Quiz 2 - Take Home

Open Notes and Internet

Instructor: A.A. Trani

Due: December 1, 2021 at midnight

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)

Problem 1

This problem analyzes the runway capacity for an airport with runway configuration shown in Figure 1. The airport fleet mix is shown in Table 1. Note that the regional airport uses the new Re-Categorization developed by FAA with 6 groups. ATC uses 2 nm as the minimum separation between arrivals and departures if mixed runway operations are in place (Note runway 5L is used for mixed operations). For this analysis we use the following technical parameters: a) in-trail delivery error of 22 seconds under IMC conditions, b) probability of violation is 5%. Arriving aircraft are "vectored" by ATC to intercept the extended centerline off the runways 5R and 5L at two fixes (points in space) located 11 miles from each runway threshold. Tables 2 and 3 show the arrival-arrival and departure-departure separations. According to Figure 1, runway 5R is the primary arrival runway and 5L is the primary departure runway.

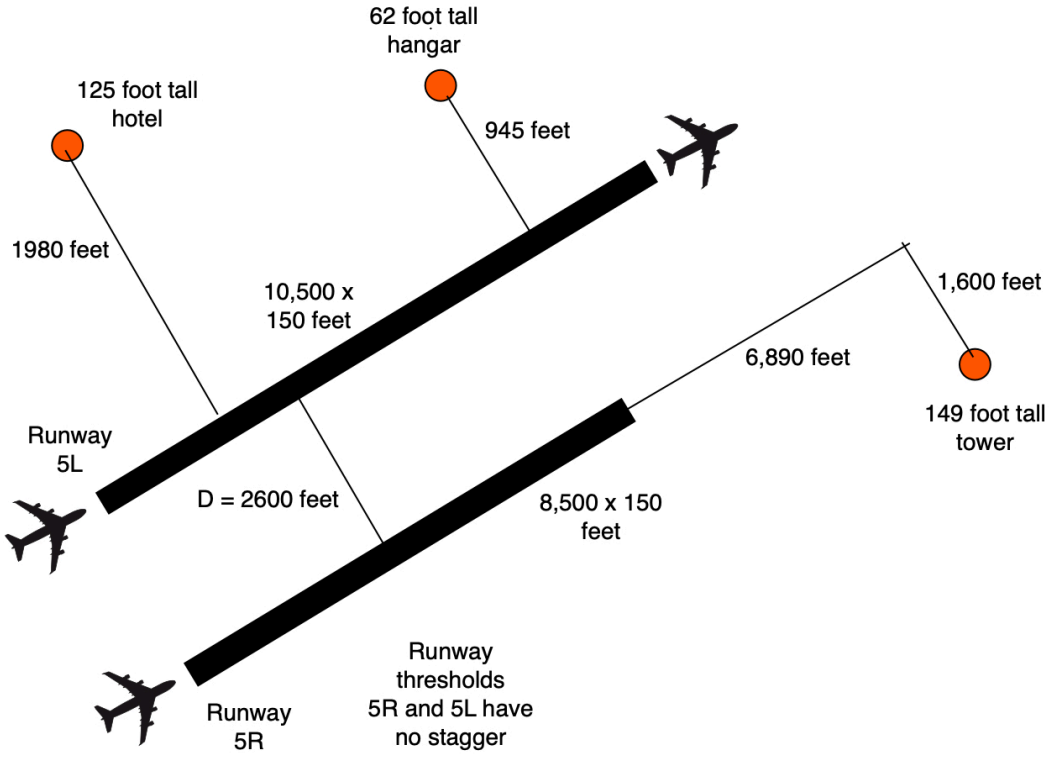


Figure 1. Runway Configuration for Problem 1.

Table 1. Runway Operational Parameters and Fleet Mix for Problem 1. RECAT Groups.

Aircraft RECAT Group	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) from FAF
RECAT C	8	59	151
RECAT D	72	53	141
RECAT E	20	50	132
Totals	100		

Table 2. Minimum arrival-arrival separations under IMC conditions. Values in are nautical miles. ***Values Shown Do Not Include Buffers.***

	Trailing Aircraft (columns)		
Lead Aircraft (below)	RECAT E	RECAT D	RECAT C
RECAT C	5	4	4
RECAT D	4	3	3
RECAT E	3	3	3

Table 3. Minimum departure-departure separations under IMC conditions. Values in are seconds. ***Buffers are Included.***

	Trailing Aircraft (columns)		
Lead Aircraft (below)	RECAT E	RECAT D	RECAT C
RECAT C	135	130	125
RECAT D	70	70	70
RECAT E	65	65	65

a) Estimate the arrival capacity of runway 5R in IMC conditions.

