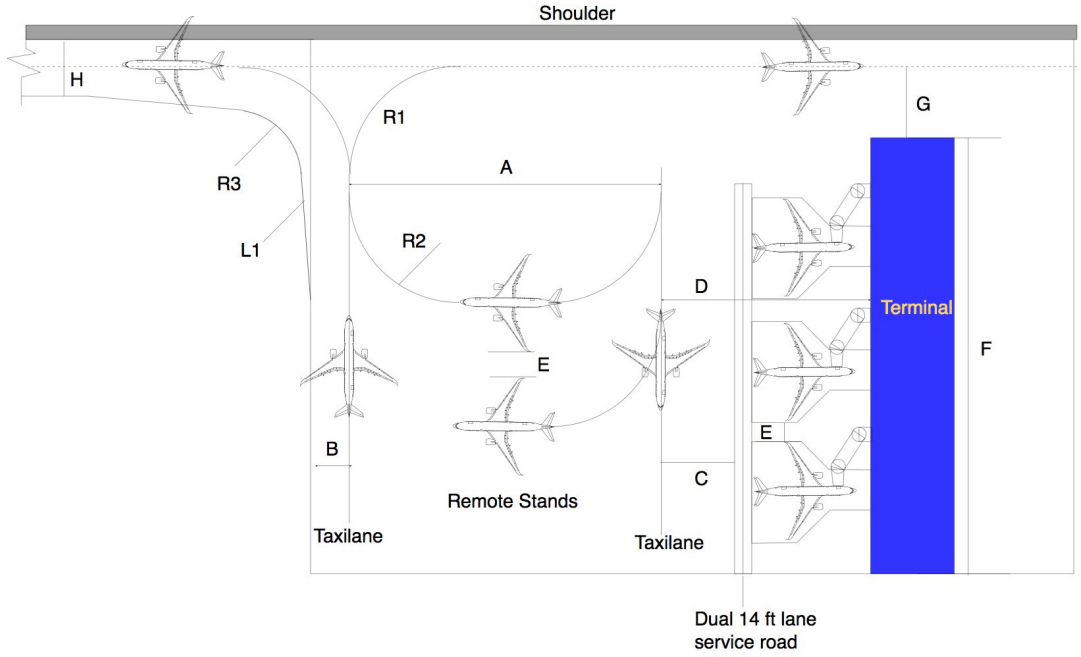
CEE 4674 Homework 7 Solution

Problem 1.

An airport is designing a new pier terminal to accommodate five Airbus A350-1000 passenger planes simultaneously per side (see Figure 1 - only 3 per side shown). The airport authority needs to know the dimensions (A through G and also radii R1 and R2) of the apron area shown in Figure 1. In your solution consider the maneuvering envelopes of the Airbus A350-1000 using the appropriate technical data. Design and draw to scale (no hand sketches will be accepted) your solution. Provide 30 feet of clearance between the nose of the aircraft and the terminal building. Clearly state all the dimensions in your drawing. Note that a two-lane service road is provided behind the parking positions of A350-1000 as shown in Figure 1. If desired, DWG files for the Airbus A350-1000 can be found at: http://www.airbus.com/aircraft/support-services/airport-operations-and-technical-data/autocad-3-view-aircraft-drawings.html.

Aircraft: A350 – 1000 TDG: 6 ADG: V



	Nomenclatures	Dimensions (feet)
A	2*Taxilane Centerline to Fixed or Movable object+ Aircraft length	138*2+242.1=518.1 177*2+242.1=596.1
B	W0	37.5
C	Taxilane Centerline to Fixed or Movable object	138 (for ADGV)
D	Taxilane Centerline to Fixed or Movable object+ Aircraft length +30 feet clearance between the nose and the building +2 lane service lane	138+242.1+30+28=438.1
E	Wingtip-Wingtip separations at gates	25
F	Terminal Length	5*(212.4)+4*25+2*25=1212
G	Taxiway Centerline to Fixed or Movable object	160

