CEE 4674 Airport Planning and Design

Geometric Design: Part 1

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Organization of this Presentation

- Review of geometric design standards
- Runway-runway separation standards
- Runway-taxiway separations
- Taxiway and taxilanes
- Runway exit types and kinematic model application
- Runway exit locations

Taxiway and Runway Design Distances

- Source of information: FAA AC 5300-13B Chapters 3, 4 and Appendix G (Tables)
- Dictated by safety analyses
- Provide sufficient space for expansion, and safe and efficient movement of aircraft
- For regular aircraft (those than can be classified according to the FAA design standard) use Tables

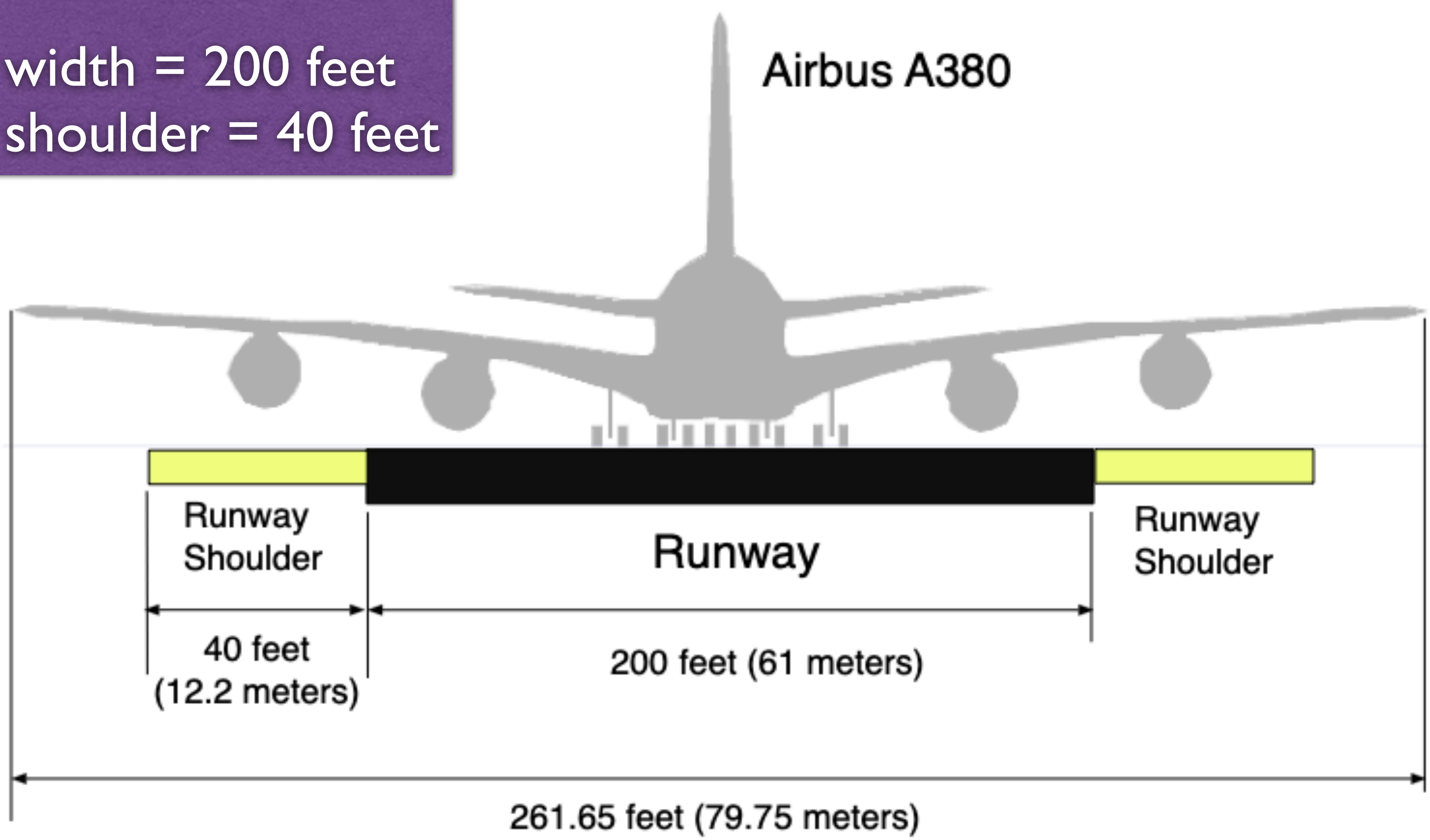
Where do I find the Runway and Taxiway Geometric Design Standards?

- Runway design standards (Chapter 3)
  - Runway design concepts (All Chapter 3)
  - Runway gradients (Section 3.16)
- Taxiway and taxilane design standards (Chapter 4)
  - Taxiway width (Section 4.4 and Table 4-2)
  - Taxiway clearance requirements (Section 4.5)
  - Parallel taxiways (Table 4-1) etc.
- Appendix G or use the FAA runway design standards matrix (web)

Impacts on Runway Design Standards

- Runway and taxiway dimensional standards for aircraft avoid possible foreign object damage to the engines

ADG VI
Runway width = 200 feet
Runway shoulder = 40 feet

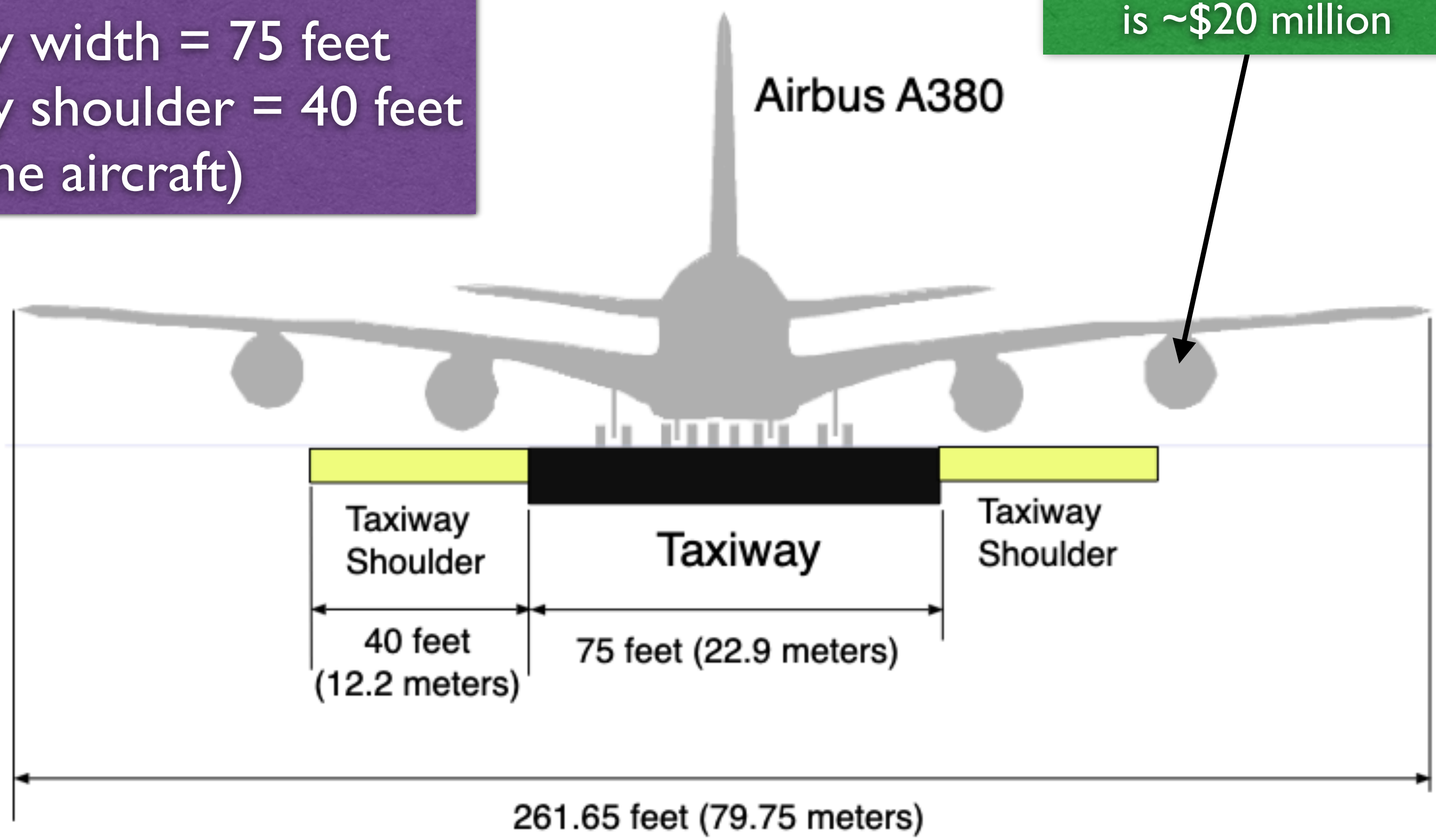


Impacts on Taxiway Design Standards

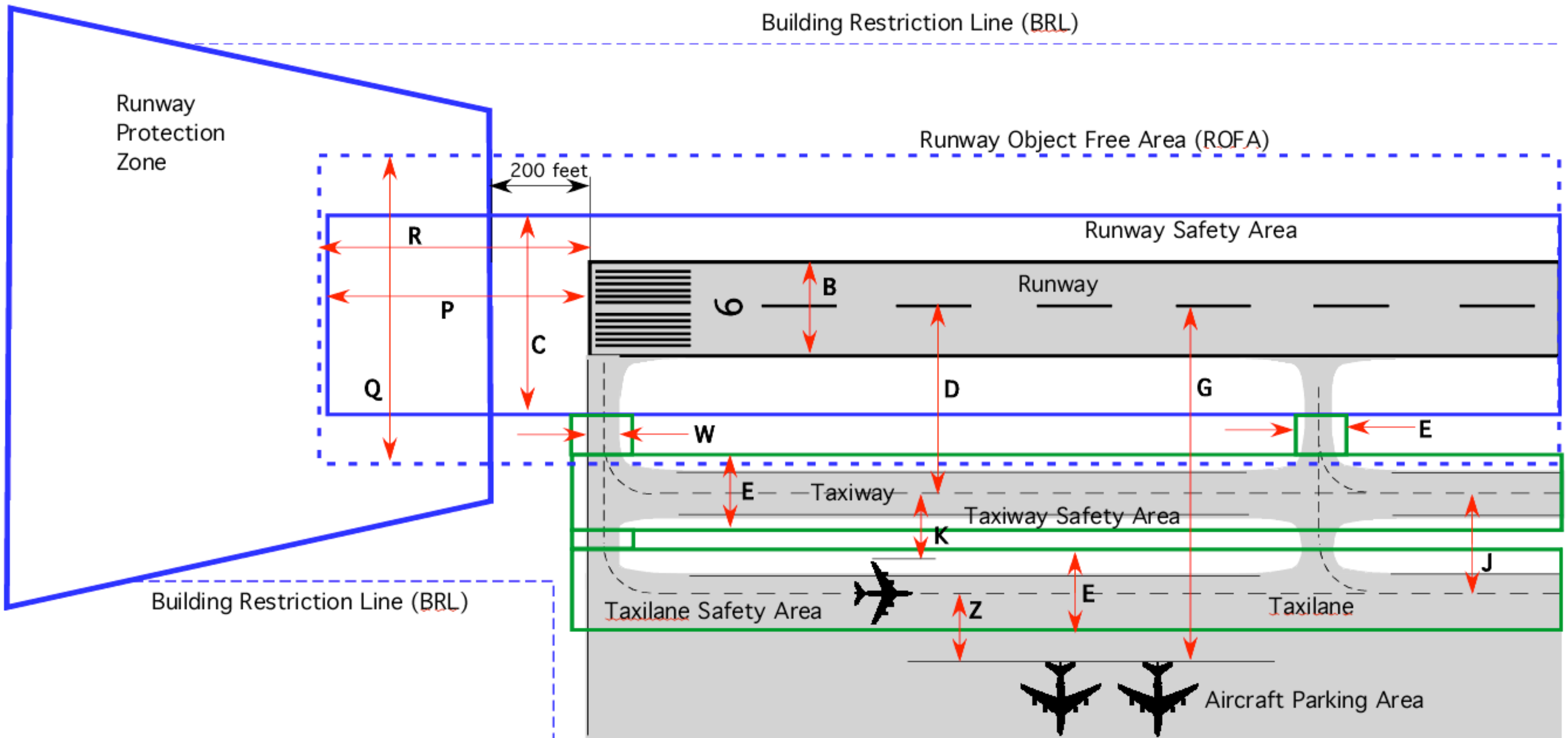
- Taxiway dimensional standards for aircraft avoid possible foreign object damage to the engines