Augmented Matrix (Tij + Bij)							
		Trailing Aircraft (Header Columns)					
Lead (column 1)	E	D	C	B	Other		Expected Value
E	118.12	112.90	107.82	107.82	103.80		E(Tij) + B(Tij)
D	157.58	112.90	107.82	107.82	103.80		122.72
C	193.25	150.26	131.66	131.66	126.30		
B	217.09	174.10	155.51	131.66	126.30		
Other	201.30	182.15	163.55	163.55	126.30		
Arrivals Only Capacity (per hour)			29.33				

b) Estimate the departure capacity of runway 5L in IMC conditions.

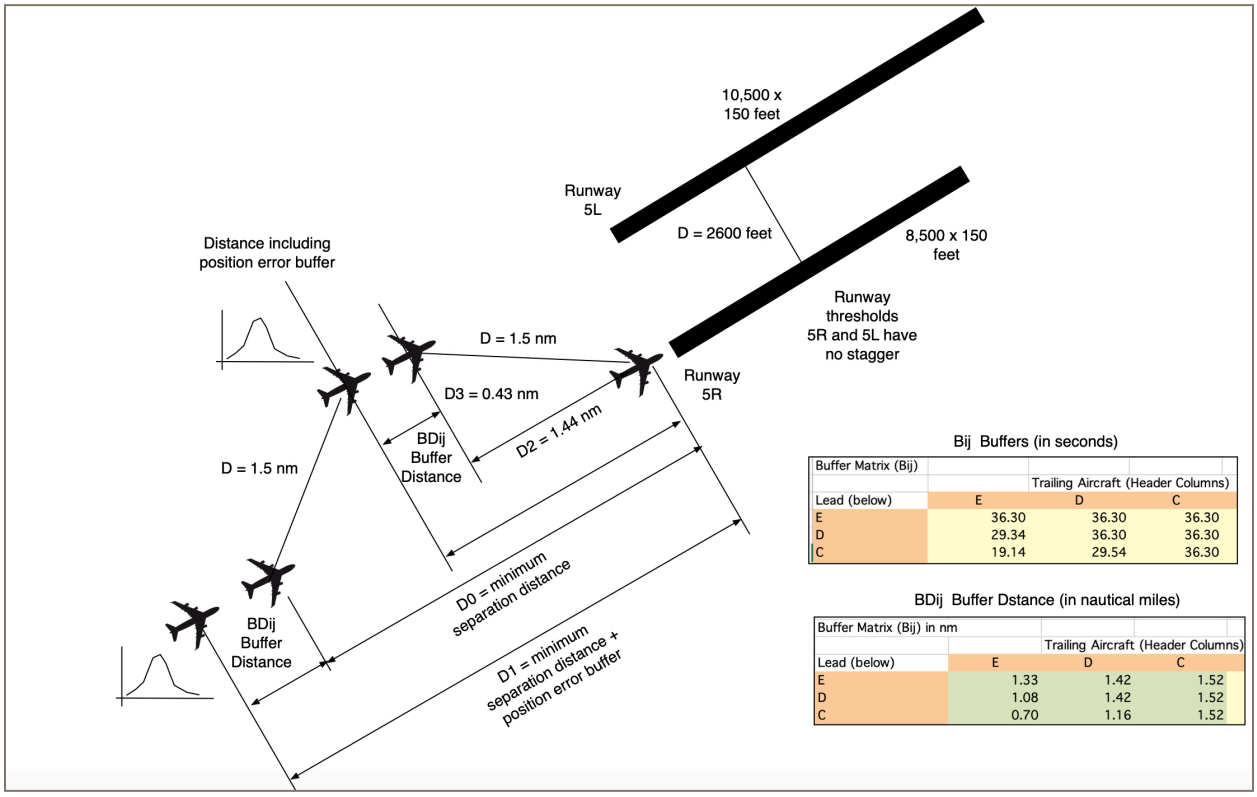
Departure-Departure Separation Matrix (seconds)							
		Trailing Aircraft (Header Columns)					
Lead (column 1)	E	D	C	B	Other		Expected Value
E	65	65	65	65	120		E(Td)
D	70	70	70	70	120		
C	135	130	125	120	120		73.848
B	140	140	140	140	120		
Other	140	140	140	140	120		
Departures Only Capacity (per hour)			48.75				

c) Find the number of additional arrivals that can be processed on runway 5L during a two-hour period with no departures at the airport. Draw the arrival-departure diagram for answers (a-c).

