Assignment 4

Solution Instructor: Trani

Problem 1

Familiarize yourself with the FAA AC 150/5220-22B and review the course notes before solving this problem.

Review the configuration of Roanoke-Blacksburg Regional Airport (ROA) using Google Earth and the Arnav database. For runway 6, ROA has approach visibility minima of 300 feet and 1/2 mile of visibility (see the bottom of chart: https://www.flightaware.com/resources/airport/ROA/IAP/RNAV+(RNP)+Z+RWY+06/pdf). For ROA, the critical aircraft are a Boeing 757-200F freighter aircraft operated by FEDEX and an Airbus A300F operated by UPS.

a) Check if ROA runway threshold 6 meets the Runway Safety Area (RSA) and Runway Object Free Area (ROFA) standards. State the dimensions of RSA and ROFA for the critical aircraft used.

For Boeing 757-200F (AAC C, ADG IV):

Runway Safety Area (RSA)

C/D/E - IV

RSA Dim.	DIM[1]	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 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)

C/D/E - IV

ROFA Dim.	DIM[1]	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Length beyond runway end	R	1,000 ft	1,000 ft	1,000 ft	1,000 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

From the design standard matrix, the critical aircraft is required to have an RSA and ROFA that extends at least 600 ft prior to the Runway 06 threshold. However, measurements using Google Earth indicate that this distance is currently occupied by a highway (I-581), instead of an RSA.

b) If an EMAS system is to be reconstructed on threshold 6, estimate the size of the arrestor bed if. Use the recommended EMAS design speed in your analysis.

According to FAA AC 150/5220-22B para 9(e), the width of the arrestor bed must be no less than the runway width (150 ft). Then, according to para 9(g), "when there is insufficient RSA available for a standard EMAS [as is the case beyond the Runway 06 threshold], the EMAS must be designed to achieve the maximum deceleration of the design aircraft within the available runway safety area. The standard exit speed is 70 knots for an EMAS design. The standard EMAS to stop a Boeing 757-200F is 435 feet.

c) Verify if ROA runway threshold 34 meets the Runway Safety Area (RSA) standards. Comment what you see in the satellite view.

A highway runs perpendicular to ROA 16/34, approximately 650 ft beyond the Rwy 16 threshold. Therefore, this also does not meet the minimum RSA length for the critical aircraft. However, EMAS 300 ft long x 169 ft wide is located at the departure end of runway (DER) 34.

d) Explain why runway threshold 24 has a displaced threshold.

ROA cannot meet the FAA's RSA and ROFA design standards, therefore, the displaced threshold is an alternative approved method to protect against obstacles If the displaced threshold at ROA Rwy 24 wasn't there, then aircraft wishing to land on Rwy 24 would need to fly higher than normal on approach to provide protection against the obstacles that are Northeast of the runway. The displaced threshold intentionally shortens the landing distance available for Rwy 24 to protect against those obstacles.

Figure 1. Boeing 757-200F at ROA Airport (A.A. Trani).

Problem 2

Use Google Earth and review the EMAS installed on runway threshold 22L at Chicago O'Hare (ORD), Figure 2 shows a picture of the EMAS system at 22L. The critical aircraft operating at ORD and using runway 22L is a Boeing 747-400F (see Figure 3).

a) Measure the runway 22L EMAS bed carefully. State the dimensions of the arrestor bed.

The EMAS dimeinsion is also available at Airnav (see below):