TDG 6
Taxiway width = 75 feet
Taxiway shoulder = 40 feet
(4 engine aircraft)

Rolls-Royce
Trent 900 engine cost
is ~$20 million



Sample Airport to Learn Design Standards



Nomenclature

B = Runway width
C = Runway safety area width
D = Runway to parallel taxiway distance
E = Taxiway safety area width
G = Runway centerline to aircraft parking area
J = Taxiway to parallel taxiway/taxilane distance

K = Taxiway to fixed/movable object
P = Runway safety area length beyond runway end
Q = Runway object free area width
R = Runway object free area length beyond runway end
W = Taxiway width
Z = Taxilane to fixed/movable object

Runway Design Standards (Appendix G)

- Quick runway geometric design dimensions are included in tables of Appendix G of FAA AC 150/5300-13B
- Alternatively: use the FAA Runway Design Standards Matrix Tool

Table G-8. Runway Design Standards Matrix, C/D/E-II

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – II			
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	100 ft	100 ft	100 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		120 ft	120 ft	120 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots

FAA Runway Design Standards Matrix Tool

Runway Design Standards Matrices Form

Instructions: Choose to view data for a single Aircraft Approach Category (AAC) and Airplane Design Group (ADG) or compare two. If you compare two, the differences between the first and second option will be highlighted in yellow.

Main Category (required):	C/D/E - III
Compare Category (optional):	- Not Selected -
Submit	Reset

C/D/E - III

Runway Dims	DIM[1]	Visual	Not Lower than 1 Mile	Not Lower than 3/4 Mile	Lower than 3/4 Mile
Runway Width [12]	B	100 ft	100 ft	100 ft	100 ft
Shoulder Width [12]		20 ft	20 ft	20 ft	20 ft
Blast Pad Width [12]		140 ft	140 ft	140 ft	140 ft
Blast Pad Length		200 ft	200 ft	200 ft	200 ft
Crosswind Component		16 knots	16 knots	16 knots	16 knots

Airbus A320neo landing at ATL runway 8L

ADG - III

AAC - C

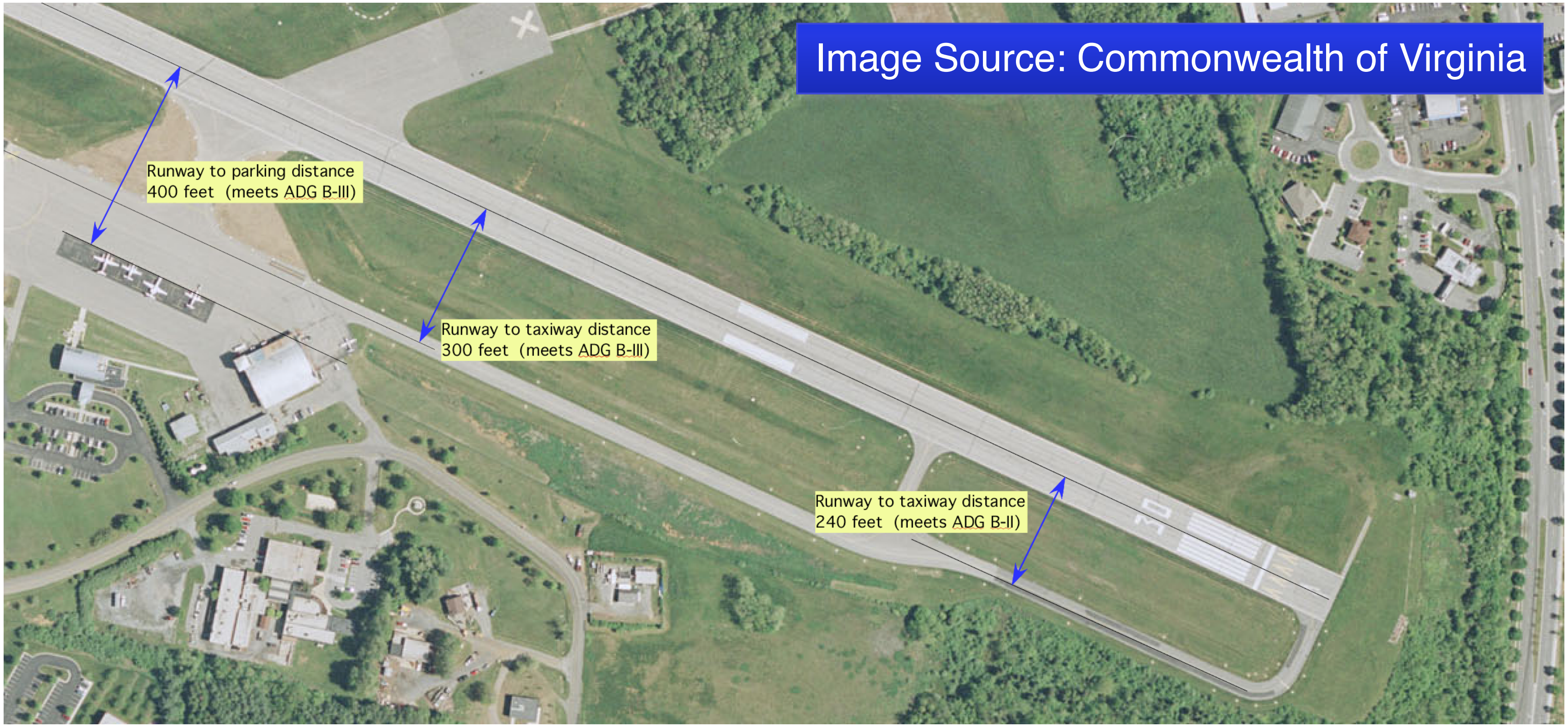
https://www.faa.gov/airports/engineering/airport_design/rdsm/

Sample Runway Design Standards Form

Table G-4. Runway Design Standards Matrix, A/B–II

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		A/B – II			
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	75 ft	75 ft	75 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		95 ft	95 ft	95 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		13 knots	13 knots	13 knots	13 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	C	150 ft	150 ft	150 ft	300 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	Q	500 ft	500 ft	500 ft	800 ft

Old Virginia Tech Airport (Before Runway Extension)



Airport had legacy parallel taxiway standards
B-II standard near runway end 30
New taxiway has been re-aligned

Runway Design Standards (D-VI)

Table G-12. Runway Design Standards Matrix, C/D/E-VI

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E – VI			
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	200 ft	200 ft	200 ft	200 ft
Shoulder Width		40 ft	40 ft	40 ft	40 ft
Blast Pad Width		280 ft	280 ft	280 ft	280 ft
Blast Pad Length		400 ft	400 ft	400 ft	400 ft
Crosswind Component		20 knots	20 knots	20 knots	20 knots
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 3.9*			
Holding Position [8]		280 ft	280 ft	280 ft	280 ft
Parallel taxiway/taxilane centerline [2, 6]	D	500 ft	500 ft	500 ft	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 following page.

Be careful with footnotes

Footnotes - be Careful for Exceptions

Footnotes:

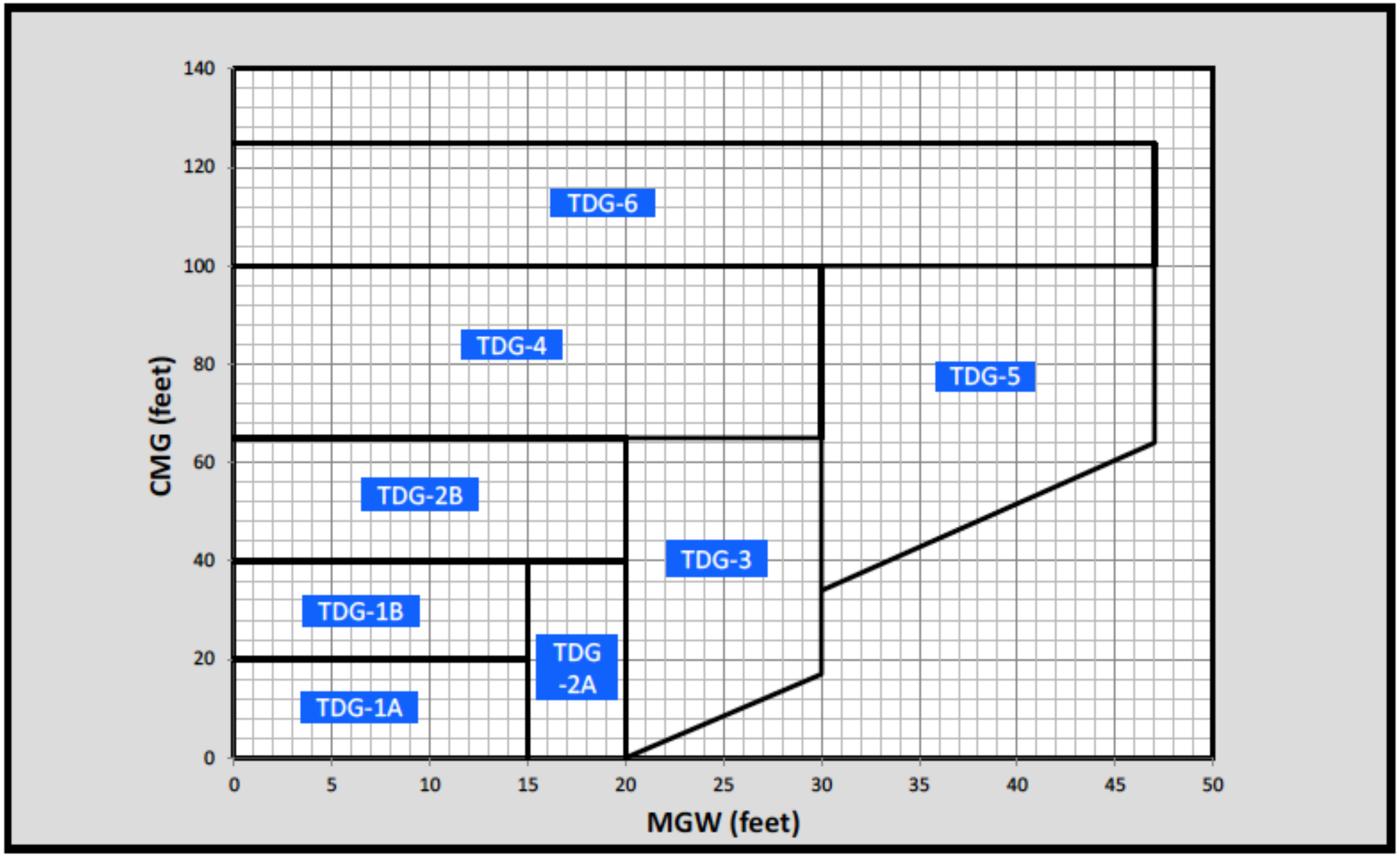
1. Letters correspond to the dimensions in Figure 3-1.
2. The runway to taxiway/taxilane centerline separation standards are for airports at sea level. For airports at higher elevations, an increase to these separation distances may be required to keep taxiing and holding aircraft clear of the inner-transitional OFZ (refer to paragraph 3.11.4). This standard cannot be used to justify a decrease in runway to taxiway/taxilane separation.
3. The standard runway centerline to parallel taxiway centerline separation distance is 400 feet (122 m) for airports at or below an elevation of 1,345 feet (410 m); 450 feet (137 m) for airports between elevations of 1,345 feet (410 m) and 6,560 feet (2,000 m); and 500 feet (152 m) for airports above an elevation of 6,560 feet (2,000 m).
4. For approaches with visibility less than 1/2-statute mile (0.8 km), runway centerline to taxiway/taxilane centerline separation increases to 400 feet (122 m).
5. For approaches with visibility less than 1/2-statute mile (0.8 km), the separation distance increases to 500 feet (152 m).
6. If the runway elevation is greater than or equal to 100 feet (30.5 m) above sea level, with approaches with visibility less than 3/4 statute mile (1.2 km), the separation distance increases by an elevation adjustment. For approaches with visibility less than 1/2-statute mile (0.8 km), the separation distance increases to 550 feet (168 m).

Footnotes - Part 2

7. Increase this distance 1 foot (0.3 m) for each 100 feet (30.5 m) above 5,100 feet (1,555 m) above sea level.
8. Increase this distance 1 foot (0.3 m) for each 100 feet (30.5 m) above sea level. For C-III aircraft, see footnote 7.
9. The RSA length beyond the runway end begins at the runway end when a stopway is not present. When a stopway is present, the length begins at the stopway end.
10. The RSA length beyond the runway end may be reduced to that required to install an EMAS (the designed set-back of the EMAS included). See the latest edition of AC 150/5220-22 for additional guidance.
11. This value only applies if that runway end is equipped with electronic or visual vertical guidance. ILS, GLS, LPV, LNAV/VNAV, and RNP lines of minima provide electronic vertical guidance. A PAPI or VASI provides visual vertical guidance. If there is no such guidance for that runway, use the value for "length beyond departure end."
12. For airplanes with maximum certificated takeoff weight greater than 150,000 lbs (68,027 kg), the standard runway width is 150 feet (46 m), the shoulder width is 25 feet (7.6 m), and the runway blast pad width is 200 feet (61 m).
13. When an RSA width of 500 feet (152 m) is not practical, an RSA width of 400 feet (122 m) is permissible.

Some Taxiway Design Elements Use TDG

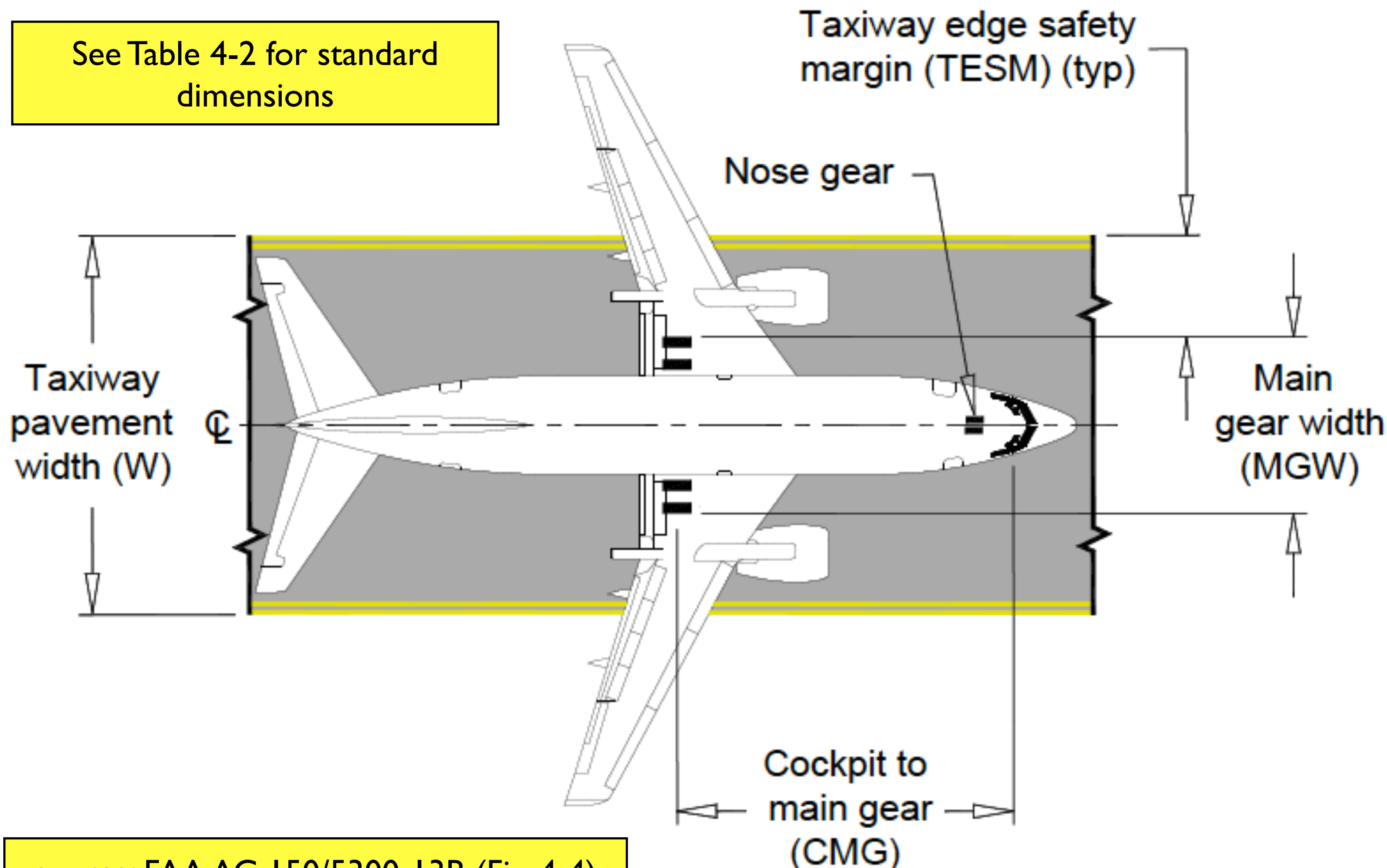
- Taxiway design group needs to be established before any taxiway design is carried out



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

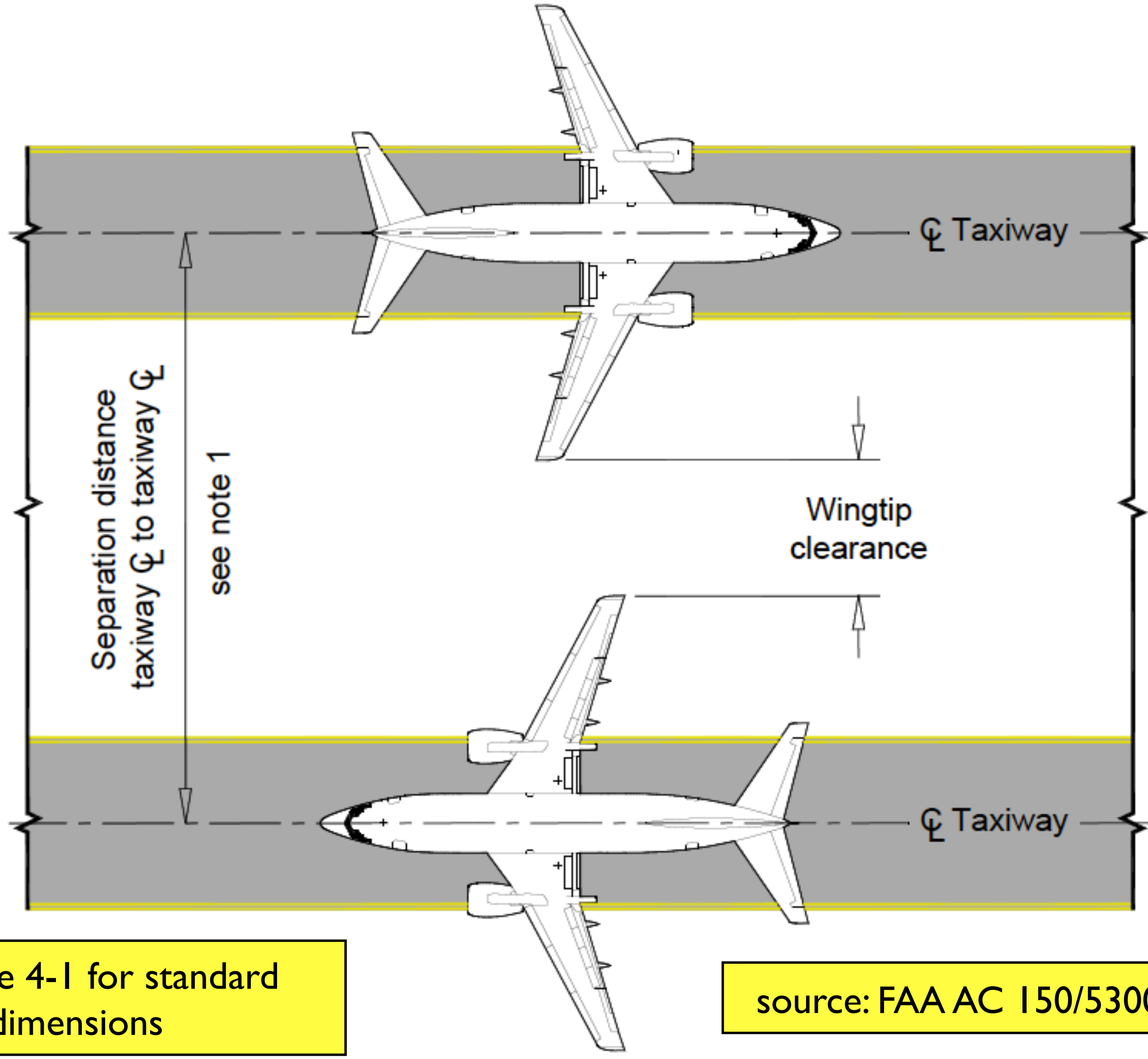
Taxiway Dimensions

See Table 4-2 for standard dimensions



source: FAA AC 150/5300-13B (Fig. 4-4)

