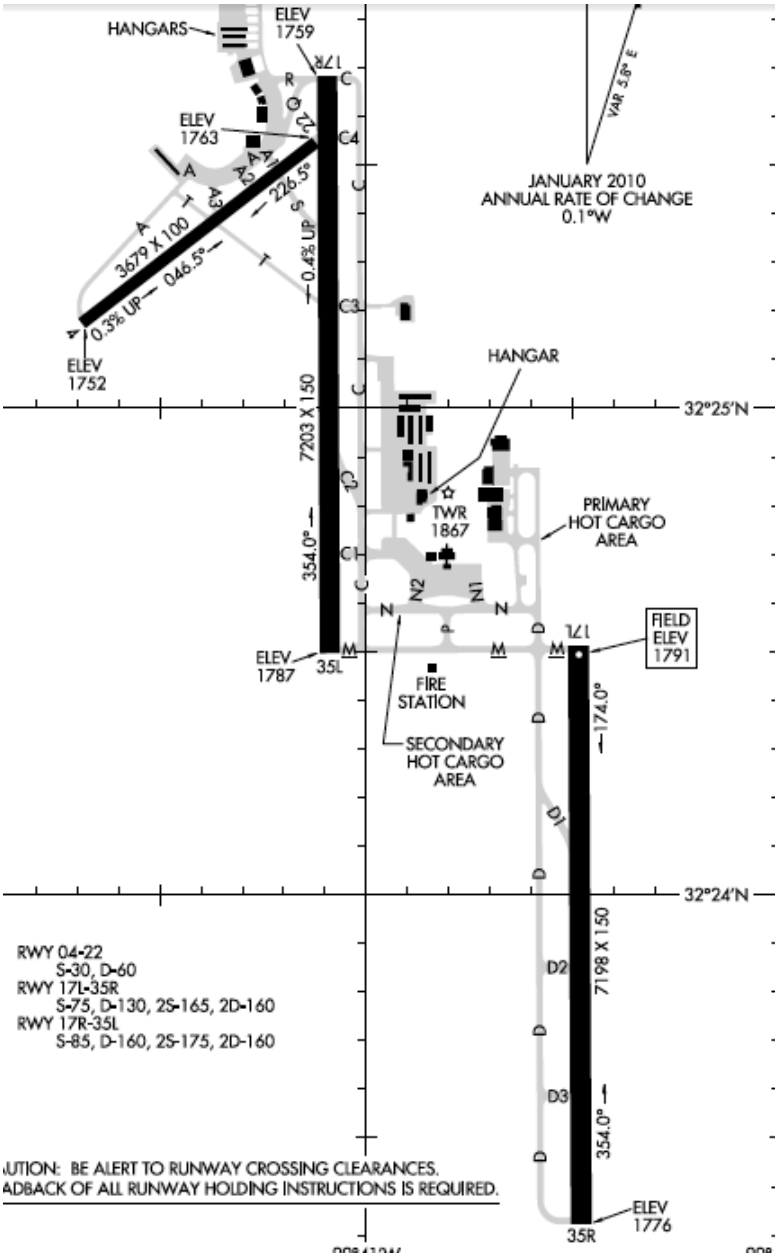
Quiz 1 (Take Home Part)

Solution

Instructor: Trani

Problem #1 (35 points)

The Abilene International Airport (ABI) solicits your services to plan future runway length requirements for the airport. The airport authority would like to attract an airline to start flight operations to the U.S. West Coast (Oakland) and Cancun, México. The airline uses Boeing 737-400 aircraft with a high-density configuration (159 seats). The aircraft has CFM56-3B2 engines rated at 22,000 pounds of thrust at sea level conditions (SLST) and the maximum takeoff weight is 150,500 lb.



In your analysis use the latest version of the aircraft 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.

a) Find the runway length needed to satisfy both routes. State the airport design temperature, airport elevation and other environmental conditions and assumptions used in your calculations. State the figure(s) in the Boeing document used in your analysis. Assume a full passenger load.