Additional Remarks

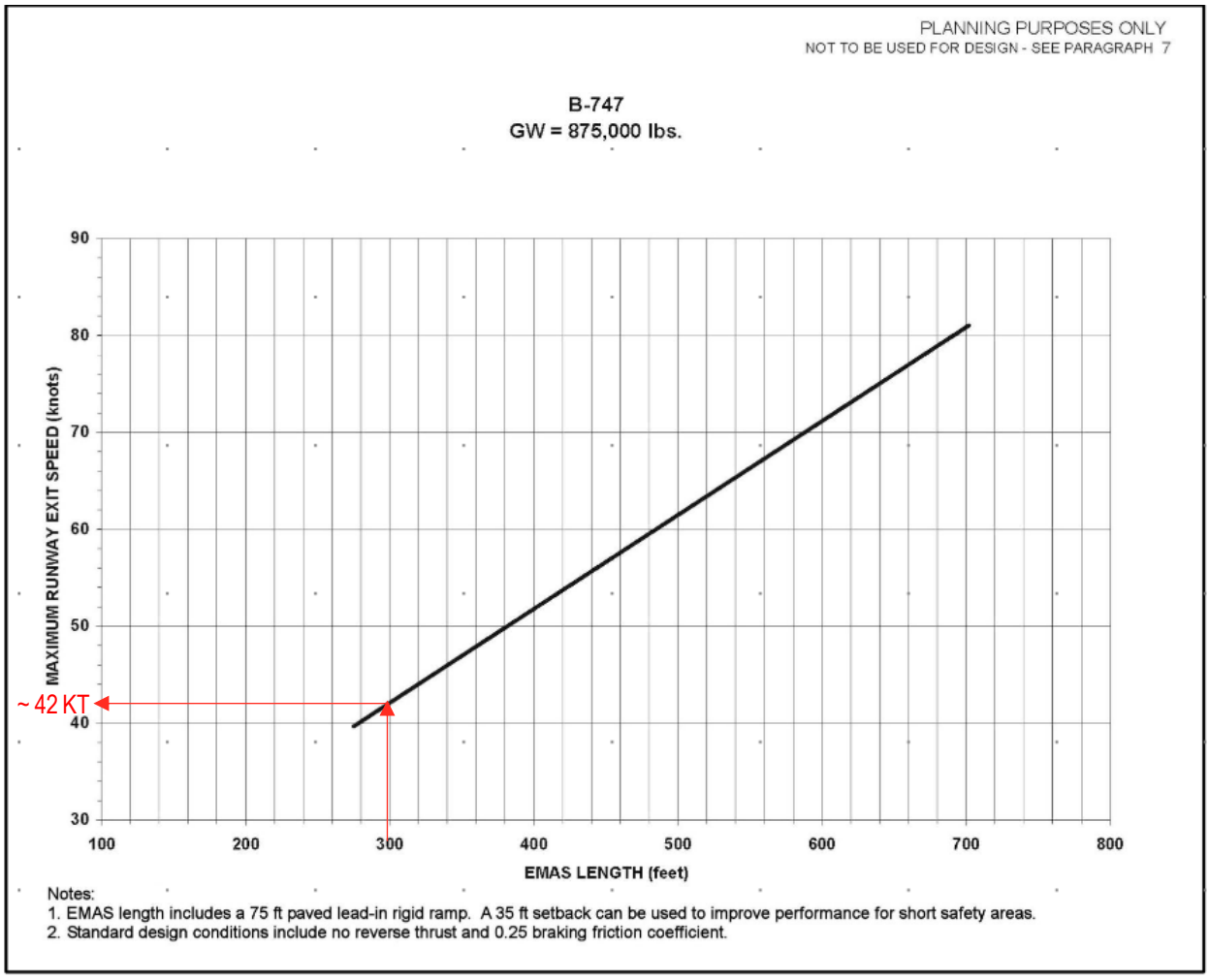
A30-10X	RWY 10X SUPPORTS THE SECOND STRAIGHT IN ILS SYSTEM I-IZJ ON RWY 10R.
A30A-04L	CLSD TO ARR.
A30A-22R	CLSD TO DEP.
E60-22L	ENGINEERED MATERIALS ARRESTING SYSTEM (EMAS), 170 FT WIDE BY 303 FT LENGTH, LCTD AT THE DER 22L.
E60-04R	ENGINEERED MATERIALS ARRESTING SYSTEM (EMAS), 170 FT WIDE BY 546 FT LENGTH, LCTD AT THE DER 04R.
-	NOISE ABATEMENT PROC IN EFFECT FM 2200 TO 0700; CTC AMGR - 773-686-2255.
-	MAG DEVIATION PSBL IMT W OF TWY Y & RWY 22L APCH ON TWY N.
-	PAEW NEAR VARIOUS TWYS.
-	PERIODIC FIRE DEPT TRNG AT N SECTOR OF THE ARPT.
-	BIRDS ON & INVOF ARPT; PYROTECHNICS & BIRD CANNONS IN USE.
-	PRIM RUN-UP LOCATION GROUND RUN UP ENCLOSURE; SECONDARY RUN UP LOCATIONS AVBL UPON REQ - CTC CIT
-	LINE UP AND WAIT AUTHORIZATION IN EFF BTWN SS AND SR AT THE FLWG INTS: RWY 28R AT TWY GG, TWY EE AND AND FF. THESE RWYS WILL BE USED FOR DEPS ONLY WHEN EXERCISING THE PROVISIONS OF THIS AUTHORIZATION.
-	ALL PART 91 & UNSKED PART 125, 133 & 135 CHARTER OPERATORS CTC SIGNATURE FLIGHT SUPPORT AT 773-686-7000
-	B747-8 CANNOT PASS ANY B747 SERIES, B787 SERIES, B777 SERIES, A350 SERIES, A340 SERIES & A330 SERIES ON TWY A
-	ASDE-X IN USE. OPERATE TRANSPONDERS WITH ALTITUDE REPORTING MODE AND ADS-B (IF EQUIPPED) ENABLED O
-	EAST AND WEST GATES ARE MANNED 24 HRS A DAY.
-	ATCT IS AUTH TO CONDUCT SIMUL DEPS FM RWY 04L/04R, RWY 22L/22R, RWY 09R WITH RWY 09L OR RWY 10L, RWY 0 28R, RWY 28C WITH RWY 27L OR RWY 27C WITH CRS DIVERGENCE BEGINNING NO LATER THAN 4 MILES FM RWY END
-	BE ALERT: TWY S1 OBND OR EB ONLY, TWY S2 INBD OR WB ONLY, TWY P1, P2, P3, P5, AND P6 NB ONLY, TWY E1, E2, E3
-	A380-800 OPR CONSTRAINTS EXIST ON RWYS, TWYS, & RAMPS - CTC ARPT OPS FOR INFO 773-686-2255.
-	DVRSN ACRS WO A PRESENCE AT ORD SHOULD CTC ARPT OPNS 773-686-2255 PRIOR TO DIVERTING TO THE EXTENT P
-	BE ALERT: THE NORTHEAST/SOUTHWEST PORTION OF TWY YY IS NOT VSBL FM THE CENTER ATCT.
-	B747-8 OPS NOT AUTHORIZED ON RWY 09R/27L, 09L/27R & 10R/28L.
-	ACFT ARE NOT PMTD TO STOP ON EITHER TWY A OR B BRIDGES.
-	RWY STATUS LGTS ARE IN OPN.
-	TWY NN1 INBD/EB ONLY; TWY NN2 OUBD/WB ONLY.
-	ACFT WITH WINGSPAN GREATER THAN 214 FT RQR 48 HRS PPR - 773-686-2255.
-	SEE LND & HOLD SHORT OPS SECTION.
-	ALERT: DUPE ALPHA-NUMERIC TWY DESIGNATORS & TRML GATE DESIGNATIONS INVOLVING THE LTRS B, C, G, H, K,

