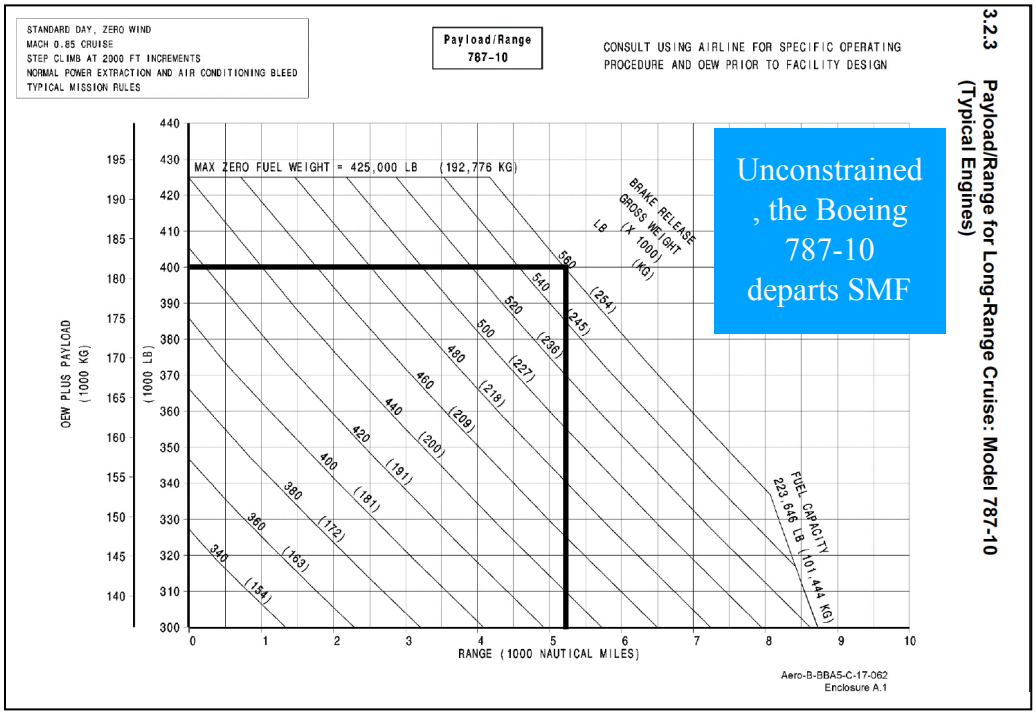
The solution varies depending upon the assumption on whether the aircraft is fully loaded or restrricted. For the current runway length.

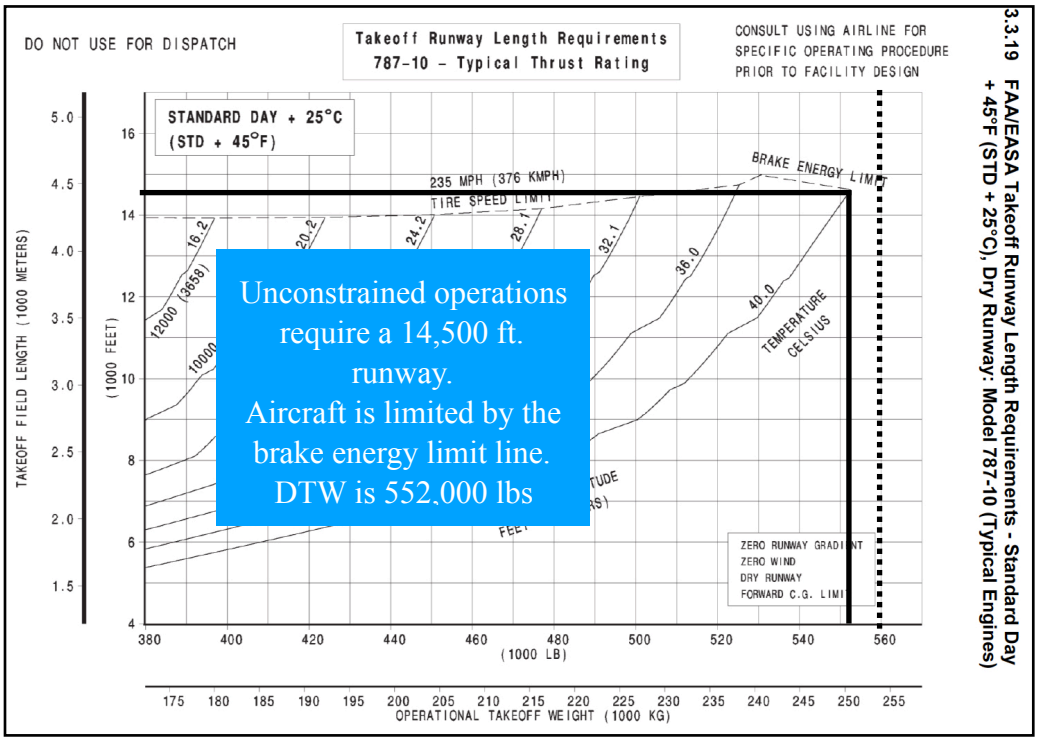
Fuel = 490,000 - 300,000 - 50000 = 140,000 lbs of fuel.