Examine the natural distance gaps between successive arrivals to runway 5R (primary arrival runway in this analysis).

Augmented Matrix (Tij + Bij)			
		Trailing Aircraft (Header Columns)	
Lead (column 1)	E	D	C
E	118.12	112.90	107.82
D	157.58	112.90	107.82
C	193.25	150.26	131.66

Convert the inter-arrival time separation matrix to distance to judge if the gap allows an arrival in the secondary runway (see the diagram below). Remember that we need a minimum of 1.5 nm plus a buffer between the arrival on the secondary runway and each one of the successive arrivals on the primary runway (two buffers shown in the figure).



Bij Buffers (in seconds)

Buffer Matrix (Bij)			
	Trailing Aircraft (Header Columns)		
Lead (below)	E	D	C
E	36.30	36.30	36.30
D	29.34	36.30	36.30
C	19.14	29.54	36.30

BDij Buffer Dstance (in nautical miles)

Buffer Matrix (Bij) in nm			
	Trailing Aircraft (Header Columns)		
Lead (below)	E	D	C
E	1.33	1.42	1.52
D	1.08	1.42	1.52
C	0.70	1.16	1.52

Figure 2. Diagram to Show Conditions for an Arrival on the Secondary Runway Under Dependent Arrival Operations. Expected Value of Buffer Distances is 1.3 nm.

Figure 3 shows the distance between successive arrivals in nautical miles. Note that some of the arrival-arrival separations offer large gaps (i.e., lead C and trailing E class aircraft). Our goal is then to evaluate if such gaps allow one arrival on the second day runway while maintaining the 1.5 nm diagonal separation plus the buffer from two successive arrivals.

Distance between successive arrivals (nm)				
		Trailing Aircraft (Header Columns)		
Lead (below)	E	D	C	
E	4.33	4.42	4.52	
D	5.78	4.42	4.52	
C	7.09	5.89	5.52	

Figure 3. Distance Between Successive Arrivals (nm).

The typical distance needed to allow an arrival on the secondary runway is estimated to be:

MinDistance = 2 * D2 + 2 * BDij

MinDistance = 2*(1.44) + 2*1.35) = 5.58 nm

Using this calculated distance, we estimate that only three cells in Figure 3 (lead C - trailing E, lead C - trailing D, lead D - E trailing) allow arrivals on the secondary runway.

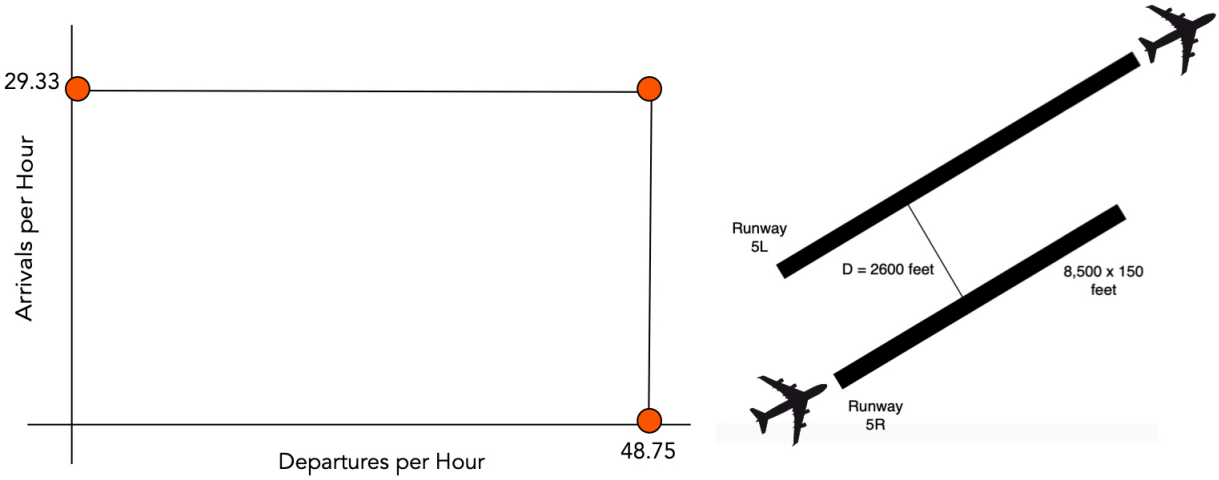
Number of arrivals per gap are:

C Leads - E Trails = (0.016)(29.33-1)*1 = 1.64 arrivals per hour

C Leads - D Trails = (0.058)(29.33-1)*1 = 0.45 arrivals per hour

D Leads - D Trails = (0.144)(29.33-1)*1 = 4.08 arrivals per hour

Total of ~6.17 arrivals per hour in the secondary runway.