Instrument Procedures

Dimensions are 170 f wide x 303 ft long

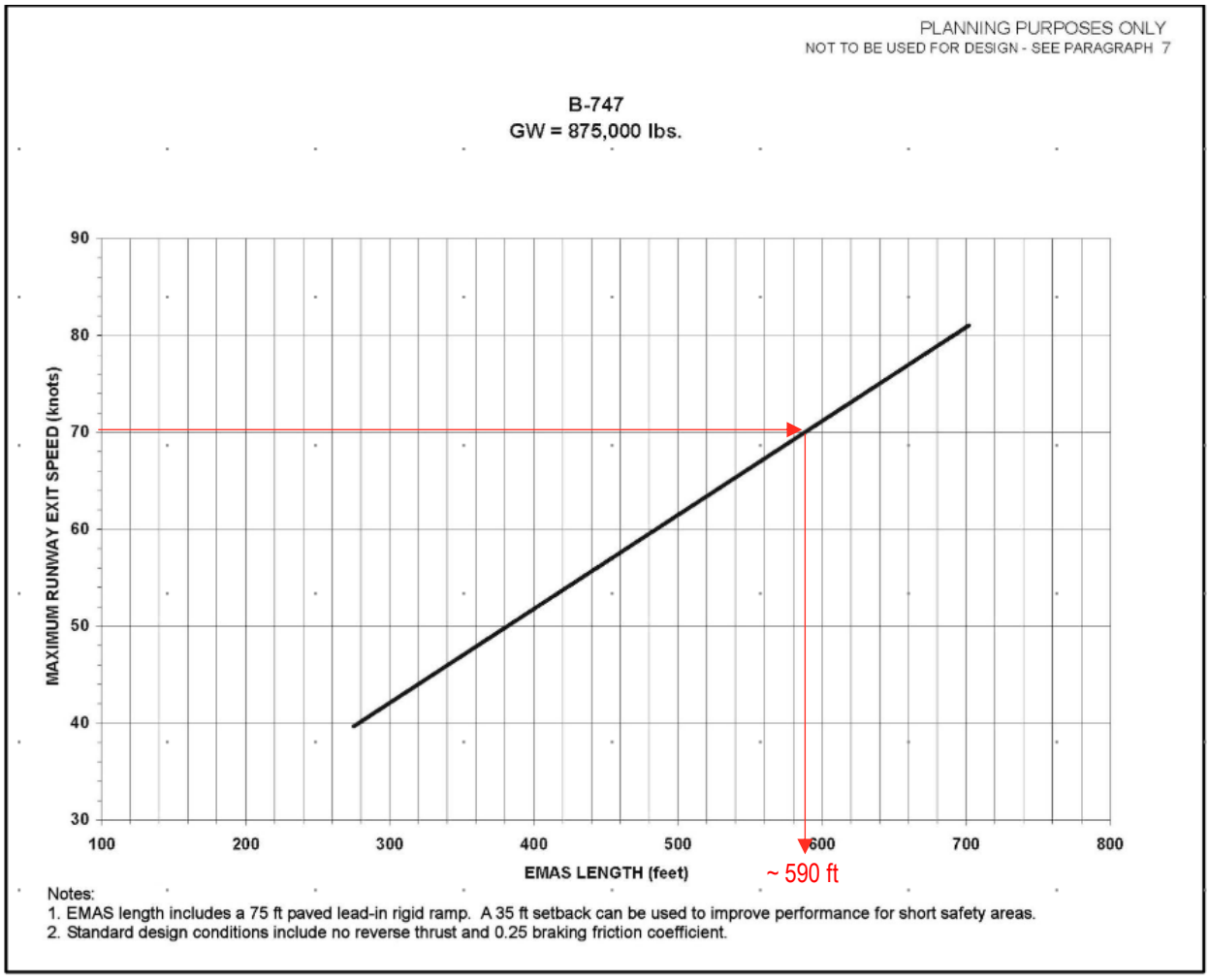
b) Estimate the EMAS design speed (based on the arrestor bed dimension in part (a)) if the critical aircraft is the Boeing 747-400F.

For the Boeing 747 (or similar), the design speed that corresponds to a 300 ft-long EMAS bed is ~ 42 Knots (see figure below):



c) Would you recommend an extension of the EMAS on runway 22L threshold? If yes, state the extension.

Ideally, we want an EMAS length corresponding to a 70-knot entrance speed. For the B747, that length is approximately 580 ft (see figure below). Therefore, we should extend the EMAS by at least 590 ft – 303 ft = 287 ft (say, 290 ft).



d) Explain the reason for the EMAS on runway 22L.

The EMAS located at the departure end of runway 22L provides an element of protection for the highway that is located just beyond the end of the EMAS bed.

e) Measure the runway 4R EMAS bed carefully. State the dimensions of the arrestor bed. Explain the reason for the difference in EMAS dimensions compared to 22L.

Using Airnav database, the EMAS is 546 feet long.

Additional Remarks

A30-10X RWY 10X SUPPORTS THE SECOND STRAIGHT IN ILS SYSTEM I-IZJ ON RWY 10R.
A30A-04L CLSD TO ARR.
A30A-22R CLSD TO DEP.
E60-22L ENGINEERED MATERIALS ARRESTING SYSTEM (EMAS), 170 FT WIDE BY 303 FT LENGTH, LCTD AT THE DER 22L.
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- PERIODIC FIRE DEPT TRNG AT N SECTOR OF THE ARPT.
- BIRDS ON & INVOF ARPT; PYROTECHNICS & BIRD CANNONS IN USE.
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- ALL PART 91 & UNSKED PART 125, 133 & 135 CHARTER OPERATORS CTC SIGNATURE FLIGHT SUPPORT AT 773-686-7000 F
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- BE ALERT: TWY S1 OBND OR EB ONLY, TWY S2 INBD OR WB ONLY, TWY P1, P2, P3, P5, AND P6 NB ONLY, TWY E1, E2, E3
- A380-800 OPR CONSTRAINTS EXIST ON RWYS, TWYS, & RAMPS - CTC ARPT OPS FOR INFO 773-686-2255.
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- SEE LND & HOLD SHORT OPS SECTION.
- ALERT: DUPE ALPHA-NUMERIC TWY DESIGNATORS & TRML GATE DESIGNATIONS INVOLVING THE LTRS B, C, G, H, K,

Instrument Procedures

Dimensions are 170 ft wide x 546 ft long

f) Find the maximum EMAS entry speed to stop the Boeing 747400F on runway 4R threshold.