ABI-CUN = 1,024 nm and ABI-OAK = 1,221 nm

CHARACTERISTICS	UNITS	MODEL 737-400					
		CFM56-3B2 ENGINES (22,000 LB SLST)			CFM56-3C ENGINES (23,500 LB SLST)		
MAX DESIGN	POUNDS	139,000	143,000	150,500	143,000	144,000	150,500
TAXI WEIGHT	KILOGRAMS	63,049	64,864	68,266	64,864	65,317	68,266
MAX DESIGN	POUNDS	138,500	142,500	150,000	142,500	143,500	150,000
TAKEOFF WEIGHT	KILOGRAMS	62,823	64,637	68,039	64,637	65,091	68,039
MAX DESIGN	POUNDS	121,000	121,000	124,000	124,000	124,000	124,000
LANDING WEIGHT	KILOGRAMS	54,885	54,885	56,245	56,245	56,245	56,245
MAX DESIGN	POUNDS	113,000	113,000	117,000	117,000	117,000	117,000
ZERO FUEL WEIGHT	KILOGRAMS	51,256	51,256	53,070	53,070	53,070	53,070
OPERATING	POUNDS	73,170	73,170	73,170	74,170	74,170	74,170
EMPTY WEIGHT (1)	KILOGRAMS	33,189	33,189	33,189	33,643	33,643	33,643
MAX STRUCTURAL	POUNDS	39,830	39,830	43,830	42,830	42,830	42,830
PAYLOAD	KILOGRAMS	18,067	18,067	19,881	19,427	19,427	19,427
SEATING CAPACITY	TWO-CLASS	146: 8 FIRST CLASS AND 138 ECONOMY					
	ALL-ECONOMY	159 AT SIX ABREAST; FAA EXIT LIMIT: 189					

OEW = 33,643 kg

PYL = 159 pax (100 kg/Pax) = 15,900 kg

OEW + PYL = 49,543 kg

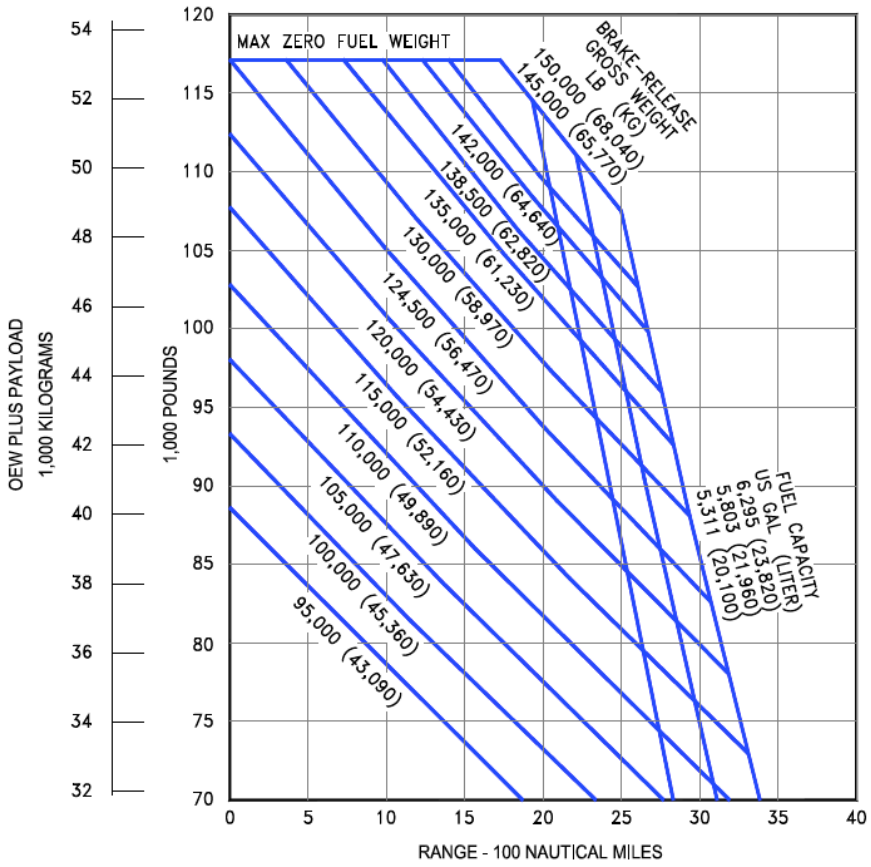
For the critical trip (to Oakland) use the payload range diagram to estimate the Desired Takeoff Weight (DTW).

DTW ~ 60,000 kg.

Design temperature is 94 degrees F or 34.4 degrees C. Note that at Abiline's elevation (1,790 feet) the Standard Temperature would be 52.6 degrees F (11.4 deg. C). Ideally we would want to use ISA + 40 deg. F. However, the Boeing manuals only offer ISA + 27 deg. F. Use those charges and consult with Boeing in a real design situation.

Takeoff Runway Length (using ISA + 15 degrees C) is 7,700 feet (dry and uncorrected).