Parallel Taxiway Dimensions



See Table 4-1 for standard dimensions

source: FAA AC 150/5300-13B (Fig. 4-5)

Taxiway Design Standards (Based on ADG Groups)

Item	ADG					
	I	II	III	IV	V	VI
Taxiway and Taxilane Protection						
TSA (maximum ADG wingspan)	49 ft (14.9 m)	79 ft (24.1 m)	118 ft (36 m)	171 ft (52 m)	214 ft (65 m)	262 ft (80 m)
TOFA [2]	89 ft (27.1 m)	124 ft (38 m)	171 ft (52 m)	243 ft (74 m)	285 ft (87 m)	335 ft (102 m)
TLOFA [2]	79 ft (24.1 m)	110 ft (34 m)	158 ft (48 m)	224 ft (68 m)	270 ft (82 m)	322 ft (98 m)
Taxiway and Taxilane Separation						
Taxiway centerline to parallel taxiway centerline [1]	70 ft (21.3 m)	101.5 ft (30.9 m)	144.5 ft (44 m)	207 ft (63 m)	249.5 ft (76.1 m)	298.5 ft (91 m)
Taxiway centerline to fixed or movable object [2]	44.5 ft (13.6 m)	62 ft (18.9 m)	85.5 ft (26.1 m)	121.5 ft (37 m)	142.5 ft (43 m)	167.5 ft (51 m)
Taxilane centerline to parallel taxilane centerline [1]	64 ft (19.5 m)	94.5 ft (28.8 m)	138 ft (42 m)	197.5 ft (60.2 m)	242 ft (74 m)	292 ft (89 m)
Taxilane centerline to fixed or movable object [2]	39.5 ft (12.2 m)	55 ft (16.8 m)	79 ft (24.1 m)	112 ft (34 m)	135 ft (41 m)	161 ft (49 m)
Wingtip Clearance						
Taxiway wingtip clearance	20 ft (6.1 m)	22.5 ft (6.9 m)	26.5 ft (8.1 m)	36 ft (11 m)	35.5 ft (10.8 m)	36.5 ft (11.1 m)
Taxilane wingtip clearance	15 ft (4.6 m)	15.5 ft (4.7 m)	20 ft (6.1 m)	26.5 ft (8.1 m)	28 ft (8.5 m)	30 ft (9.1 m)

Note 1: See Figure 4-5.
Note 2: See Figure 4-6.
Note 3: See paragraphs 4.5.3.1 and 4.5.4.1 for TSA and TOFA standards at fillets.

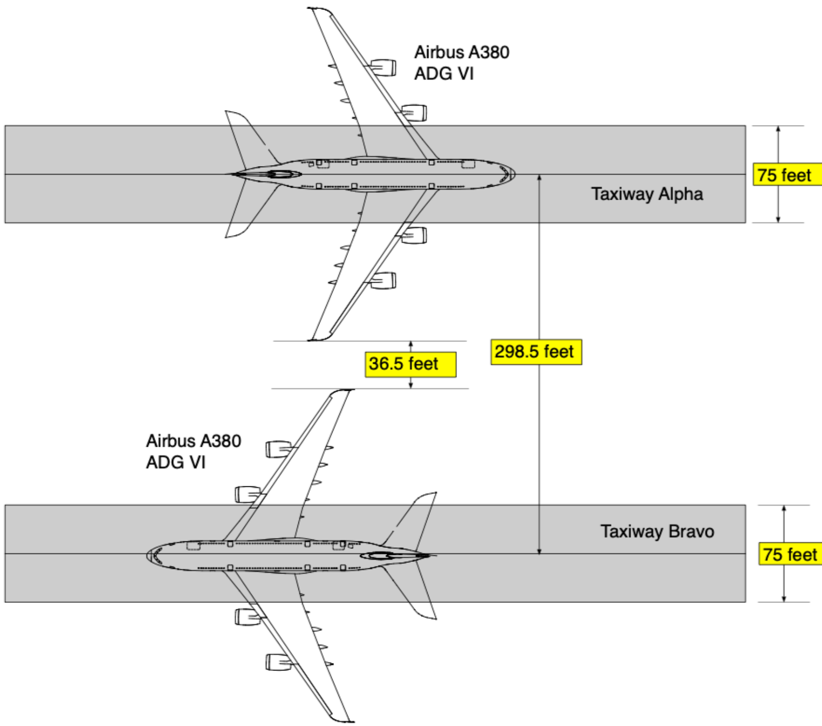
source: FAA AC 150/5300-13B (Table 4-1)

Taxiway Design Standards (Based on ADG Groups) Have Changed

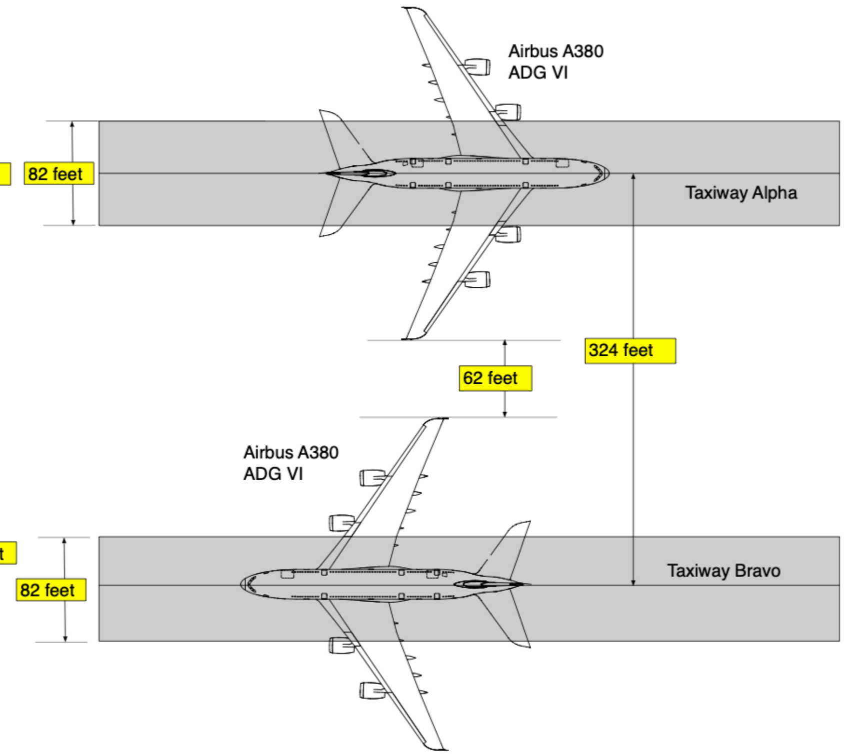
Example:
Taxiway to Taxiway Distance for ADG VI

Item	ADG					
	I	II	III	IV	V	VI
Taxiway and Taxilane Separation						
Taxiway centerline to parallel taxiway centerline [1]	70 ft (21.3 m)	101.5 ft (30.9 m)	144.5 ft (44 m)	207 ft (63 m)	249.5 ft (76.1 m)	298.5 ft (91 m)

FAA AC 150/5300-13B



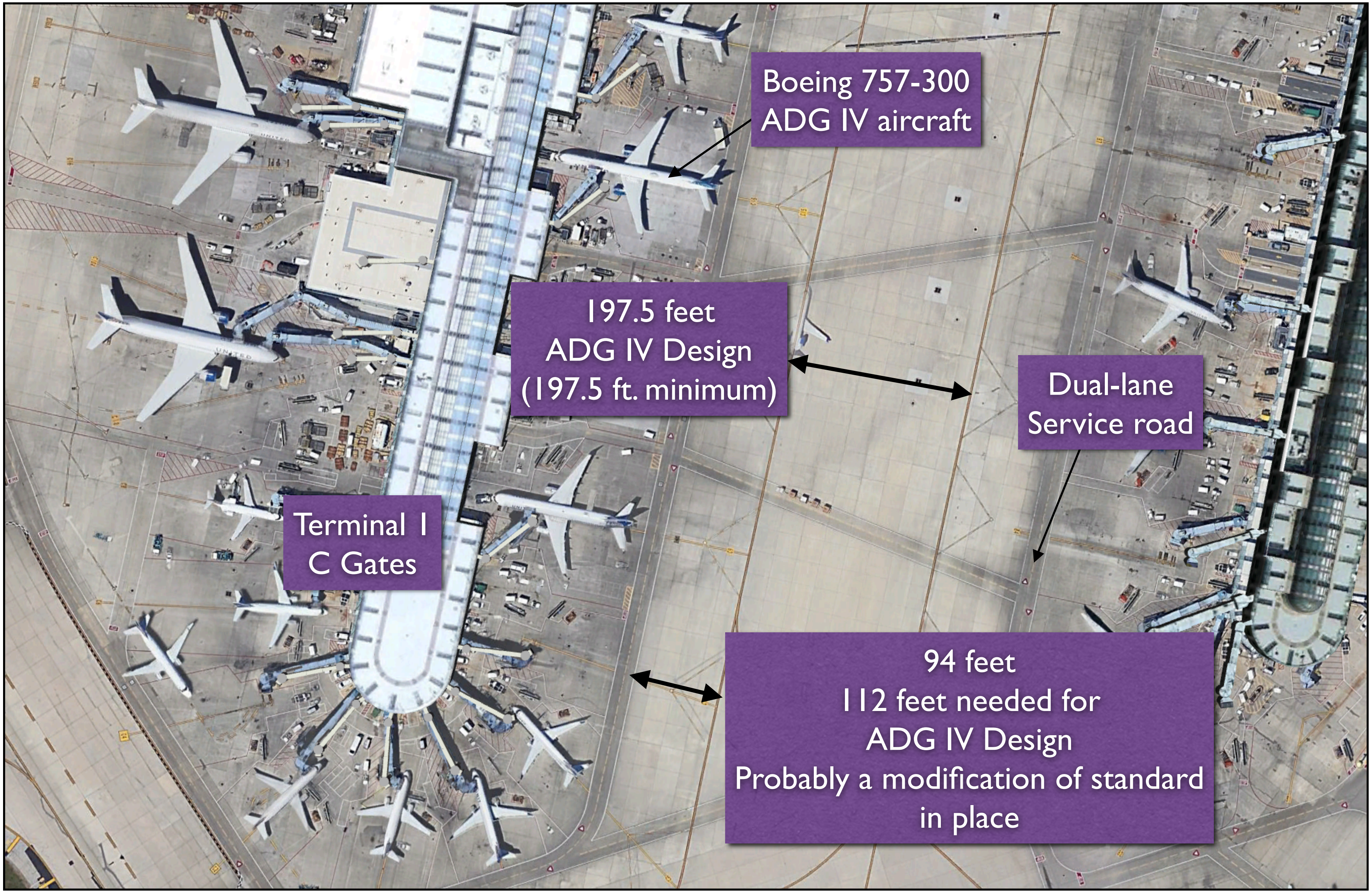
FAA AC 150/5300-13A



Reduction of 25.5 feet in taxiway-taxiway centerline separation (for ADG VI)