For the Boeing 747 (or similar), the design speed that corresponds to a 550 ft-long EMAS bed is very close to the design speed of 70 knots (~ 66 knots if you read from the figure below).

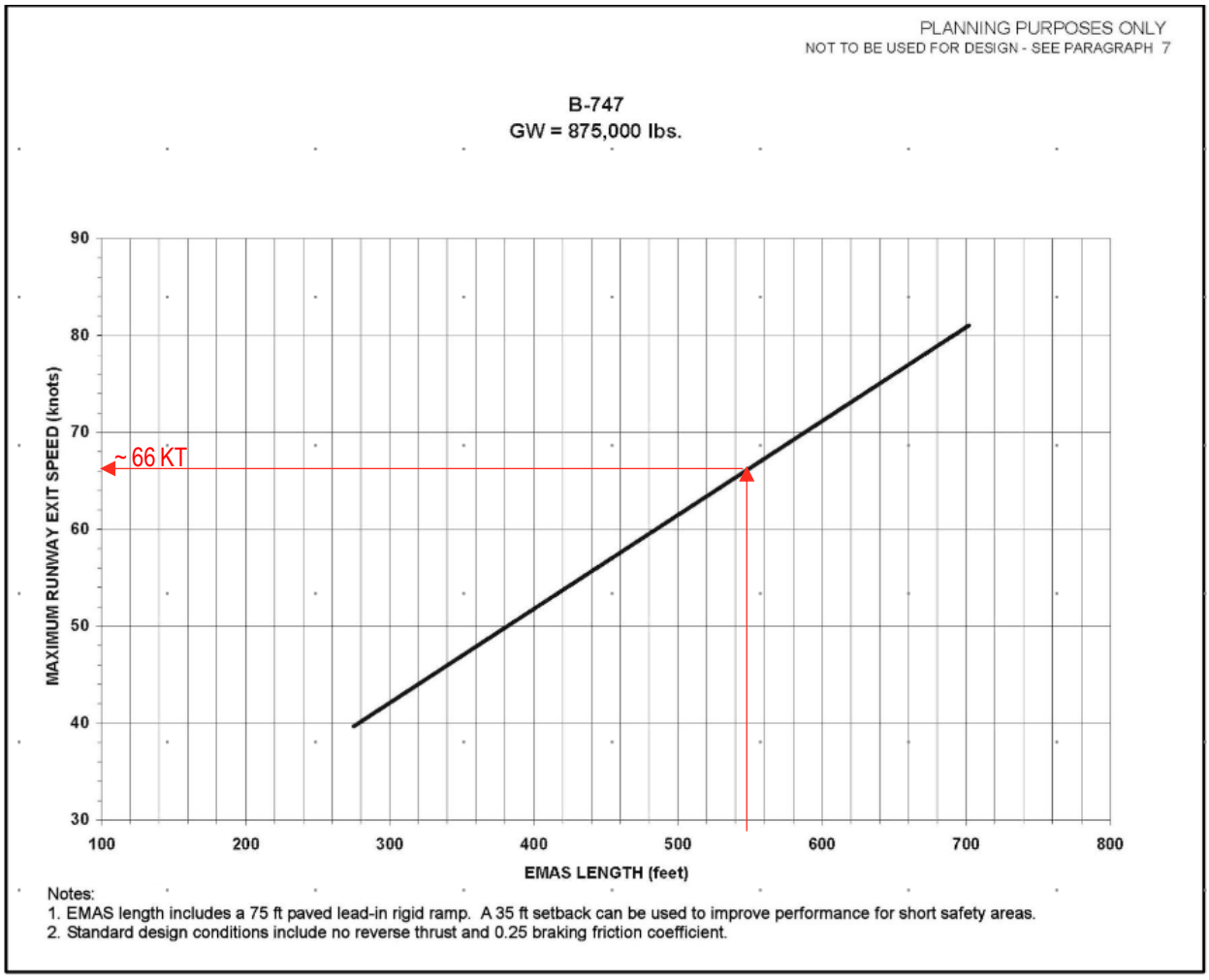

PLANNING PURPOSES ONLY
NOT TO BE USED FOR DESIGN - SEE PARAGRAPH 7
B-747
GW = 875,000 lbs.
MAXIMUM RUNWAY EXIT SPEED (knots)
90
80
70
60
50
40
30
~ 66 KT
100
200
300
400
500
600
700
800
EMAS LENGTH (feet)
Notes:
1. EMAS length includes a 75 ft paved lead-in rigid ramp. A 35 ft setback can be used to improve performance for short safety areas.
2. Standard design conditions include no reverse thrust and 0.25 braking friction coefficient.

Figure 2. Runway 22L Engineered Material Arresting System (EMAS) at Chicago O'Hare (ORD) Airport (A.A. Trani).

Figure 3. Boeing 747-400F Operating at ORD Airport (A.A. Trani).