Arrival-Departure Diagram for Parts (a-b). Arrivals on Runway 5R. Departures on 5L.

d) Briefly explain why ATC designates runway 5L as the primary departure runway.

Because the runway is the longest of the two. Long runways are needed for departures.

e) Find the maximum departure runway capacity if both runways are used during a period of no arrivals to the airport. State your assumptions about how do you operate runways 5L and 5R with departure operations.

Runways 5L and 5R are separated by 2600 feet with no stagger at the departure threshold. Hence they can be operated independently.

The departure capacity will be double of that estimated for runway 5L or 97.5 departures per hour.

f) If the weather conditions are VMC, can arrivals occur on runways 5L and 5R simultaneously? Explain the runway separation rule used.

Yes,. The VMC rule states that 700 feet is needed for independent VMC operations and 1,200 feet for ADG groups V and VI. So as long as the wake vortex interaction between the two aircraft is mitigated such operations are possible in VMC conditions. This is done by flying two aircraft near perpendicular to each other in the final approach coarse.

Problem 2 (30 Points)

This problem analyzes the obstructions to navigation for the airport configuration shown in Figure 1. Both runways are precision runways with ILS category 1 approach capability.

a) Analyze the three objects shown in Figure 1 and determine if any of the objects is an an obstruction to navigation. In your analysis, include checks to FAR Part 77, OFZ and new siting criteria (OCS). Clearly state the surface or criteria violated (if any).

149-foot tall tower analysis

The lateral distance from the extended runway centerline to the edge of the approach surface (semi-width of approach surface) at 6890 feet from runway is:

Semi width of approach surface = 500 + 0.15 * (6890-200) = 1,503.5 feet. Hence the tower is just outside the approach surface and therefore the transitional surface needs to be investigated.

Height of edge of approach surface = (6890-200) / 50 = 133.8 feet

The transitional surface increases at a rate of 7:1 after the edge of the approach surface. The height of the transition surface at the location of the tower is:

Height of transition surface = 133.8 + (1600- 1503.5) / 7 = 133.8 + 13.78 = 147.6 feet

The tower is an obstruction to navigation because it has a height of 149 feet (1.4 foot violation).

Using an OCS criteria, the tower is inside the OCS polygon (extends to 10,000 feet from the end of the runway assuming no clearway present). OCS has a slope of 40:1, therefore the tower is below the OCS surface (OCS surface at 6890 feet is 172.25 feet).

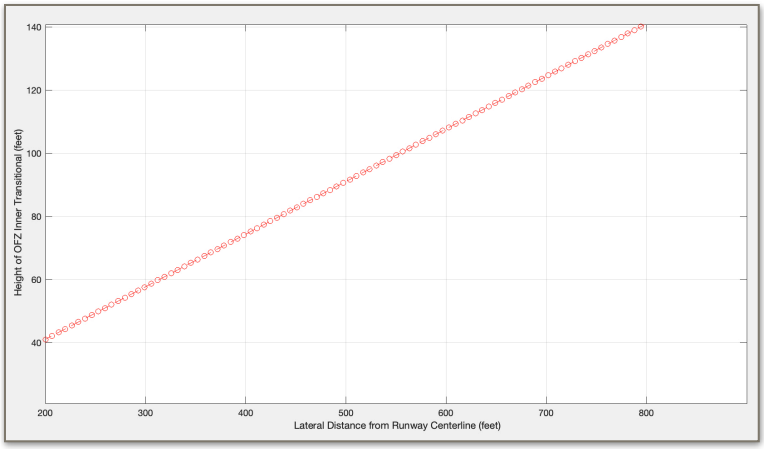
62-foot tall hangar analysis

The semi-width of the primary surface for a precision runway is 500 feet (1,000 feet total width). The hangar is in the transitional surface.

The height of the transition surface at the location of the hangar is = (945- 500) / 7 = 63.6 feet

The hangar is not an obstruction to navigation because is below the maximum permissible height by 1.6 feet.

The hangar does not violate the inner transitional OFZ surface (see the Category 1 surface below).