Example Taxilane Design at Chicago O'Hare Airport

Example Taxilane Design at Chicago O'Hare Airport



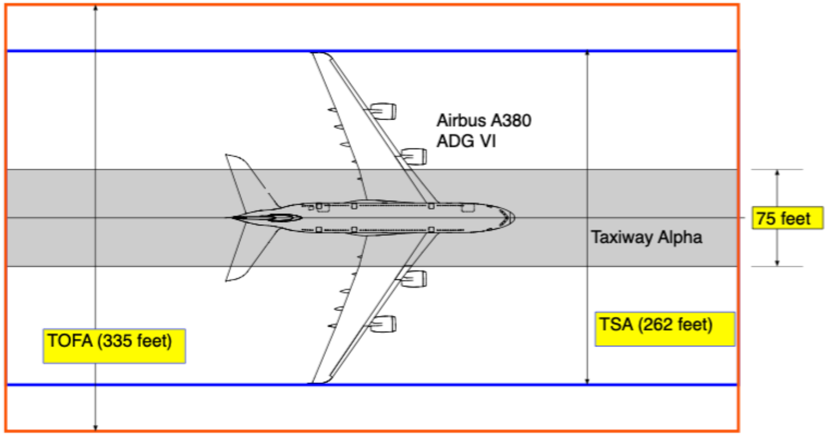
Legacy Airports May Have Different Geometric Design Standards on Multiple Parts of the Airfield

- Geometric design standards evolve over time
- Legacy airports like Chicago ORD may have different design standards on various parts of the airfield
- Pilots and ATC controllers need to be aware of the limitations of such geometric design standards in order to avoid accidents
- Many airports have special taxiway-taxilane routes to handle large aircraft (such as Airbus A380 or ADG VI).

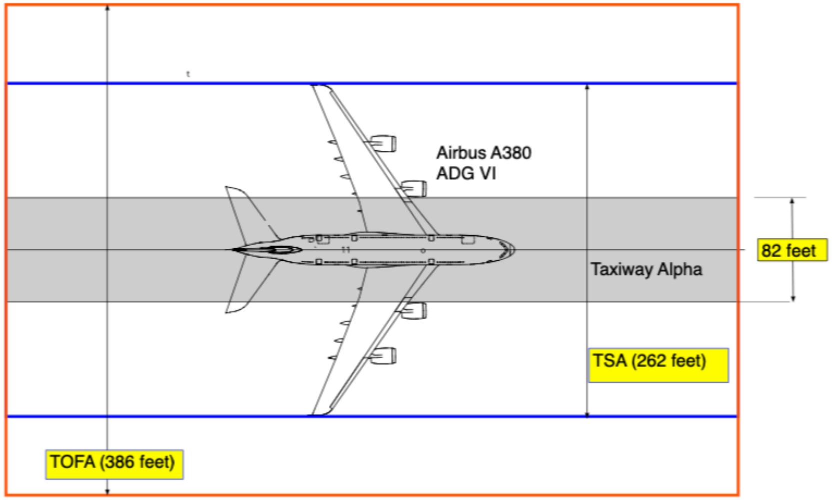
Significant Changes in Taxiway Object Free Areas (Based on ADG Groups)

Example:
Taxiway Object Free Areas for ADG VI

FAA 150/5300-13B
TOFA - 335 feet



FAA 150/5300-13A
TOFA - 386 feet



Reduction of 51 feet feet in TOFA width for ADG VI

Taxiway Design Standards (Based on TDG Groups)

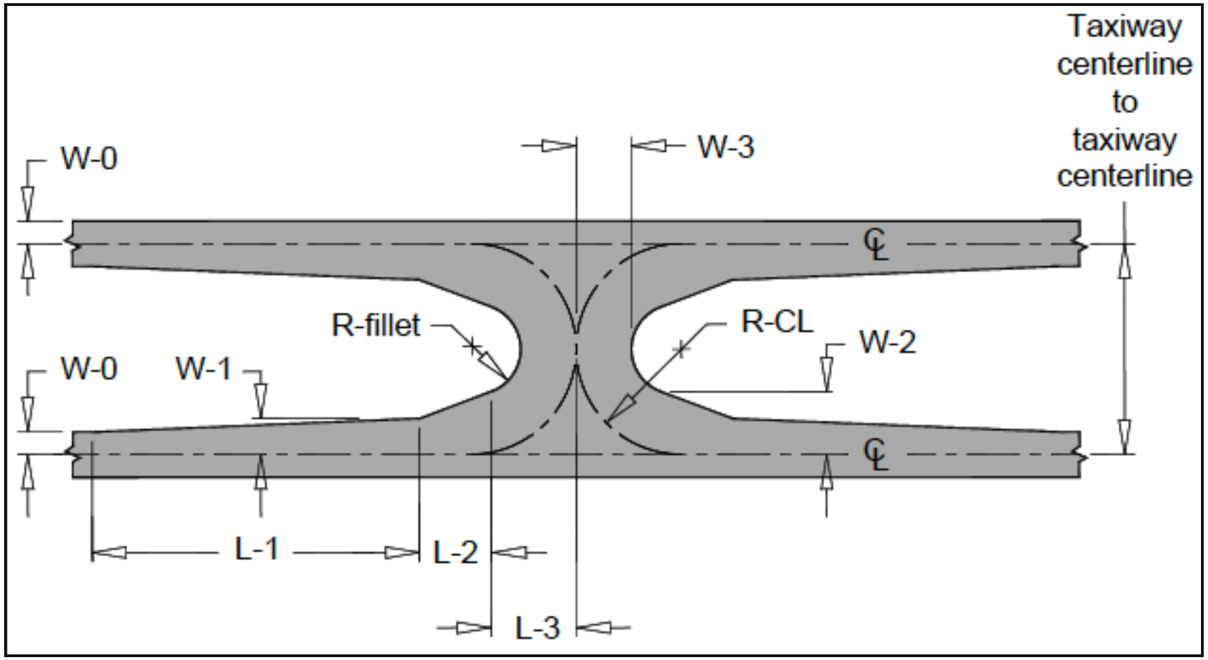
source: FAA AC 150/5300-13B (Table 4-2)

Item	TDG							
	1A	1B	2A	2B	3	4	5	6
Taxiway/Taxilane Width [1]	25 ft (7.6 m)	25 ft (7.6 m)	35 ft (10.7 m)	35 ft (10.7 m)	50 ft (15.2 m)	50 ft (15.2 m)	75 ft (22.9 m)	75 ft (22.9 m)
Taxiway Edge Safety Margin [1]	5 ft (1.5 m)	5 ft (1.5 m)	7.5 ft (2.3 m)	7.5 ft (2.3 m)	10 ft (3 m)	10 ft (3 m)	14 ft (4.3 m)	14 ft (4.3 m)
Taxiway Shoulder Width [2]	10 ft (3 m)	10 ft (3 m)	15 ft (4.6 m)	15 ft (4.6 m)	20 ft (6.1 m)	20 ft (6.1 m)	30 ft (9.1 m)	30 ft (9.1 m)
Taxiway/Taxilane Centerline to Parallel Taxiway/Taxilane Centerline w/180 Degree Turn	See Table 4-6 and Table 4-7.							

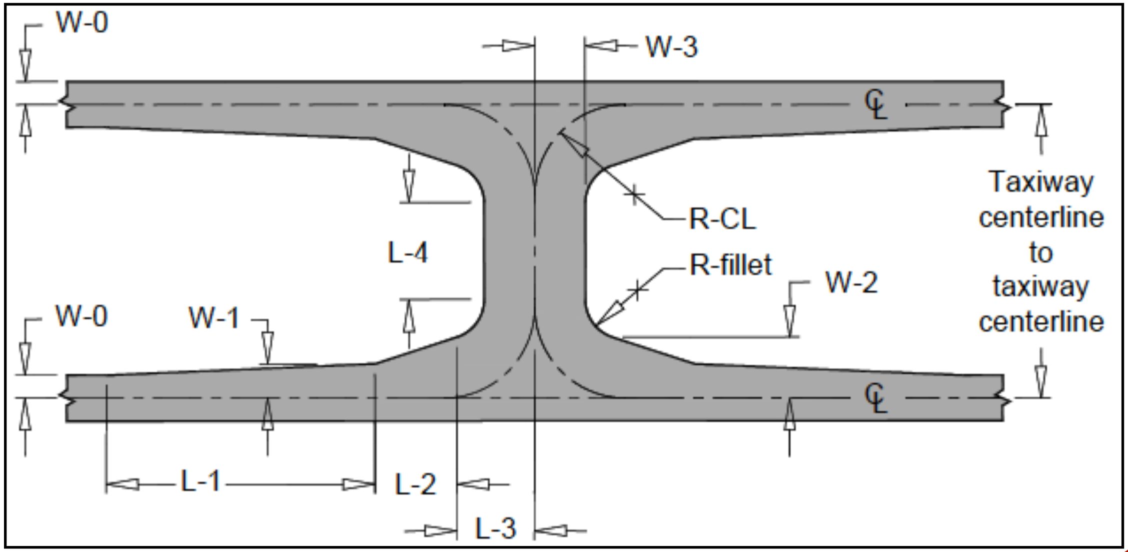
Note 1: See Figure 4-4.

Note 2: When the most demanding aircraft has four engines and is TDG 6, the standard taxiway shoulder width is 40 feet (12.2 m).