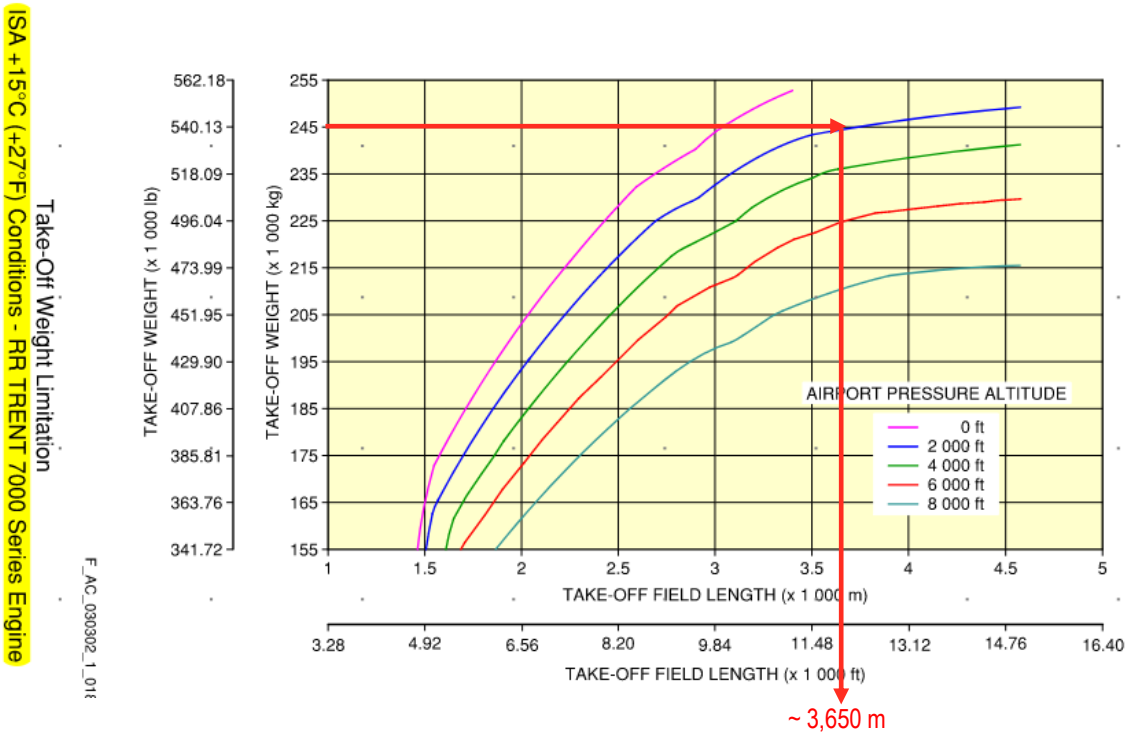
Problem 3

Design a runway for a new airport located 2,000 feet above mean sea level conditions. The critical aircraft is the Airbus A330-800 with Rolls-Royce Trent 7000 Series Engines (see Figure 4). The design temperature for the airport is ISA + 15 degrees C. The airline would like to fly long-haul routes requiring takeoff weights up to 245 metric tons.

Figure 4. Airbus A330-800 at Atlanta Airport (A.A. Trani).

a) Find the runway length needed to satisfy the design constraints.

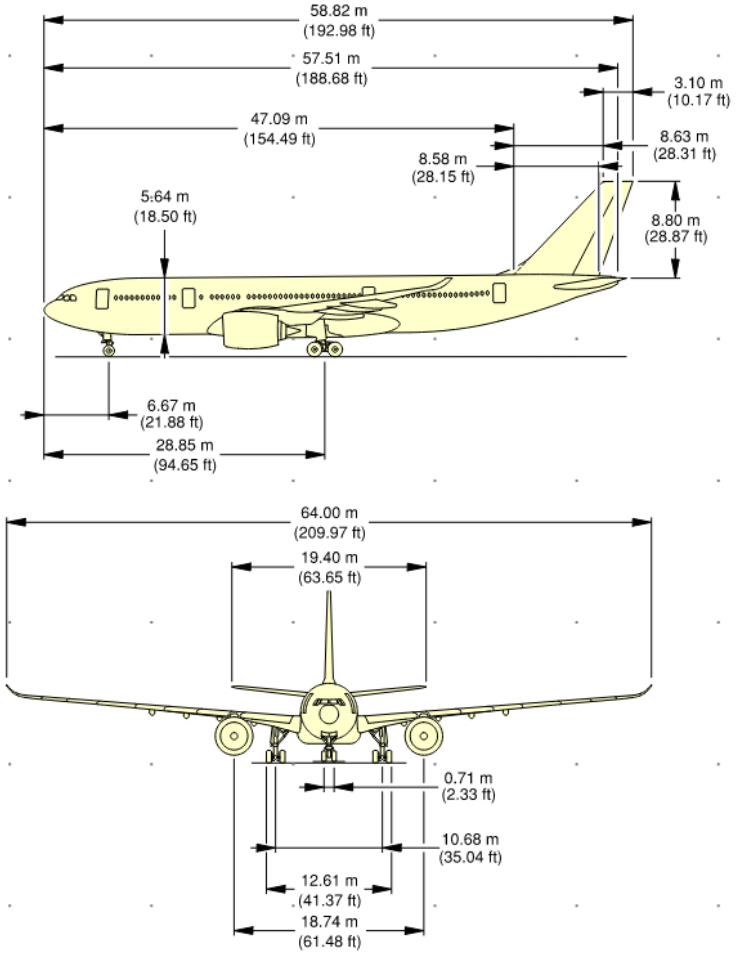
**ON A/C A330-800



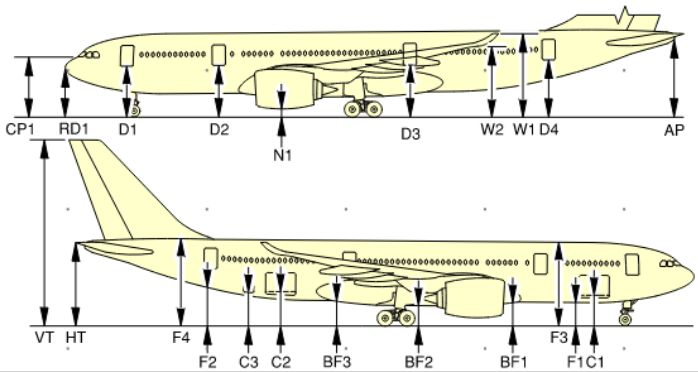
The runway length needed is approximately 3,650 m (12,000 ft)

b) Find the runway width needed to support the critical aircraft.