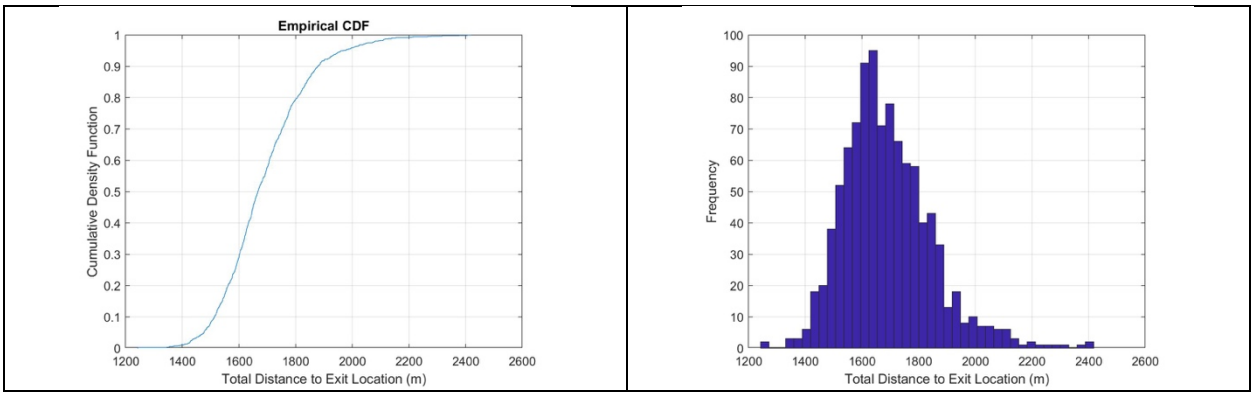
L1	AC 2012, AC 2014	365; 433
R1	R-CL(AC 2012 90; AC 2014 90; AC 2012 180; Airbus Document)	130; 115; 175; 150 (should >120 based on Airbus Document
R2	R-CL	130; 115; 175; 150;177

Problem 2.

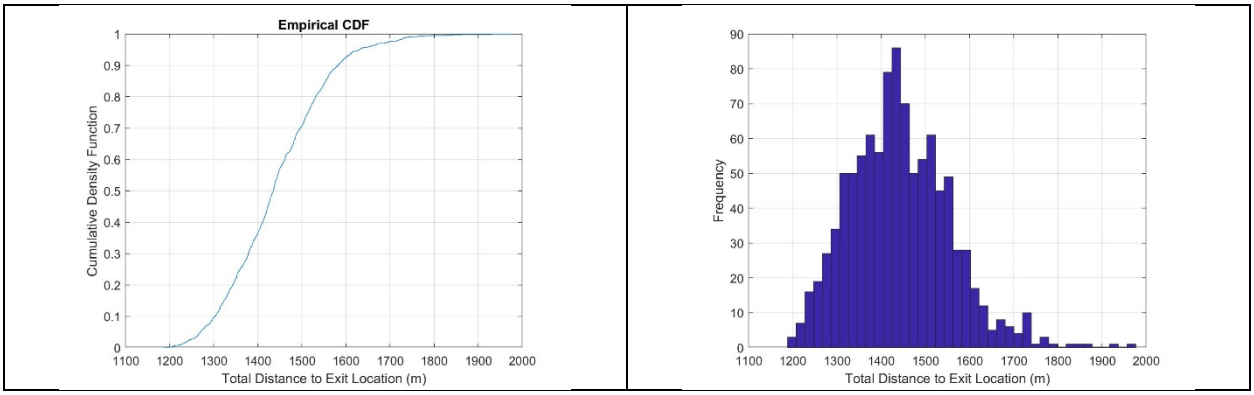
a) Plot the Three Cumulative Exit Distance curves (one for each aircraft) and clearly state the selected runway exit locations (i.e., the distance from the runway threshold to the point of curvature of each runway exit).