Taxiway Crossover Designs (with 180 deg. reversal)



Crossover Taxiway Where Direction Reversal is Needed **Based on TDG**



Crossover Taxiway Where Direction Reversal is Needed **Based on ADG**

Crossover Taxiway Design Standards (Based TDG Group)

Table 4-6. Crossover Taxiways with Direction Reversal Between Taxiways Based on TDG

Dimension (See Figure 4-22)	TDG 1A	1B	2A	2B	3	4	5	6
Taxiway Centerline to Centerline Distance	50	100	100	162	162	250	250	312
W-0 (ft)	12.5	12.5	17.5	17.5	25	25	37.5	37.5
W-1 (ft)	25	22	26	31	37	45	55	60
W-2 (ft)	25	50	50	81	81	125	125	156
W-3 (ft)	21	29	34	44	51	65	78	88
L-1 (ft)	58	115	111	213	206	365	354	472
L-2 (ft)	0	39	39	72	71	118	117	152
L-3 (ft)	21	29	34	44	51	65	78	88
R-Fillet (ft)	0	0	0	0	0	0	0	0
R-CL (ft)	25	50	50	81	81	125	125	156

Note: 1 ft = 0.305 m

source: FAA AC 150/5300-13B (Table 4-6)

Crossover Taxiway Design Standards (Based on ADG Group)

Dimension (see Figure 4-23)	TDG																	
	1A	1B		2A		2B			3		4			5		6		
	ADG																	
	II	II	III	II	III	II	III	IV	III	IV	III	IV	V	IV	V	IV	V	VI
Taxiway Centerline to Centerline Distance	70	102	144	102	144	102	144	207	144	207	144	207	249	207	249	207	249	298
W-0 (ft)	12.5	12.5	12.5	17.5	17.5	17.5	17.5	17.5	25	25	25	25	25	37.5	37.5	37.5	37.5	37.5
W-1 (ft)	21	18	18	23	23	26	30	26	36	33	35	41	45	51	55	51	55	59
W-2 (ft)	21	31	32	39	36	51	72	52	72	57	72	104	125	104	125	104	125	149
W-3 (ft)	16	29	19	32.5	23.5	71.5	47	30.5	55	38	121	74.5	65.5	88.5	78	133.5	103.5	90.5
L-1 (ft)	53	92	94	98	93	180	206	180	197	177	303	345	364	329	353	411	440	466
L-2 (ft)	0	46	46	45	45	84	76	84	77	83	140	131	118	132	117	179	173	156
L-3 (ft)	21	44	32	39	36	72	47	52	55	57	121	74	65	89	78	133	104	90
L-4 (ft)	28	4	46	4	62	0	0	69	0	69	0	0	0	0	0	0	0	0
R-Fillet (ft)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-CL (ft)	21	49	41	49	41	51	72	69	72	69	72	103.5	124.5	103.5	124.5	103.5	124.5	149
Steering Angle (degrees)	50	50	50	50	50	77	57	50	57	50	85	61	50	61	50	76	63	52

Note: 1 ft = 0.305 m

source: FAA AC 150/5300-13B (Table 4-7)

Crossover Taxiways (TDG vs. ADG)

Table 4-6. Crossover Taxiways with Direction Reversal Between Taxiways Based on TDG

Dimension (See Figure 4-22)	TDG 1A	1B	2A	2B	3	4	5	6
Taxiway Centerline to Centerline Distance	50	100	100	162	162	250	250	312

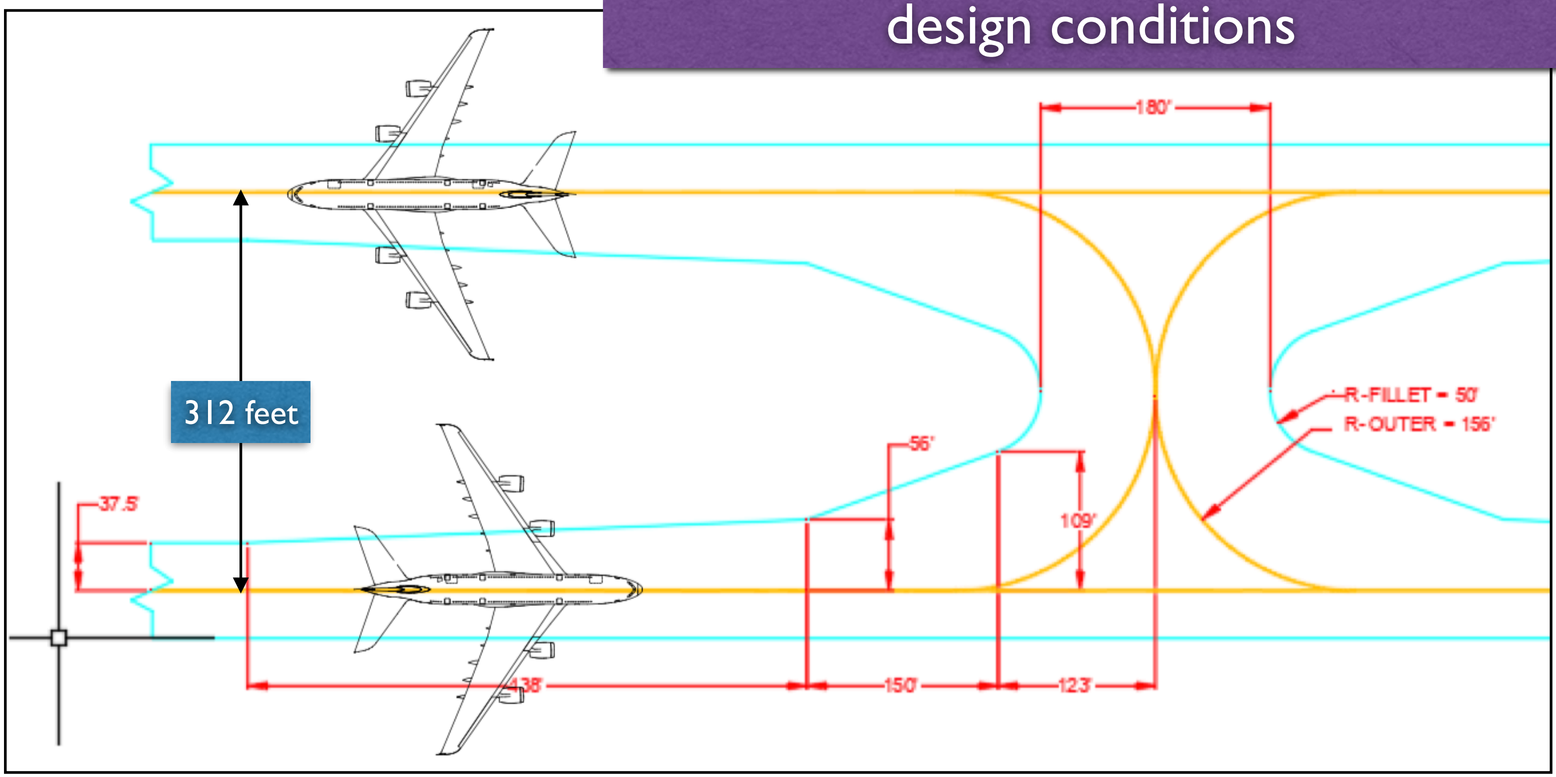
Table 4-7. Crossover Taxiways with Direction Reversal Between Taxiways Based on ADG

Dimension (see Figure 4-23)	TDG																	
	1A	1B		2A		2B			3		4			5		6		
	ADG																	
	II	II	III	II	III	II	III	IV	III	IV	III	IV	V	IV	V	IV	V	VI
Taxiway Centerline to Centerline Distance	70	102	144	102	144	102	144	207	144	207	144	207	249	207	249	207	249	298

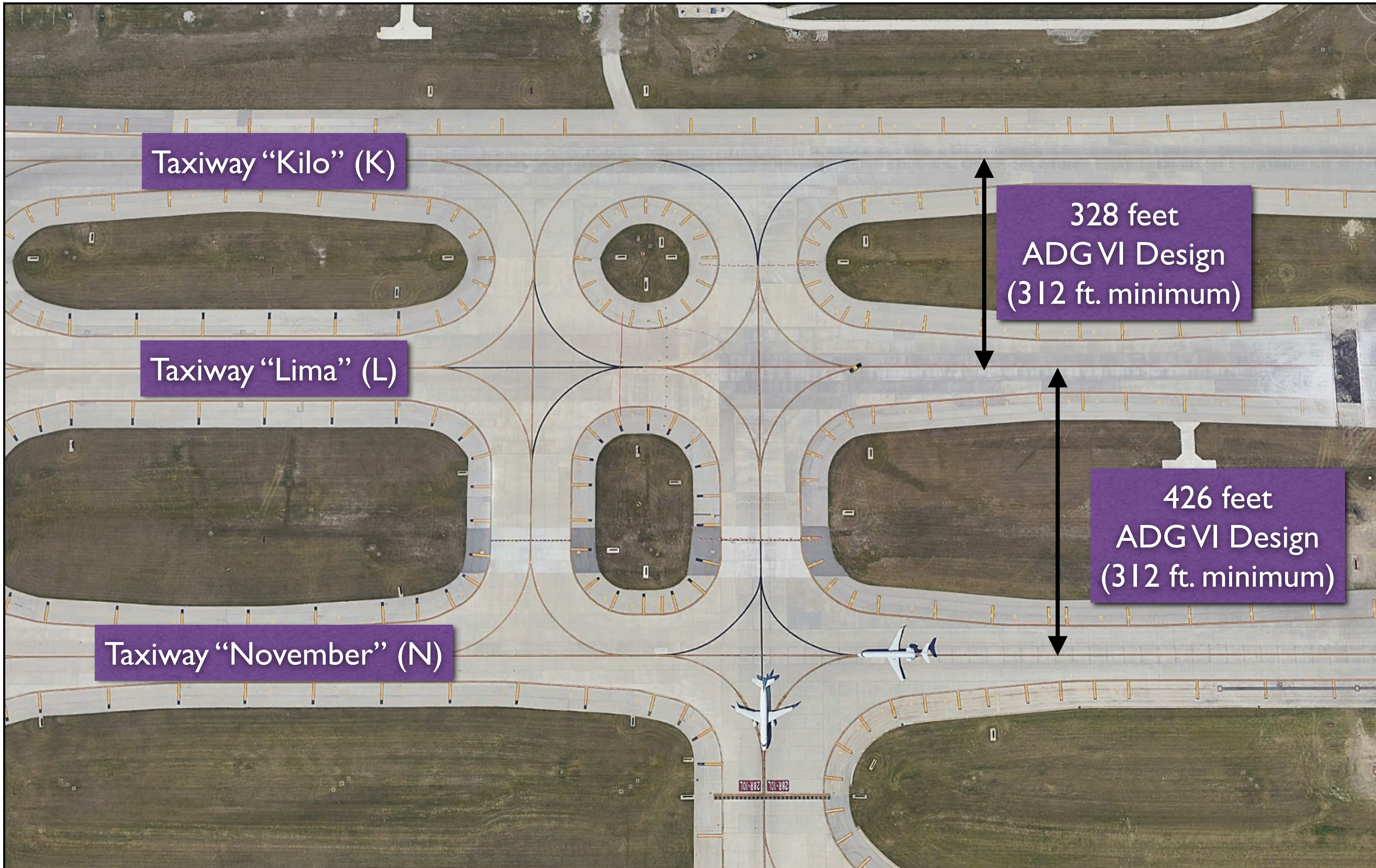
Crossover Taxiway Design for A380 (TDG vs. ADG)