****ON A/C A330-800**



**ON A/C A330-800



A/C CONFIGURATION		MRW 238 900 kg (526 684 lb)				135 000 kg (297 624 lb)				A/C JACKED	
		FWD CG (25%)		AFT CG (33.2%)		FWD CG (20%)		AFT CG (40%)		FDL = 6.5 m (21.33 ft)	
		m	ft	m	ft	m	ft	m	ft	m	ft
DOORS	D1	4.49	14.74	4.58	15.01	4.59	15.06	4.71	15.45	6.34	20.79
	D2	4.68	15.34	4.73	15.50	4.82	15.82	4.88	16.02	6.33	20.78
	D3	5.07	16.63	5.04	16.55	5.31	17.41	5.25	17.23	6.34	20.79
	D4	5.56	18.24	5.48	17.99	5.86	19.23	5.72	18.78	6.55	21.49
	C1	2.57	8.44	2.64	8.67	2.69	8.83	2.79	9.14	4.34	14.23
	C2	3.26	10.69	3.21	10.52	3.53	11.57	3.43	11.26	4.39	14.40
	C3	3.32	10.90	3.26	10.70	3.61	11.83	3.49	11.46	4.39	14.40
FUSELAGE	F1	1.95	6.39	2.01	6.59	2.07	6.80	2.16	7.08	3.68	12.06
	F2	2.49	8.18	2.45	8.05	2.75	9.02	2.67	8.76	3.68	12.06
	F3	7.63	25.04	7.69	25.22	7.77	25.48	7.84	25.72	9.33	30.60
	F4	8.30	27.25	8.23	27.01	8.60	28.21	8.47	27.79	9.33	30.60
	BF1	2.07	6.79	2.11	6.92	2.23	7.30	2.27	7.46	3.68	12.07
	BF2	1.85	6.07	1.85	6.08	2.05	6.74	2.04	6.70	3.26	10.70
	BF3	2.41	7.90	2.38	7.80	2.65	8.70	2.59	8.49	3.64	11.96
	CP1	5.30	17.38	5.40	17.72	5.37	17.63	5.52	18.12	7.24	23.75
	RD1	4.25	13.93	4.35	14.29	4.32	14.16	4.47	14.68	6.22	20.40
WINGS	W1	7.97	26.16	7.91	25.97	8.25	27.07	8.14	26.72	9.06	29.74
	W2	6.70	21.97	6.65	21.81	6.96	22.85	6.87	22.54	7.84	25.71
TAILPLANE	HT	8.26	27.11	8.14	26.69	8.63	28.31	8.41	27.59	8.98	29.47
	AP	7.77	25.48	7.64	25.07	8.13	26.67	7.91	25.96	8.50	27.88
	VT	17.92	58.79	17.79	58.36	18.29	60.00	18.06	59.27	18.62	61.09
ENGINE/ NACELLE	N1	0.65	2.12	0.67	2.20	0.82	2.69	0.85	2.77	2.18	7.14
	N1 WITH DRAIN MAST	0.62	2.03	0.65	2.12	0.79	2.60	0.82	2.69	2.16	7.07

Aircraft wingspan (S): 209.97 ft

Tail height (VT): 58 ft

Therefore, AAC C and ADG V

C/D/E - V

Runway Dims	DIM[1]	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		35 ft	35 ft	35 ft	35 ft
Blast Pad Width		220 ft	220 ft	220 ft	220 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots

For visibility down to ½ mile, the required runway width is 150 ft

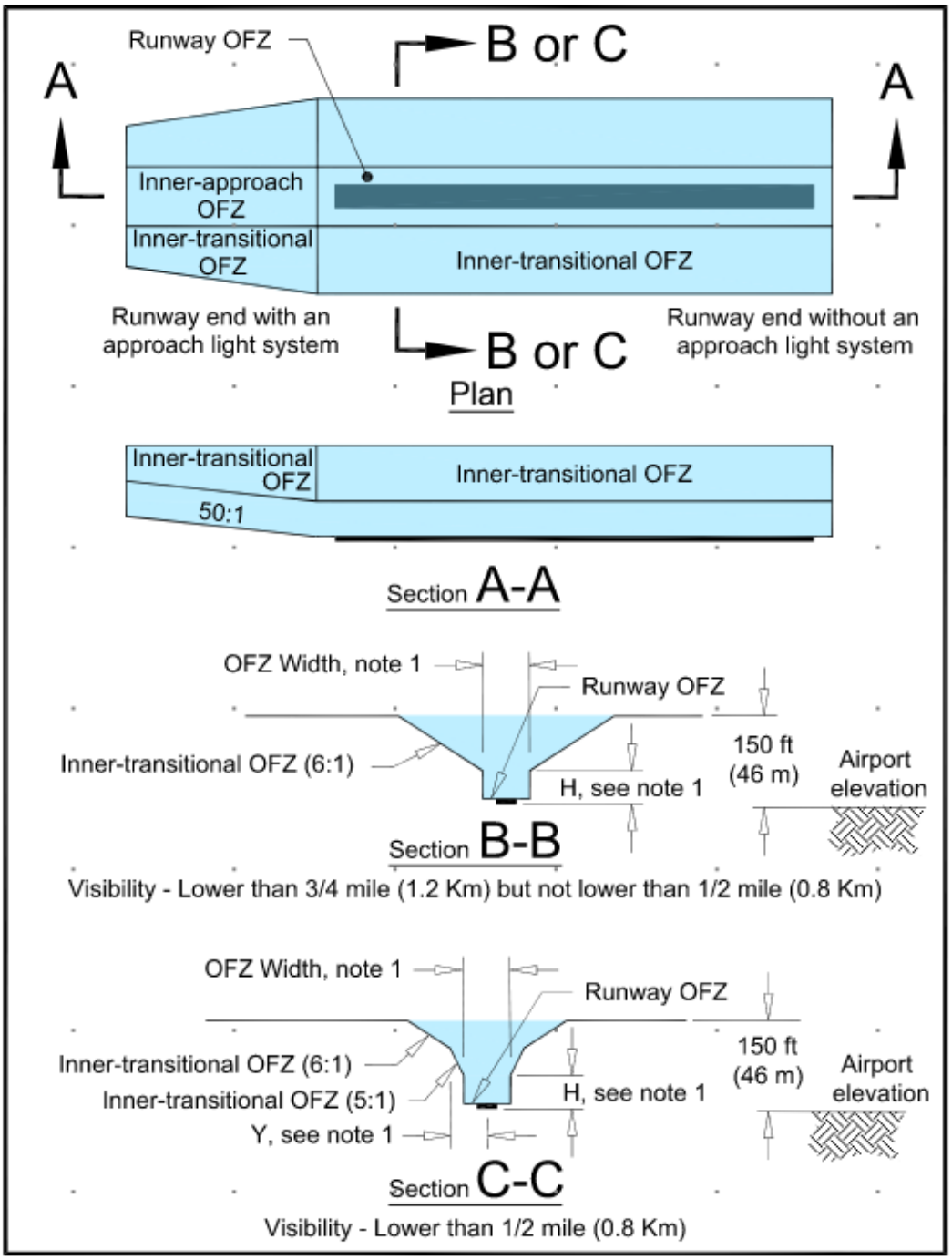
c) Find the dimensions of the RSA, ROFA , OFZ (various components), and RPZ surfaces required for the critical aircraft. Assume the airport will have a Category I instrument landing system with visibility down to 1/2 mile. Make a table with your answers.

Table is from Appendix G of AC 150/5300-13B:

Table G-11. Runway Design Standards Matrix, C/D/E-V

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – V			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs* 3.3 *and* 3.7.1			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		35 ft	35 ft	35 ft	35 ft
Blast Pad Width		220 ft	220 ft	220 ft	220 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 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	1,000 ft	1,000 ft	1,000 ft	1,000 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
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional		*Refer to paragraph* 3.11			
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	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft

Figure 3-22. OFZ for Operations on Runways by Large Aircraft with Lower Than ¾ Statute Mile (1.2 km) Approach Visibility Minimums



Note 1: Refer to paragraphs 3.11.2, 3.11.3, and 3.11.4 for dimensional values.

Based on visibility minima down to ½ mile in the problem, we use the OFZ dimensions in the sectional area B-B in the figure above. Based on aircraft wingspan (S) of 209.97 ft and runway threshold elevation (E) of 2,000 ft, the critical height of inner-transitional OFZ surface (H) equals 61 – 0.094(210 ft) – 0.003(2000 ft) = 13.74 ft

Finally, the ROFZ begins 200 ft beyond the runway threshold, extends 200 ft in length, and for large aircraft, is 400 ft wide from each side of the runway centerline.

d) Draw to scale (use Autocad or any CAD program of your choice) a plan view of the runway, RSA, ROFA, OFZ and RPZ surfaces.

e) If the airport authority wants to build a new 82-foot tall hangar to be located 610 feet from the runway centerline (perpendicular to the runway - see Figure 5) estimate if the hangar is in violation of the inner OFZ surface for Instrument Landing System Category I operations.

For large aircraft, if the visibility is greater than ½ mile (which in this case it is), then distance "Y" in the figure will be the same width as the ROFZ, which is 400 ft from the runway centerline. Since the object also does not violate the critical height, it is therefore not in violation of the inner OFZ surface.

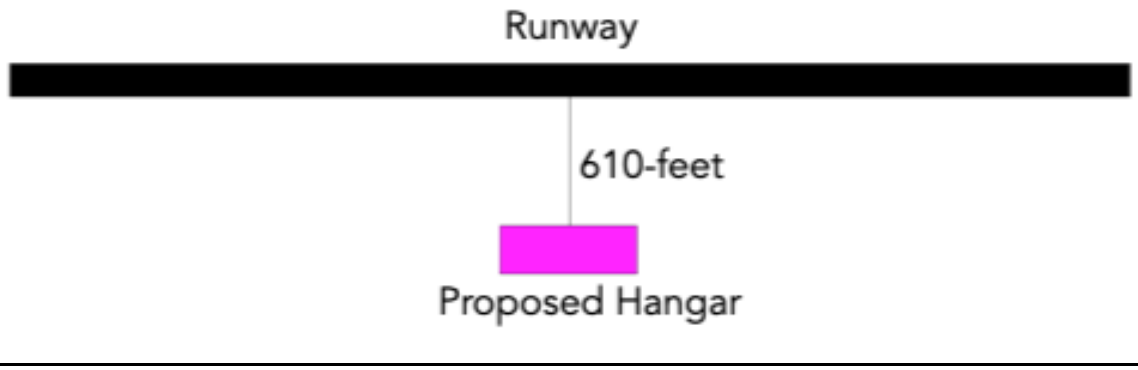


Figure 5. Proposed Hangar.