Use 41 knots of runway exit speed for 30-degree angle exits.

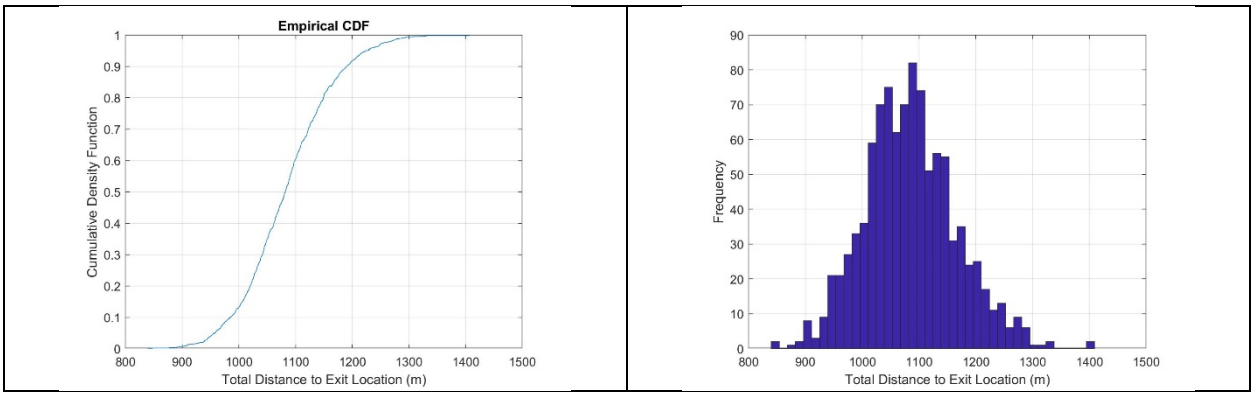
- Boeing 787-8



- Airbus A320



- Bombardier Q400

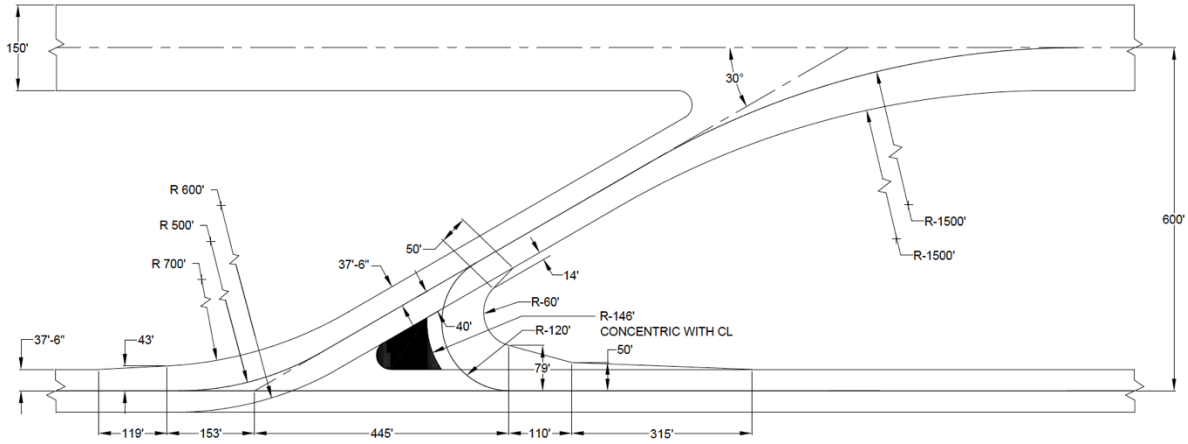


To accommodate 85% of aircraft, the exits should be located at 1850m, 1550m, 1150m for Boeing 787-8, Airbus A320, and Bombardier Q400, respectively. For bi-directional use, the locations of exits could be 1150m (Q400, B787 from opposite direction), 1500m (A320 from both directions), 1850m (B787, and Q400 from opposite direction) from each runway threshold.

b) Provide (do not draw) all relevant dimensions of the high-speed runway exit based on the critical aircraft (only one for all three exits). State the Taxiway Design Group used.