Landing Runway Length is 6,200 feet (wet pavement)



Runway length corrections needed: Wet pavement conditions and grade. ABI has 0.4% grade.

Correction: add 10 feet for each foot of elevation difference between centerlines. The estimated centerline elevation at ABI is (7203 x 0.4/100 = 28.8 feet). Thus add 290 feet to the solution obtained before.

Runway Length needed = 7990 feet or round to 8,000 feet (Dry and grade corrected solution).

Note: FAA does not consider the wet pavement solution for the takeoff maneuver in the latest version of the analysis. If 15% correction is applied to the Boeing 737-400 design chart the runway length will be 8,860 feet instead.

b) Is a runway extension needed? If yes, explain the justification of the proposed runway extension.

Yes a runway extension is needed. The existing runway is short by 797 feet if the dry and grade corrected solution is used.

c) Find the maximum "belly" cargo the airline could carry if the plane flies 500 nm instead. Assume the flight is 85% full (typical load factor).

If a 500 nm trip is made, with the current runway length of 7,203 feet.

New payload = 13,515 kg, OEW + PYL = 47,158 kg, DTW(500) ~ 53,000 kg. Takeoff Runway Length = 5,300 feet with 85% load factor and no cargo. The aircraft is restricted to 59,000 kg of DTW for a runway that is 6,900 feet (uncorrected for grade). Note that adding 290 feet of grade correction to 6,900 feet yields the existing runway length of 7,203 feet. The aircraft could carry 6,000 kg of "belly" cargo.