- Crossover taxiway distance based on TDG is 312 feet between taxiway centerlines
- Crossover taxiway distance based on ADG is 298 feet between taxiway centerlines

Use the most demanding of the two design conditions



Example Crossover Taxiway Design at Chicago O'Hare Airport



Taxiway Safety Margins are Important for Safe Airport Operations

Main gear width ~ 29.5 feet
CMG ~ 36 feet
Taxiway width 35 feet

TDG 3
Taxiway Safety Margin = 10 feet

Saab 2000
taxiing at BCB Airport

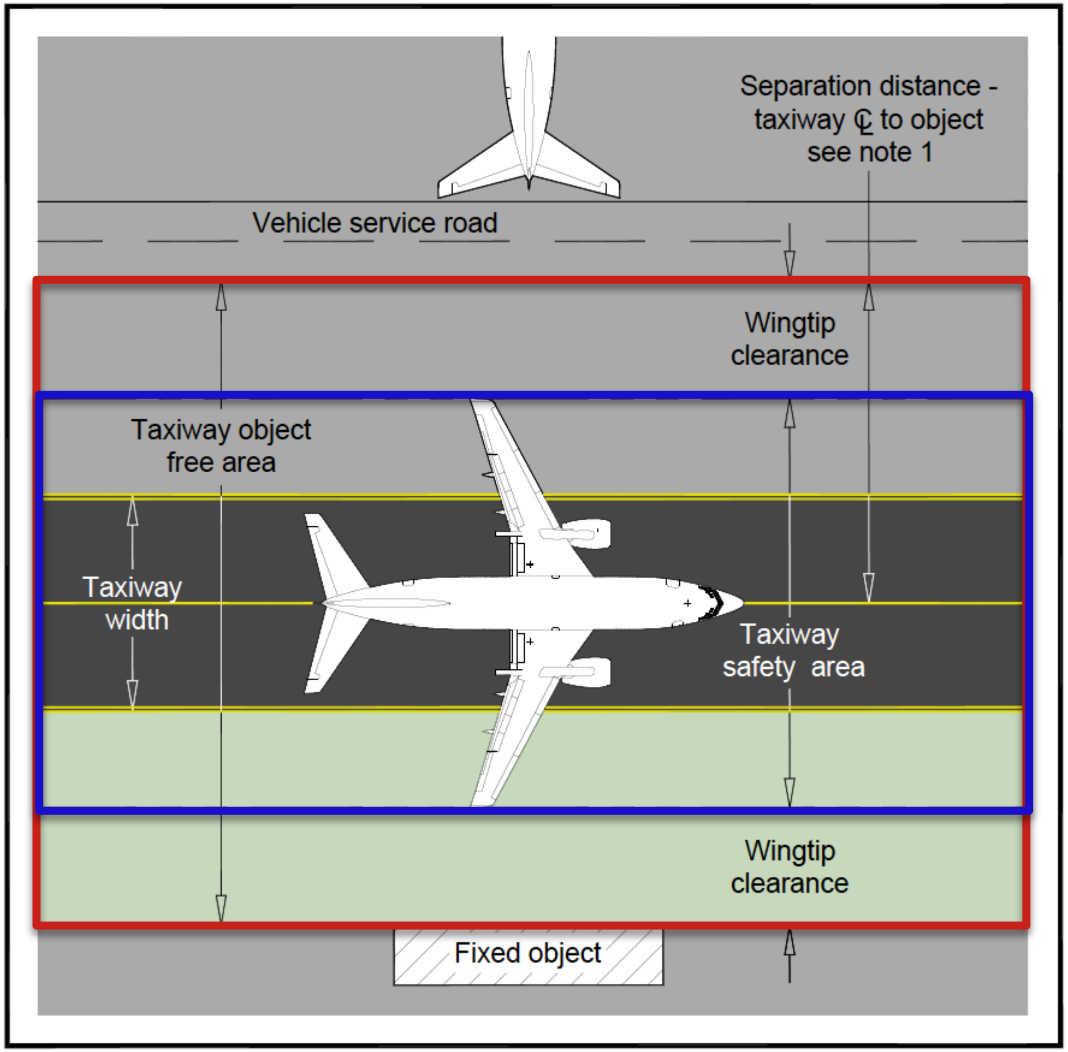
Taxiway Safety Margins are Important for Safe Airport Operations

- The aircraft comes close to the taxiway edge
- FAA taxiway edge safety margin is 14 feet for ADG VI

Taxiway Centerline Separation from Fixed or Movable Objects

Taxiways Object Free Area (TOFA) (red)

Taxiway Safety Area (TSA) in blue



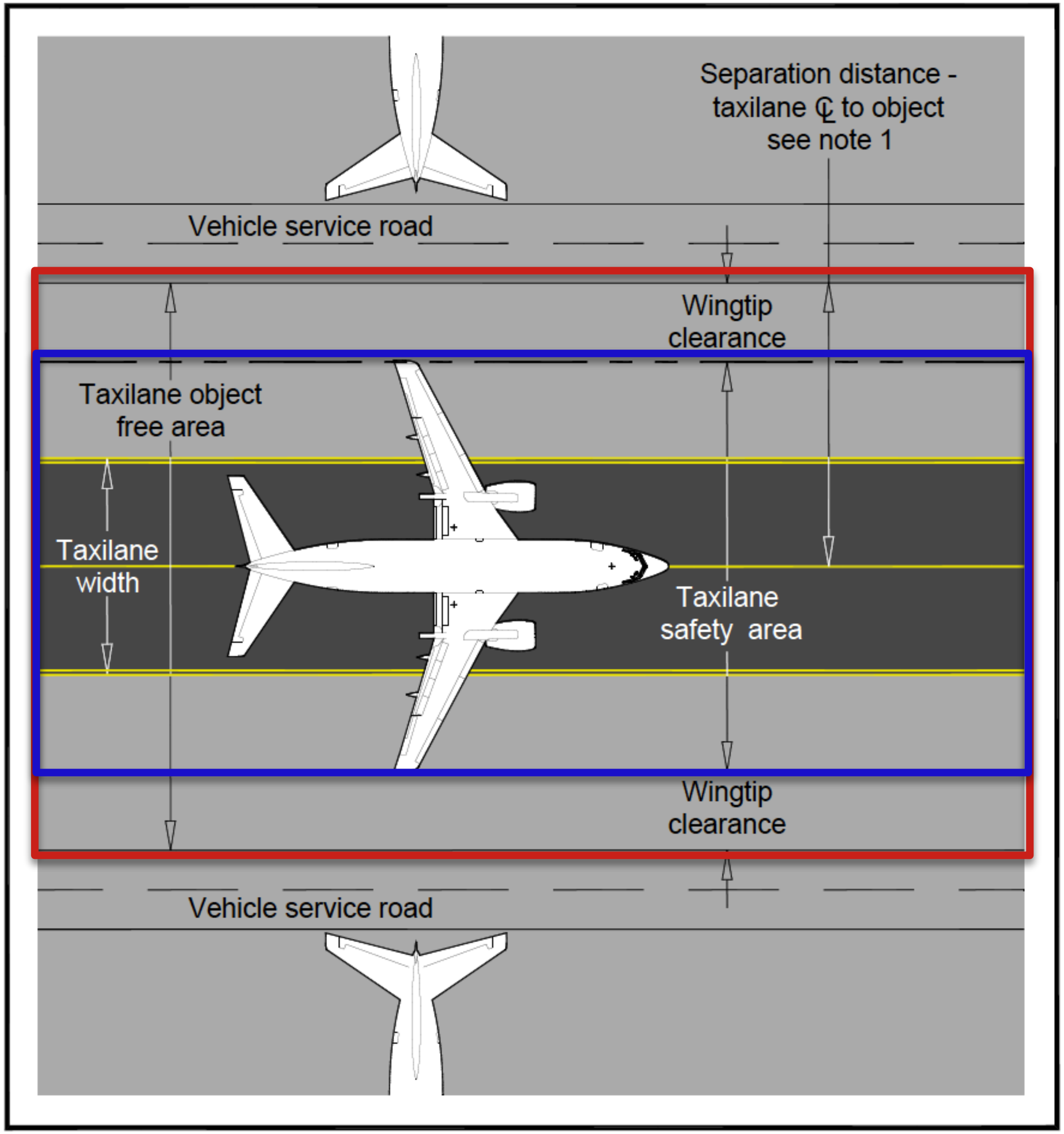
Note 1: Refer to Table 4-1 for standard separation distances between taxiways and fixed or moveable objects.

source: FAA AC 150/5300-13B (Figure 4-6)

Taxilane Separation from Fixed or Movable Objects from Taxilane (Apron Taxiway)

Taxilanes do have Object Free Areas

source: FAA AC 150/5300-13B (Figure 4-8)



Note 1: Refer to Table 4-1 for standard separation distances between taxilanes and fixed or moveable objects.

Example (Dulles International Airport)