- Boeing 787-8 AAC: C, ADG: V, TDG: 5
- Airbus A320 AAC: C, ADG: III, TDG: 3
- Bombardier Q400 AAC: C, ADG: III, TDG: 5

Since the critical TDG is 5, apply relevant dimensions for TDG 5.



c) Estimate the percent of Boeing 787-8 aircraft that could take the second high-speed exit (i.e., one designed for A320s).

According to the simulation results, only 10% of Boeing 787-8 can take the second high-speed exit located at 1550 m.

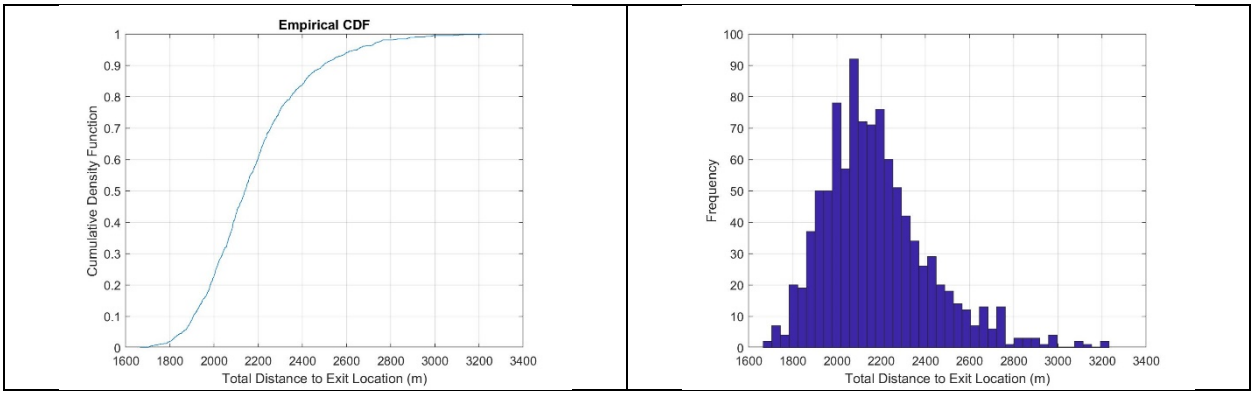
d) Compare the runway exit locations Points of Curvature of your design with the locations of three high-speed exit locations at Chicago O'Hare runway 10C - designated P3, P5 and P6 (see diagram in Figure 3). Comment.

According to Google Earth, the locations of P3, P5, and P6 are 1260m, 1700m, 2010m, respectively. ORD has a fleet mix of many regional jets, narrow-body commercial aircraft and heavy aircraft bigger than the Boeing 787-8. P6 is perhaps well suited for larger heavy aircraft.

e) Design a 90-degree runway exit to "catch" all aircraft that are not able to take anyone of the three high-speed. Select the exit location so that the 90-degree runway exit does not overlap with the last high-speed exit.

Solution 1: For 90-degree angle exit, apply 15 knots as the exit speed.

- Boeing 787-8, 90-degree runway exit



According to the given aircraft data, the dominant aircraft is Boeing 787-8. Then, the 90-degree runway exit should be installed at the end of the runway (PC starts at 2924 meters from the runway threshold) meters.

Solution 2: From the FAA Runway Location Guidance Table (see picture below) a low speed exit located 2,743 meters from the runway threshold can accommodate 100% of the aircraft in wet conditions.