With 227 passengers, the fuel per passenger is 616 lbs.

d) Find the unconstrained (i.e., maximum takeoff weight) runway length needed to operate the Boeing 787-10 from Sacramento using the design temperature conditions of the airfield. Compare the constrain design (Part a) with the unconstrained solution. Comment.

The maximum takeoff weigh of the aircraft is listed at 560,000 lbs (see payload range diagram or tables). The aircraft, however, is limited to a 14,500 ft runway by brake energy limits. The maximum departure weight is 552,000 lbs. (395,000 lbs = PYL + OEW). With a 14,500 ft long runway, the aircraft can carry 95,000 lbs of payload. 95,000 lbs of payload is good for 337 passengers + 9.1 metric tons of belly cargo.





Problem # 2 (30 points)

Several years ago, the Charleston (WV) Yeager Airport (CRW) experienced a geotechnical collapse of a retention wall on runway 5 end (see Figure 1). The collapse took down the EMAS system. Your job is to define the characteristics of the new EMAS system using the most recent fleet mix at Yeager Airport.

a) Aircraft operating at Yeager today include the Bombardier CRJ-200, CRJ-700 and the CRJ-900 aircraft. Design the dimensions of an EMAS system that is capable of stopping such aircraft at the recommended runway exit speed. If some aircraft in the fleet at CRW are not included in the EMAS data provided by the FAA, provide a rational design method using similar aircraft in weight to those included in the FAA EMAS document. Explain your rationale. State the runway exit speed used and the EMAS length.

Figure 1. Charleston (West Virginia) Airport Runway 5 end after geotechnical collapse of retention wall.

Table 1. with EMAS length solutions for various aircraft

Aircraft	MTOW (lbs)	EMAS length (feet)
Bombardier CRJ-200	53,000	330
Gulfstream G-III	69,700	430
Douglas DC-9	114,000	380
Bombardier CRJ-900	84,500	**400-430 feet is a good estimate**

b) If the largest commercial aircraft operating at CRW is the Bombardier CRJ-900, find the FAA Runway Design Code (RDC) of the airport.