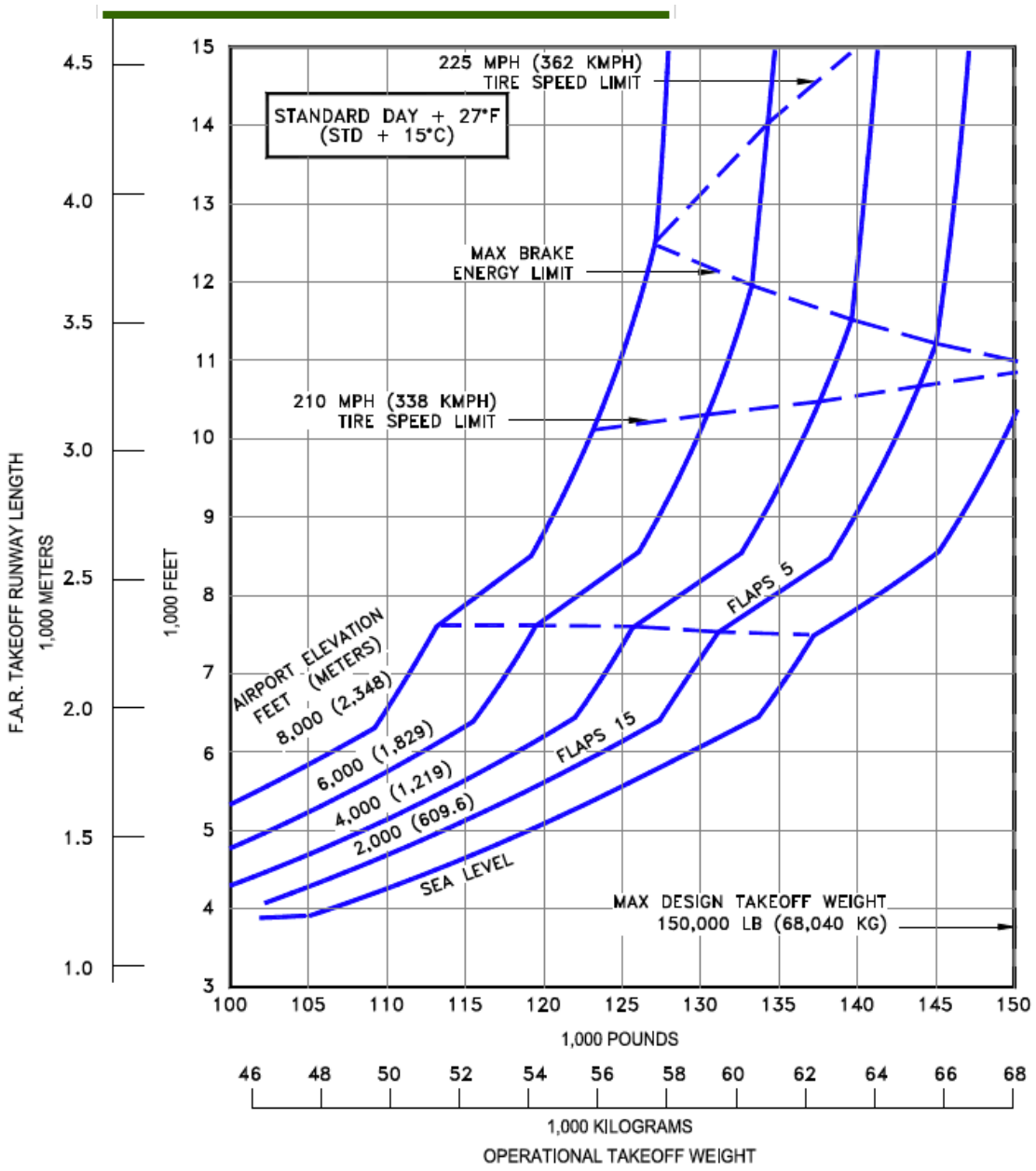


Figure 3.3.16 in Boeing 737 Airport Planning and Design Document.

Problem #2 (35 points) - Short Answers

a) A new airport is to be designed to service various business jets including the Embraer Lineage 1000E - a business jet version of the Embraer 190. State the FAA aircraft design group, taxiway design group, approach speed group, wake vortex classification used in airport design.

ADG = III, TDG = 3, approach speed group = C, Large aircraft (wake vortex).

b) Explain why an airport master plan requires various disciplines beyond engineering. Provide a concrete example on how diversity of backgrounds in the master plan team can help the master plan effort.

Because airports need financing and community support.

c) Use Google Earth and study the configuration of RDU airport. Can the airport conduct simultaneous independent approaches in bad weather conditions? RDU has a Precision Runway Monitor system in place today.

RDU has 3,500 feet between runways. With a PRM radar, the airport is authorized to conduct simultaneous and independent approaches.

d) For the Van Nuys Airport estimate the four declared distances when taking off or landing on runway 16R. Measure the runway safety areas for runway 16R and state if they meet the requirements. The largest aircraft operating at Van Nuys is a Gulfstream 650. The maximum approach speed for the G650 is 130 knots.

TORA = 8,001 feet, TODA = 8,001 feet, ASDA = 8,001 feet and LDA = (8,001 - 1,432 feet) = 6,569 feet.

Problem # 3 (30 points) Short Answers

a) Find the average fuel burned per nautical mile for the Boeing 737-400 in Problem 1 when the aircraft flies 1,500 nm. Compare to the fuel burn per nautical mile for two other trips: 1000 and 500 nm. Assume 85% load factor. Explain the trend in fuel burn as a function of distance. Make a plot to explain the trends.

The fuel burn per nautical mile decreases monotonically from 7.3 kg/minute (for a 500 nm trip) to 6.0 kg/min for a 1,500 nm trip.

b) Find the critical height of the inner transitional OFZ at points located at two points: 200 and 700 feet perpendicular from the runway centerline. The runway is designed for ILS Category III operations. The airport is located 3,200 feet above mean sea level conditions and the critical aircraft is an Airbus A330-300.

(b) For CAT-II/III runways, the inner-transitional OFZ begins at the edges of the ROFZ and inner-approach OFZ, then rises vertically for a height "H," then slopes 5 (horizontal) to 1 (vertical) out to a distance "Y" from runway centerline, and then slopes 6 (horizontal) to 1 (vertical) out to a height of 150 feet (46 m) above the established airport elevation.

(i) In U.S. customary units,

$$H_{feet} = 53 - 0.13(S_{feet}) - 0.0022(E_{feet}) \text{ and}$$

$$Y_{feet} = 440 + 1.08(S_{feet}) - 0.024(E_{feet}).$$

(ii) In SI units,

$$H_{meters} = 16 - 0.13(S_{meters}) - 0.0022(E_{meters}) \text{ and}$$

$$Y_{meters} = 132 + 1.08(S_{meters}) - 0.024(E_{meters}).$$

At 200 feet from runway Centerline the critical height is 20.2 feet. At 700 feet is 116.1 feet using Cat III formulas above.

c) A small general aviation is to be constructed in Idaho. The elevation of the proposed site is 2,300 feet. The design temperature is 85 deg. F. The airport is likely to service turboprop aircraft with more than 10 seats. This includes the King Air B350 and Pilatus PC-12. Find the runway length needed.

The runway length need is 6,700 feet for airport. No correction is required fort turboprop.