FAA AC 150/5300-13a Runway Location Guidance

Table 4-9. Exit taxiway cumulative utilization percentages

DISTANCE THRESHOLD TO EXIT	WET RUNWAYS				DRY RUNWAYS							
	RIGHT & ACUTE ANGLED EXITS				RIGHT ANGLED EXITS				ACUTE ANGLED EXITS			
	S	T	L	H	S	T	L	H	S	T	L	H
0 ft (0 m)	0	0	0	0	0	0	0	0	0	0	0	0
500 ft (152 m)	0	0	0	0	0	0	0	0	1	0	0	0
1000 ft (305 m)	4	0	0	0	6	0	0	0	13	0	0	0
1500 ft (457 m)	23	0	0	0	39	0	0	0	53	0	0	0
2000 ft (610 m)	60	0	0	0	84	1	0	0	90	1	0	0
2500 ft (762 m)	84	1	0	0	99	10	0	0	99	10	0	0
3000 ft (914 m)	96	10	0	0	100	39	0	0	100	40	0	0
3500 ft (1067 m)	99	41	0	0	100	81	2	0	100	82	9	0
4000 ft (1219 m)	100	80	1	0	100	98	8	0	100	98	26	3
4500 ft (1372 m)	100	97	4	0	100	100	24	2	100	100	51	19
5000 ft (1524 m)	100	100	12	0	100	100	49	9	100	100	76	55
5500 ft (1676 m)	100	100	27	0	100	100	75	24	100	100	92	81
6000 ft (1829 m)	100	100	48	10	100	100	92	71	100	100	98	95
6500 ft (1981 m)	100	100	71	35	100	100	98	90	100	100	100	99
7000 ft (2134 m)	100	100	88	64	100	100	100	98	100	100	100	100
7500 ft (2286 m)	100	100	97	84	100	100	100	100	100	100	100	100
8000 ft (2438 m)	100	100	100	93	100	100	100	100	100	100	100	100
8500 ft (2591 m)	100	100	100	99	100	100	100	100	100	100	100	100
9000 ft (2743 m)	100	100	100	100	100	100	100	100	100	100	100	100

Notes:

S - Small, single engine	12,500 lbs (5670 kg) or less
T - Small, twin engine	12,500 lbs (5670 kg) or less
L - Large	12,500 lbs (5670 kg) to 300,000 lbs (136080 kg)
H - Heavy	300,000 lbs

f) What is the recommended distance between the new runway centerline and the parallel taxiway at the airport? Explain.

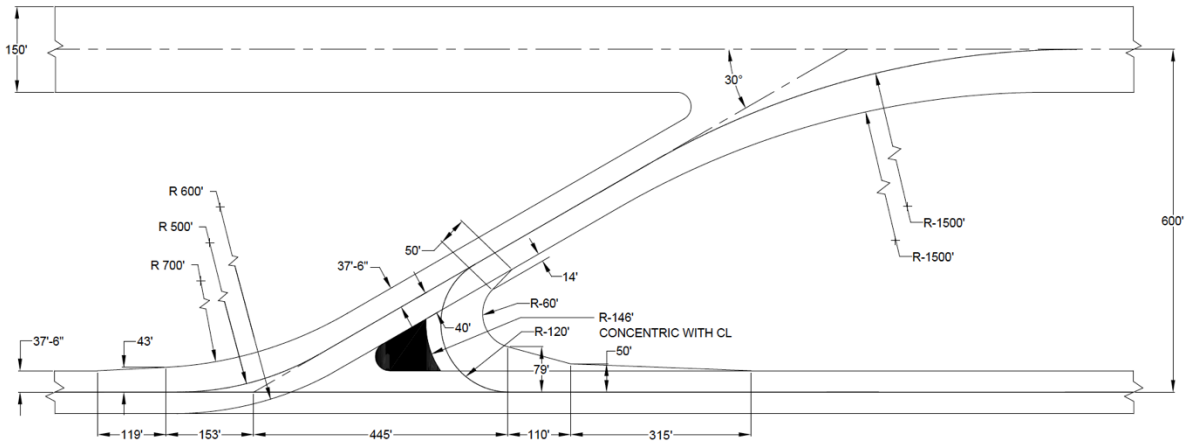
Initial solution:

According to the AC 150/5300-13A, the runway separation to the parallel taxiway is defined by the elevation of the airport. (for 90 degree exit design)

"The standard runway centerline to parallel taxiway centerline separation distance is 400 feet for airports at or below an elevation of 1,345 feet; 450 feet for airports between elevations of 1,345 feet and 6,560 feet; and 500 feet for airports above an elevation of 6,560 feet."