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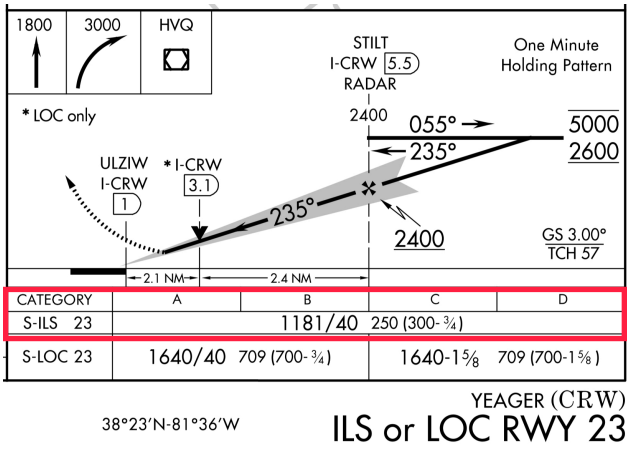
c) For CRW, estimate the dimensions of the RSA, OFZ, OFA and RPZ. The airport has approaches down to 3/4 mile (see Figure 2).



Runway Protection

Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1000 ft	1000 ft	1000 ft	1000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	C	500 ft	500 ft	500 ft	500 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	1000 ft	1000 ft	1000 ft	1000 ft
Length prior to threshold [11]	P	600 ft	600 ft	600 ft	600 ft
Width	Q	800 ft	800 ft	800 ft	800 ft
Runway Obstacle Free Zone (ROFZ)					
Length		*Refer to paragraph 308*			
Width		*Refer to paragraph 308*			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1700 ft	1700 ft	1700 ft	2500 ft
Inner Width	U	500 ft	500 ft	1000 ft	1000 ft
Outer Width	V	1010 ft	1010 ft	1510 ft	1750 ft
Acres		29.465	29.465	48.978	78.914
Departure Runway Protection Zone (RPZ)					
Length	L	1700 ft	1700 ft	1700 ft	1700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1010 ft	1010 ft	1010 ft	1010 ft
Acres		29.465	29.465	29.465	29.465

Figure 2. Instrument Landing System (ILS) approach for runway 23 at CRW. Source: Flightaware. Note the red rectangle with 300 feet RVR and 3/4 mile visibility minima for ILS approach to runway 23.

d) Inspect the runway end for runway 23. Explain the reason for a displaced threshold. Explain if the dimension of the displaced threshold is consistent with current design criteria.

Terrain is a factor for landings on runway 23. We need 600 feet prior to the landing runway to protect the RSA. With the displaced threshold, the RSA criteria is compliant.

e) Inspect the runway end for runway 5. Explain the reason for a displaced threshold. Explain if the dimension of the displaced threshold is consistent with current design criteria.

Terrain is a factor for landings on runway 5. We need 600 feet prior to the landing runway to protect the RSA. With the displaced threshold, the RSA criteria is met. However, the RSA beyond the runway (runway 23) requires an EMAS on the threshold 5.

Problem # 3 (30 points)