125-foot tall hotel analysis

The semi-width of the primary surface for a precision runway is 500 feet (1,000 feet total width). The transitional surface ends at a distance (150*7 + 500) = 1550 feet from the runway centerline. The hotel is not in the transitional surface but in the horizontal surface. transitional surface.

The height of the horizontal surface at the location of the hotel is = 150 feet.

The hotel is not an obstruction to navigation because is below the height of the horizontal surface.

b) If any of the objects is an obstruction to navigation, what remedial actions can the airport authority take the mitigate the problem? Explain.

Problem 3 (30 Points)

a) Specify the dimensions needed to construct a taxiway crossover to link two new parallel taxiways to be constructed at an airport (see Figure 3). **Design the crossover taxiway to satisfy the TDG criteria allowing aircraft to reverse direction (see Figure 3)**. The design aircraft is the Boeing 777-300ER (see Figure 2). Clearly state all the dimensions needed to draw your solution (L1, L2, L3, etc.).

The critical aircraft is ADG V and TDG 6 (see Appendix 1 of the AC 15300-13).

Manufacturer	Aircraft	AAC	ADG	TDG	Wing-span	Tail Height	Length	CMG	Wheel-base	MGW Outer to Outer	MTOW	V_{REF}/ Approach Speed
					ft (m)	ft (m)	ft (m)	ft (m)	ft (m)	ft (m)	lbs (kg)	kts
Boeing	777-300	D	V	6	199.8 (60.90)	61.5 (18.75)	242.5 (73.90)	112.3 (34.20)	102.4 (31.21)	42.3 (12.90)	660,000 (299371)	149
Boeing	777-300ER	D	V	6	212.6 (64.80)	61.8 (18.84)	242.5 (73.90)	112.3 (34.20)	102.4 (31.21)	42.3 (12.90)	775,000 (351534)	149

Paragraph 411 of the FAA advisory circular explains the design guidelines of crossover taxiways. Table 4-14 shows the design dimensions of crossover taxiways if reversal is needed (180-degree turn) **based on TDG design group. The minimum dimension is 312 feet.** Note that dimension of taxiway-taxiway distance based ADG group with reversal is 267 feet (see Table 4-15 in the Advisory Circular). **Therefore, the design of our crossover taxiway must use 312 as the distance between taxiways and use the dimensions in Table 4-14 (highlighted in red).**

Table 4-14. Crossover taxiways with direction reversal between taxiways based on TDG

Dimension (See Figure 4-23)	TDG							
	1A	1B	2	3	4	5	6	7
Taxiway Centerline to Centerline Distance	70	105	162	162	240	240	312	312
W-0 (ft)	12.5	12.5	17.5	25	25	37.5	37.5	41
W-1 (ft)	20	20	28	36	43	53	56	56
W-2 (ft)	20	34	53	62	83	87	109	109
W-3 (ft)	37	57	90	104	138	168	180	180
L-1 (ft)	48	106	198	198	355	340	438	400
L-2 (ft)	0	35	65	65	100	100	150	150
L-3 (ft)	31	41	65	65	94	108	123	123
R-Fillet (ft)	15	20	30	20	40	35	50	50
R-CL (ft)	35	52.5	81	81	120	120	156	156

b) Draw to scale the taxiway crossover to link the two new parallel taxiways. Clearly state all the dimensions in your solution.