In this problem, I assumed the elevation of the airport is 1,000ft. Then, the distance between the new runway centerline and the parallel taxiway is 400ft.

Refinement (check for high-speed runway exit standards)



The recommended standard for high-speed runway exits is 600 feet (between runway and taxiway centerlines).

Problem 3.

a) Specify (do not draw) the dimensions of a crossover taxiway shown in Figure 4 using the FAA taxiway design methods contained in Chapter 4 of the Advisory Circular 5300-13A. The critical aircraft is the Boeing 747-8i. Specify all dimensions shown in Figure 4 considering the critical aircraft operating at the airport.

Boeing 747-8 AAC: D, ADG: VI, TDG: 5

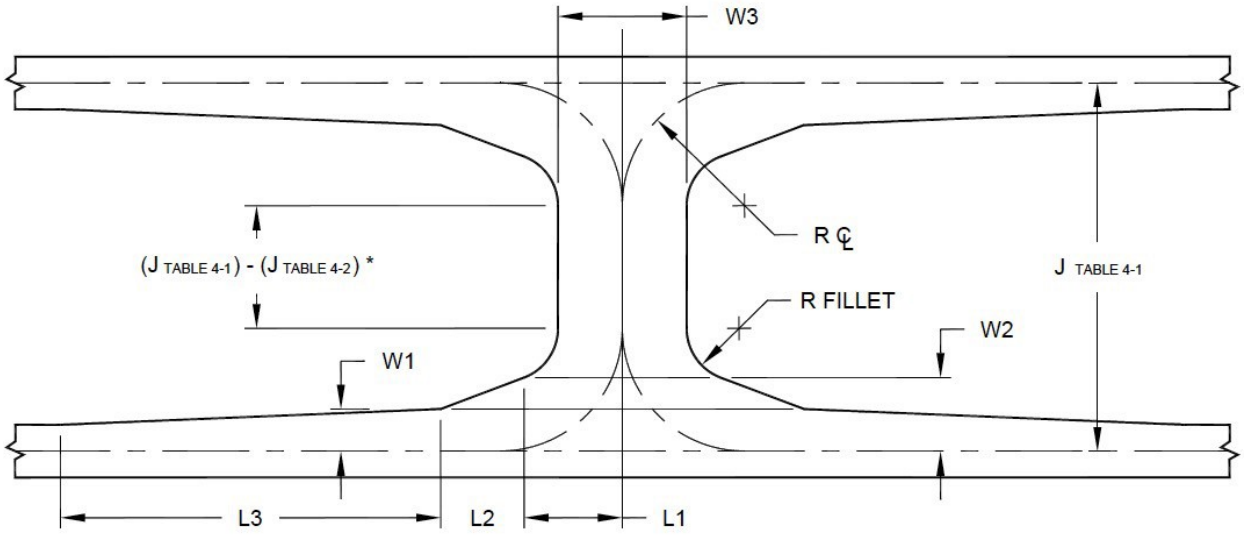

W3
R ℄
(J TABLE 4-1) - (J TABLE 4-2) *
J TABLE 4-1
R FILLET
W2
W1
L3
L2
L1

Table 4-15. Crossover taxiways with direction reversal between taxiways based on ADG