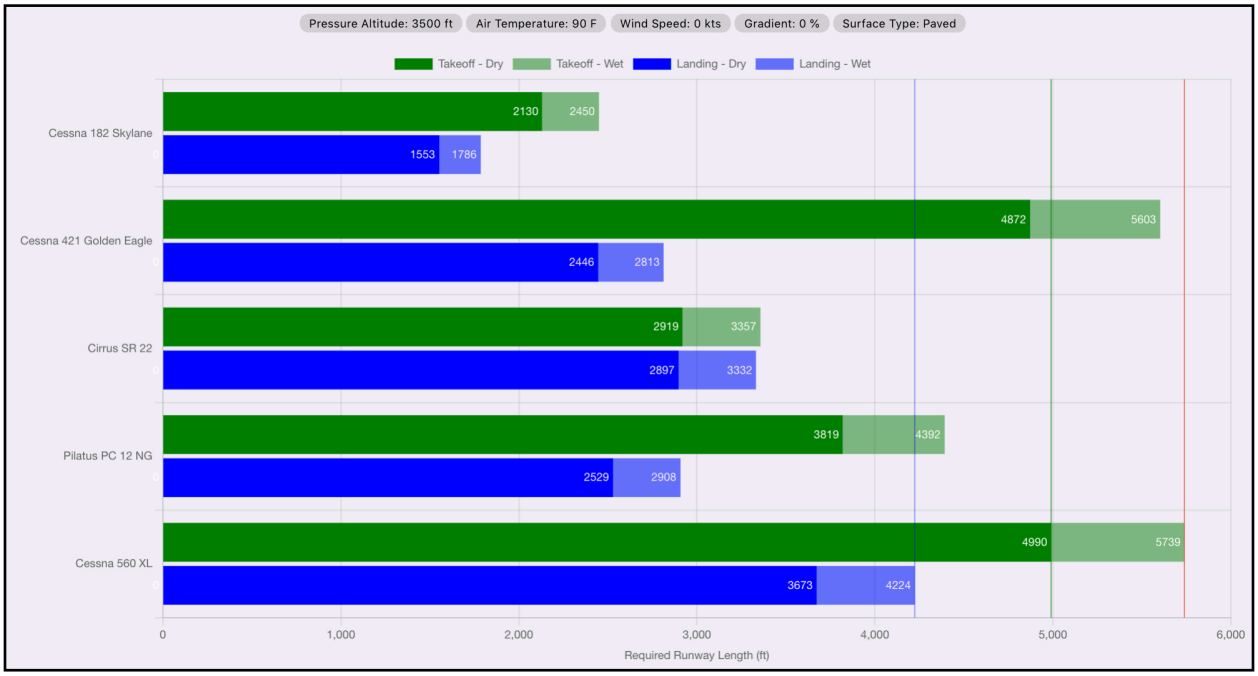
Use the experimental Small Aircraft Runway Length Analysis Tool (SARLAT) demonstrated in class to design the runway length for a new General Aviation airport to be constructed at a site located 3,500 feet above sea level. Data from a temperature survey yields a mean daily maximum temperature of the hottest month of 90 degree F. Table 2 shows the aircraft fleet mix expected to operate at the airport. Use the default load factors in the SARLAT tool.

Table 2. Expected Aircraft Fleet at Proposed General Aviation Airport. Aircraft in Boldface Text are shown in the Picture.

Aircraft Type	Representative Aircraft	Sample Picture
Single Engine Piston	**Cirrus SR-22** Cessna 182	
Multi-engine Piston	**Cessna 421**	
Turboprop Aircraft	**Pilatus PC-12**	

Aircraft Type	Representative Aircraft	Sample Picture
Turbofan Aircraft	**Cessna 560XL**	

a) Report the critical aircraft **dry pavement takeoff and landing** conditions.



Runway Design Solution (dry pavement)

Critical takeoff (dry) runway length required is 4,990 feet for the Cessna Citation 560XLS.

Critical landing (dry) runway length required is 3,674 feet for the Cessna Citation 560XLS.

b) Report the **wet pavement takeoff and landing** for the critical aircraft.

Runway Design Solution (wet pavement)

Critical takeoff (wet) runway length required is 5,739 feet for the Cessna Citation 560XLS.

Critical landing (wet) runway length required is 4,224 feet for the Cessna Citation 560XLS.

c) Find the runway length needed to operate the fleet mix of aircraft if the airport client wants to provide enough runway for both dry and wet conditions.

Runway length = 5,739 feet (round to 5,800 feet).

d) The Federal Government (through FAA) helps public airports to pay for the runway infrastructure. Based on economic analyses, the Federal Government will fund a **wet landing runway and dry takeoff runway** as part of the Airport Improvement Program funds. Find the runway length that FAA will pay for the airport. Compare to the airport client solution (part c).

FAA pays for a 4,990 (5,000 ft) runway

e) Compare the solution obtained in part (d) using SARLAT with the current FAA Advisory Circular 150/5325-4b design curves for the same class of aircraft. Explain any differences observed.

FAA AC 150/5325-4b use 75% fleet (Cessna 560 XL is that group) and 60% load factor, requires 5,900 feet of runway at 3,500 feet and 90 deg. C using the 100% fleet solution.