Problem 4

Figure 6 shows a runway configuration to be studied. The airport serves ADG V and AAC D aircraft. The airport has visibility criterial less than 3/4 miles.

A) Considering that the airport would like to comply with RSA and ROFA, find the declared distances (TORA, TODA, and ASDA) for departures on runway 09.

Table G-11. Runway Design Standards Matrix, C/D/E-V

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – V			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs 3.3 and 3.7.1*			
Runway Width	B	150 ft	150 ft	150 ft	150 ft
Shoulder Width		35 ft	35 ft	35 ft	35 ft
Blast Pad Width		220 ft	220 ft	220 ft	220 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	1,000 ft	1,000 ft	1,000 ft	1,000 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	1,000 ft	1,000 ft	1,000 ft	1,000 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
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional		*Refer to paragraph 3.11*			
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	1,700 ft	1,700 ft	1,700 ft	2,500 ft
Inner Width	U	500 ft	500 ft	1,000 ft	1,000 ft
Outer Width	V	1,010 ft	1,010 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,700 ft	1,700 ft	1,700 ft	1,700 ft
Inner Width	U	500 ft	500 ft	500 ft	500 ft
Outer Width	V	1,010 ft	1,010 ft	1,010 ft	1,010 ft
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 3.9*			
Holding Position [8]		250 ft	250 ft	250 ft	280 ft
Parallel taxiway/taxilane centerline [3, 5]	D	400-500 ft	400-500 ft	400-500 ft	400-500 ft
Aircraft parking area	G	*Refer to paragraph 5.4.1.2*			
Helicopter touchdown pad		*Refer to AC 150/5390-2*			

Note: Values in the table are rounded to the nearest foot. 1 foot = 0.305 meters.

Note: See the Footnotes on the page after Table G-12.

The dimensions of the ROFA, RSA, RPZ are provided in Table G.11 of Appendix G in the advisory circular 150/5300-13B.

B) Repeat the procedure while departing from runway 27.
C) Find the landing distance available while landing on runway 27. Explain how you protect the RSA.

Landing on runway 27

We need to protect an RSA and ROFA **prior** to the landing runway threshold of 600 feet. The lake is 500 feet from the runway end; hence a 100-foot displaced threshold is recommended.

The RSA and ROFA needed for safety beyond the runway end if 1,000 feet. There are 650 feet between the runway end and the highway. Therefore, 350 feet of runway is not usable to achieve compliance with RSA and ROFA requirements. The Landing Distance Available is:

$$LDA = 9500 - (600 - 500) - (1000 - 650) = 9{,}050\ feet$$

A 100-foot displaced threshold is needed on runway 27.

D) Find the landing distance available while landing on runway 09.

Landing on runway 09

We need to protect an RSA and ROFA **prior** to the landing runway threshold of 600 feet. The highway is 650 feet from the runway end; hence **no displaced threshold is required**.

The RSA and ROFA needed for safety beyond the runway end if 1,000 feet. There are 500 feet between the runway end and the lake (for an aircraft landing on runway 09 and departing the far end of the runway). Therefore, 500 feet of runway is not usable to achieve compliance with RSA and ROFA requirements. The Landing Distance Available (LDA for runway 09) is:

$$LDA = 9500 - (1000 - 500) = 9{,}000\ feet$$

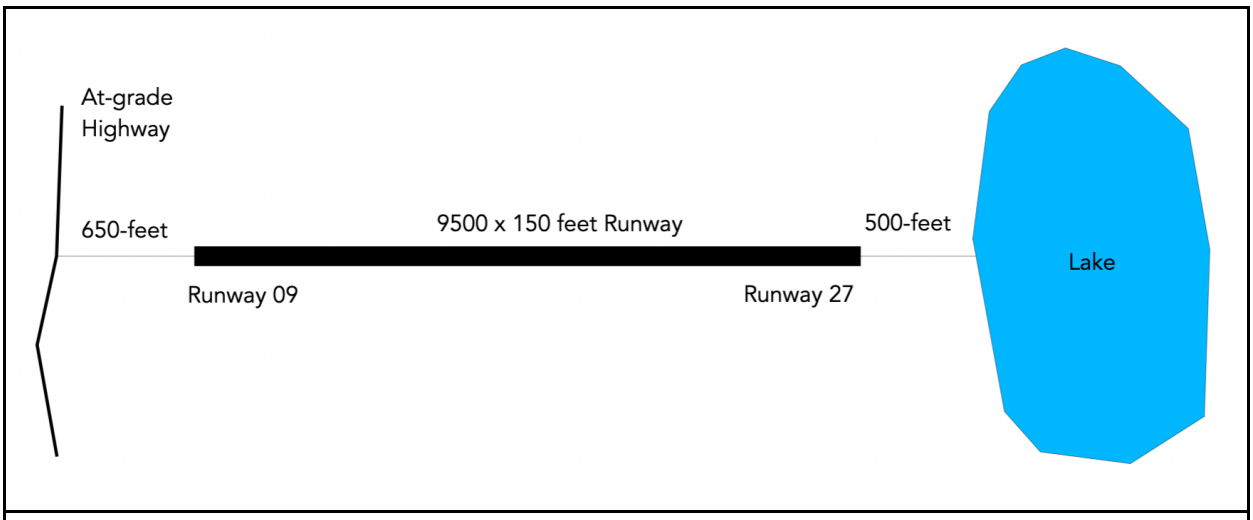


Figure 6. Runway Configuration for Problem 4.