Dimension (see Figure 4-24)	TDG										
	2		3		4	5		6		7	
	ADG										
	III	IV	III	IV	IV	IV	V	V	VI	V	VI
Taxiway Centerline to Centerline Distance	152	215	152	215	215	215	267	267	324	267	324
W-0 (ft)	17.5	17.5	25	25	25	37.5	37.5	37.5	37.5	41	41
W-1 (ft)	28	33	38	43	45	57	54	61	56	61	56
W-2 (ft)	53	33	62	43	89	94	86	120	100	120	100
W-3 (ft)	96	65	109	78	149	179	141	200	167	200	167
L-1 (ft)	198	213	210	217	366	359	347	476	444	433	404
L-2 (ft)	65	0	55	0	96	90	90	130	135	130	135
L-3 (ft)	64	102	64	98	86	99	104	109	128	109	128
L-4 (ft)	0	75	0	75	0	0	27	0	24	0	24
R-Fillet (ft)	25	75	15	65	20	15	50	15	65	15	65
R-CL (ft)	76	70	76	70	107.5	107.5	120	133.5	150	133.5	150
Steering Angle (degrees)	54	50	54	50	59	59	50	66	54	50	50

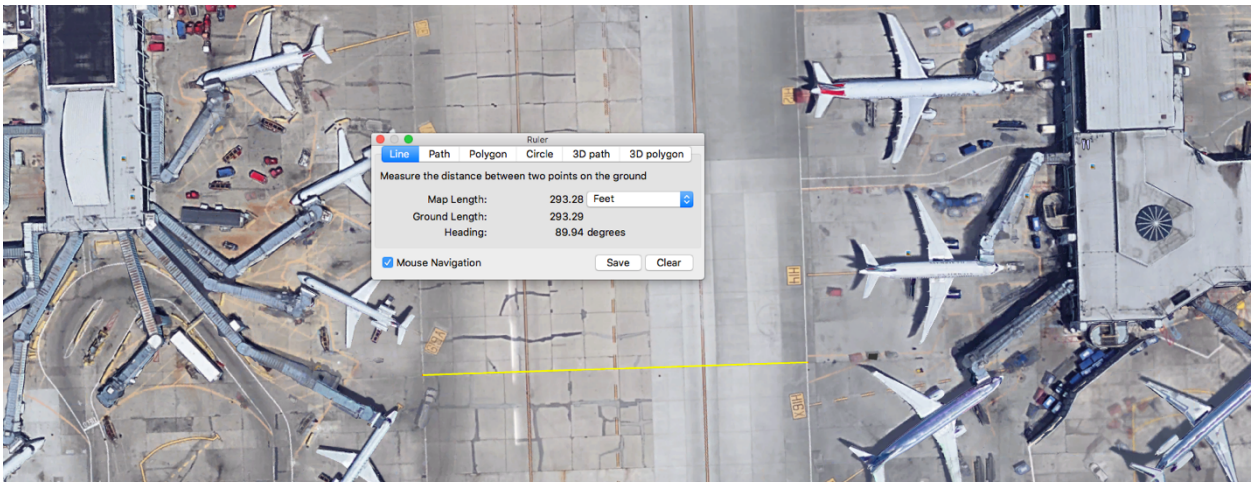
b) Briefly contrast the dimensional standards used in this design and those used in Problem 2.

Compared to a high-speed exit, the crossover taxiway has wider and shorter connection road (W-3). Due to the high speed (41 knots), the high-speed exit has very large radius (1500 feet radius). On the other hand, the 90-degree exit has a radius of 250 feet due to its low speed requirement (15 knots).

Problem 4.

a) Estimate the critical FAA ADG group operating at ORD Airport and parking between terminals G and H (see Figure 5). Note that a dual taxi lane is provided between terminals G and H.

The taxi lane between terminal G and H is dual. Then, the width of taxi lane is 2.3 times wingspan + 30ft. Therefore, the critical aircraft's wingspan is around 115 and it means ADG III (wingspan: 79~118ft).



b) Estimate the critical FAA ADG group operating at ORD Airport on taxiways "Alpha" and "Bravo" (see Figure 5). Alpha and Bravo are perimeter taxiways around the terminals at the airport.

The two-parallel taxiway distance is around 250ft. Then, the ADG group is IV (215ft of taxiway centerline to parallel taxiway centerline).