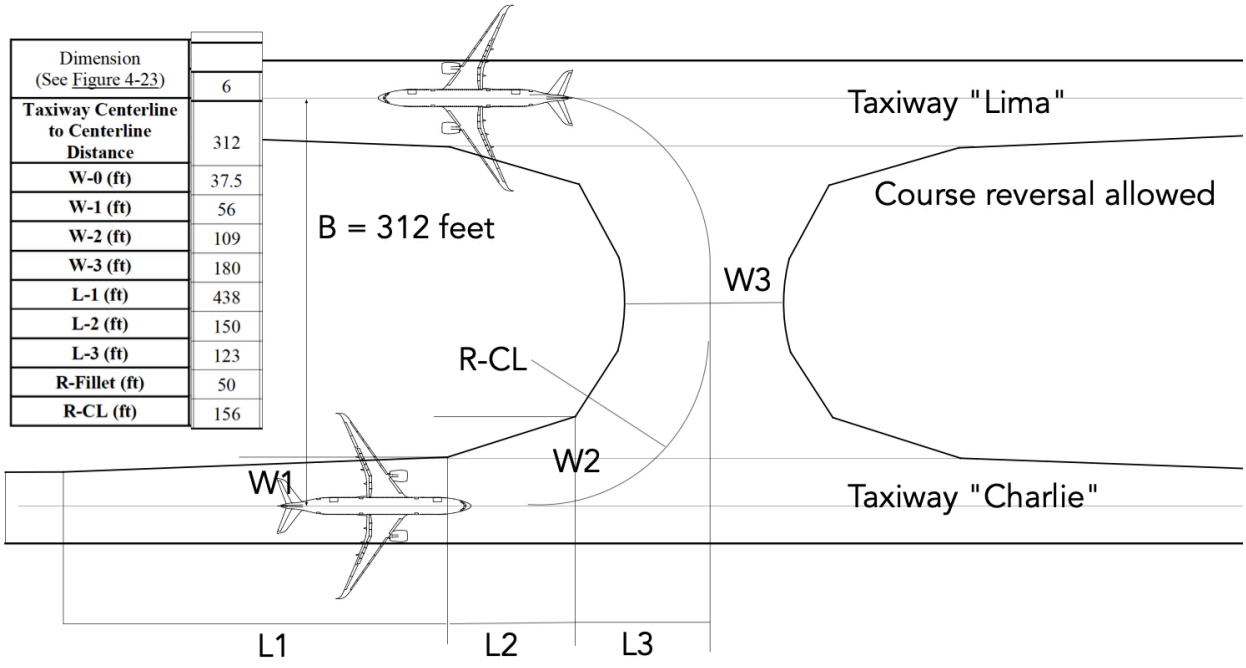


Figure 4. Geometric Design of Crossover Taxiway for Boeing 777-300ER with Reversal Allowed.

c) If the **taxiway reversal would have been avoided,** state the minimum distance between parallel taxiways.

If a taxiway does not require a 180-degree turn (or reversal), the taxiway to taxiway dimension is either the distance supplied in Table 4-1 in the FAA Advisory Circular or according to paragraph 411.b "twice the radius of a standard 90-degree turn."

Table 4-1 of the FAA Advisory Circular 5300-13a.

ITEM	DIM (See Figure 3-26)	ADG I	II	III	IV	V	VI
TAXIWAY SEPARATION							
Taxiway Centerline to Parallel Taxiway/Taxilane Centerline [1]	J	70 ft (21 m)	105 ft (32 m)	152 ft (46.5 m)	215 ft (65.5 m)	267 ft (81 m)	324 ft (99 m)
Taxiway Centerline to Fixed or Movable Object	K	44.5 ft (13.5 m)	65.5 ft (20 m)	93 ft (28.5 m)	129.5 ft (39.5 m)	160 ft (48.5 m)	193 ft (59 m)
Taxilane Centerline to Parallel Taxilane Centerline [1]		64 ft (19.5 m)	97 ft (29.5 m)	140 ft (42.5 m)	198 ft (60 m)	245 ft (74.5 m)	298 ft (91 m)
Taxilane Centerline to Fixed or Movable Object		39.5 ft (12 m)	57.5 ft (17.5 m)	81 ft (24.5 m)	112.5 ft (34 m)	138 ft (42 m)	167 ft (51 m)

b. Crossover taxiways without direction reversal. When a crossover taxiway is not designed for direction reversal from a taxiway to a parallel taxiway the centerline to centerline separation of the parallel taxiways is equal to twice the radius of a standard 90 degree turn or the separation required by the ADG, whichever is greater. The fillets for such crossover taxiways may always be based on standard 90 degree turns (see Figure 4-25).

Comparing twice the radius of a 90-degree turn (R=115 feet or 230 feet total) with the minimum distance provided in Table 4-1 for ADG-V, we conclude that the minimum distance between parallel taxiways without reversal is 267 feet.

Table 4-9. Standard intersection details for TDG 6

TDG 6							
Dimension (See Figure 4-13, Figure 4-14, and Figure 4-15)							
Δ (degrees)	30	45	60	90	120	135	150
W-0 (ft)	37.5	37.5	37.5	37.5	37.5	37.5	37.5
W-1 (ft)	44	46	49	55	56	56	55
W-2 (ft)	60	71	81	95	92	98	100
L-1 (ft)	313	347	387	433	440	436	430
L-2 (ft)	160	170	160	145	130	140	150
L-3 (ft)	16	29	47	95	230	338	537
R-Fillet (ft)	0	0	0	0	50	50	50
R-CL (ft)	150	150	150	115	140	150	150
R-Outer (ft)	350	285	250	180	185	194	192

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