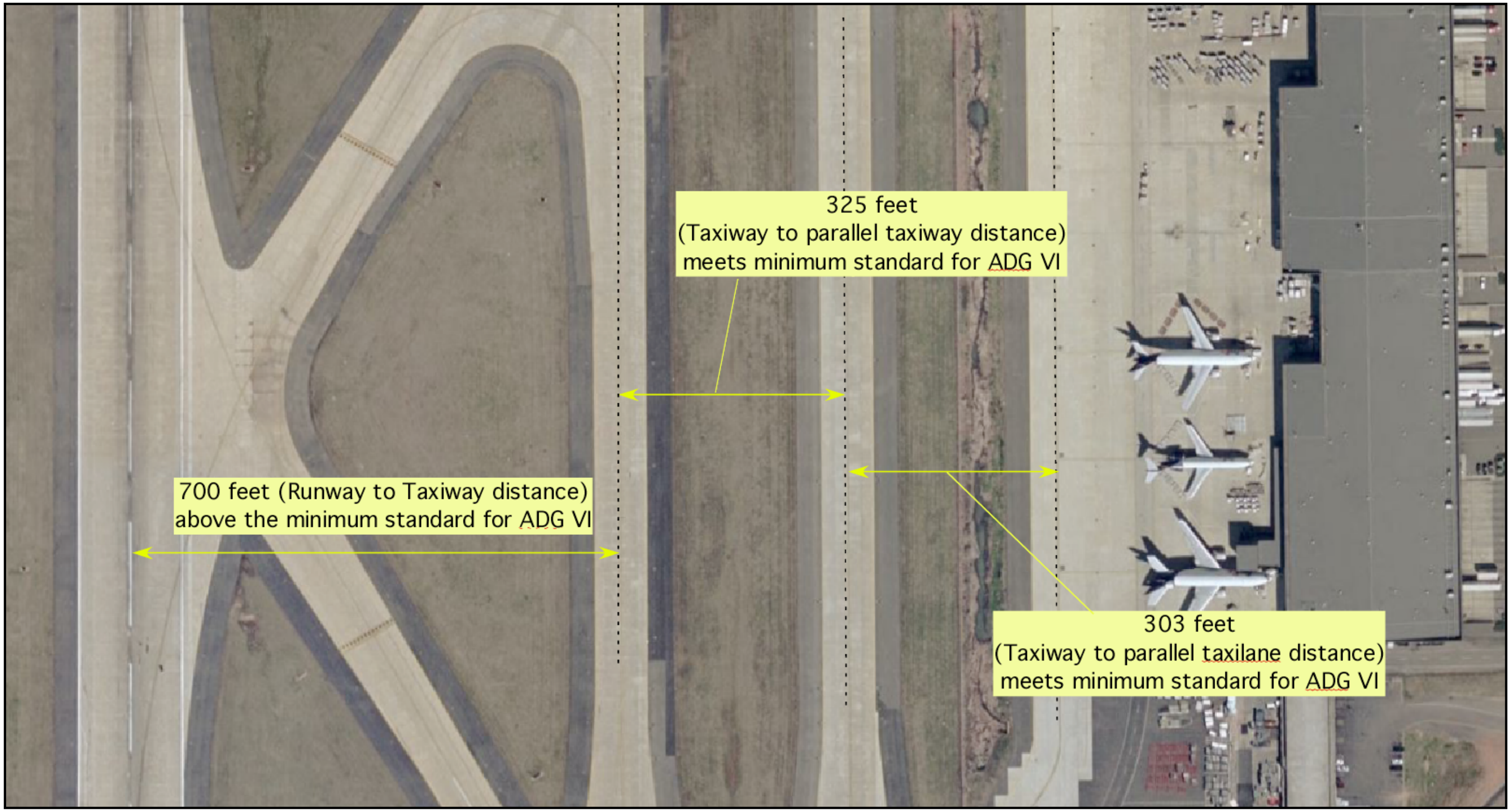


Image Source: U.S. Geological Survey

Rules for Derivation of Taxiway/Taxilane Separation Standards

Dimension	Old Rule (until 2021)	New Rule Applies Today
Taxiway centerline to parallel taxiway centerline	**1.2** times airplane wingspan plus 10 feet	**1.1** times airplane wingspan plus 10 feet
Taxiway centerline to fixed or movable object	**0.7** times airplane wingspan plus 10 feet	**0.6** times airplane wingspan plus 10 feet
Taxilane centerline to parallel taxilane centerline	**1.1 t**imes airplane wingspan plus 10 feet	**1.075** times airplane wingspan plus 10 feet
Taxilane centerline to fixed or movable object	**0.6** times airplane wingspan plus 10 feet	**0.575** times airplane wingspan plus 10 feet

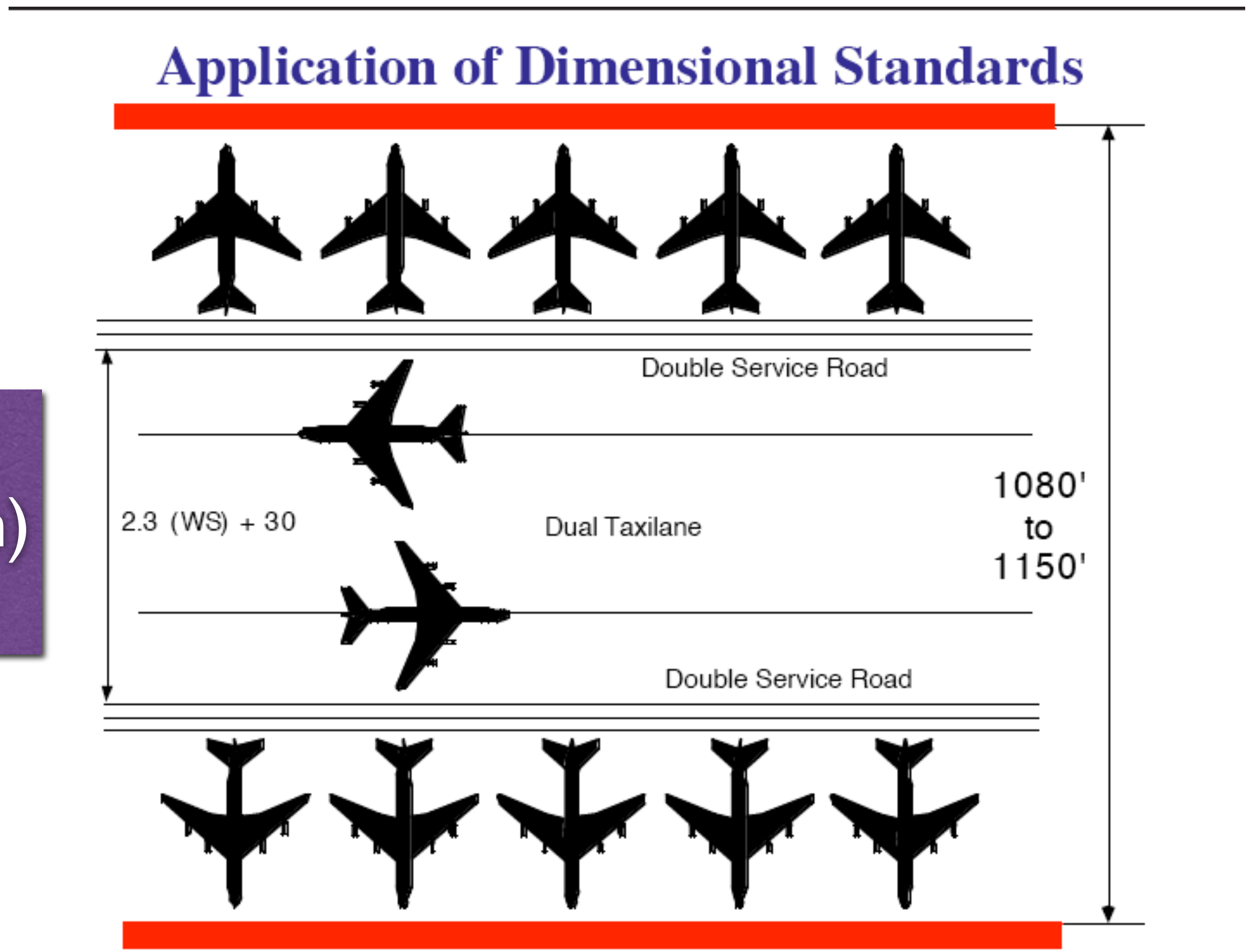
Aircraft Rights-of-Way Near Gate Areas

- Dual taxilanes
- **2.3 times airplane wingspan** plus 30 feet (10 m)
- Aircraft parked at gates require wingtip to wingtip separations at gates or tie-down areas for safety:
  - 10 ft. (3 m.) for aircraft in groups I and II
  - 15 ft. (5 m.) for group III
  - 20 ft. (6 m.) for group IV
  - 25 ft. (8 m.) for group V
  - 30 ft. (10 m.) for group VI

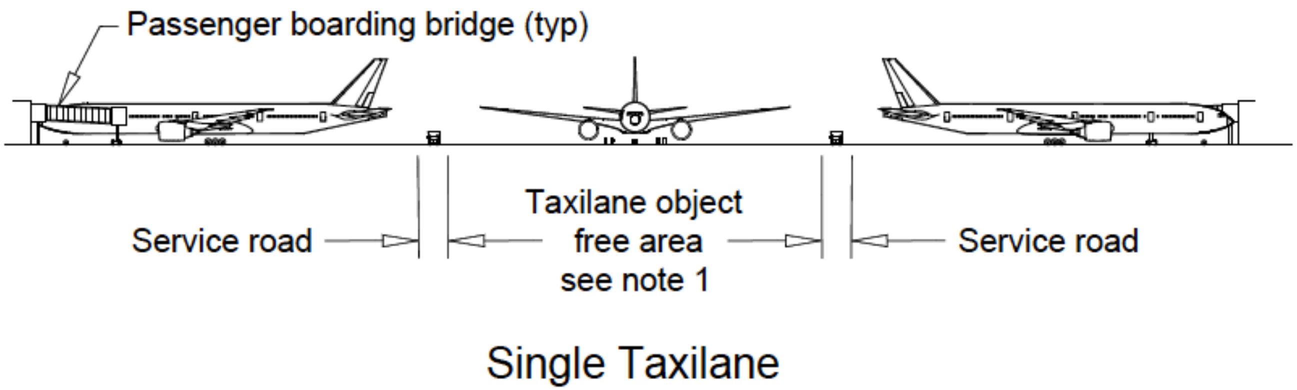
Source: FAA AC 150/5300-13

Old Rule: Dual Taxilane Between Two Terminal Buildings (Concourses)

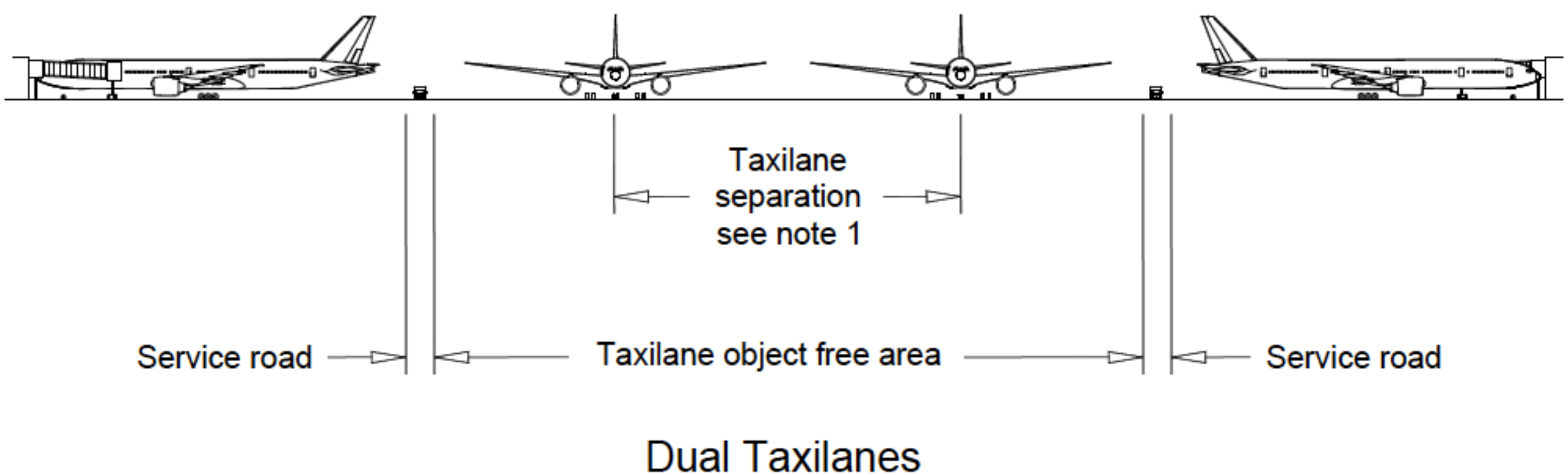
Old Rule:
2.3 (wingspan) + 30 feet



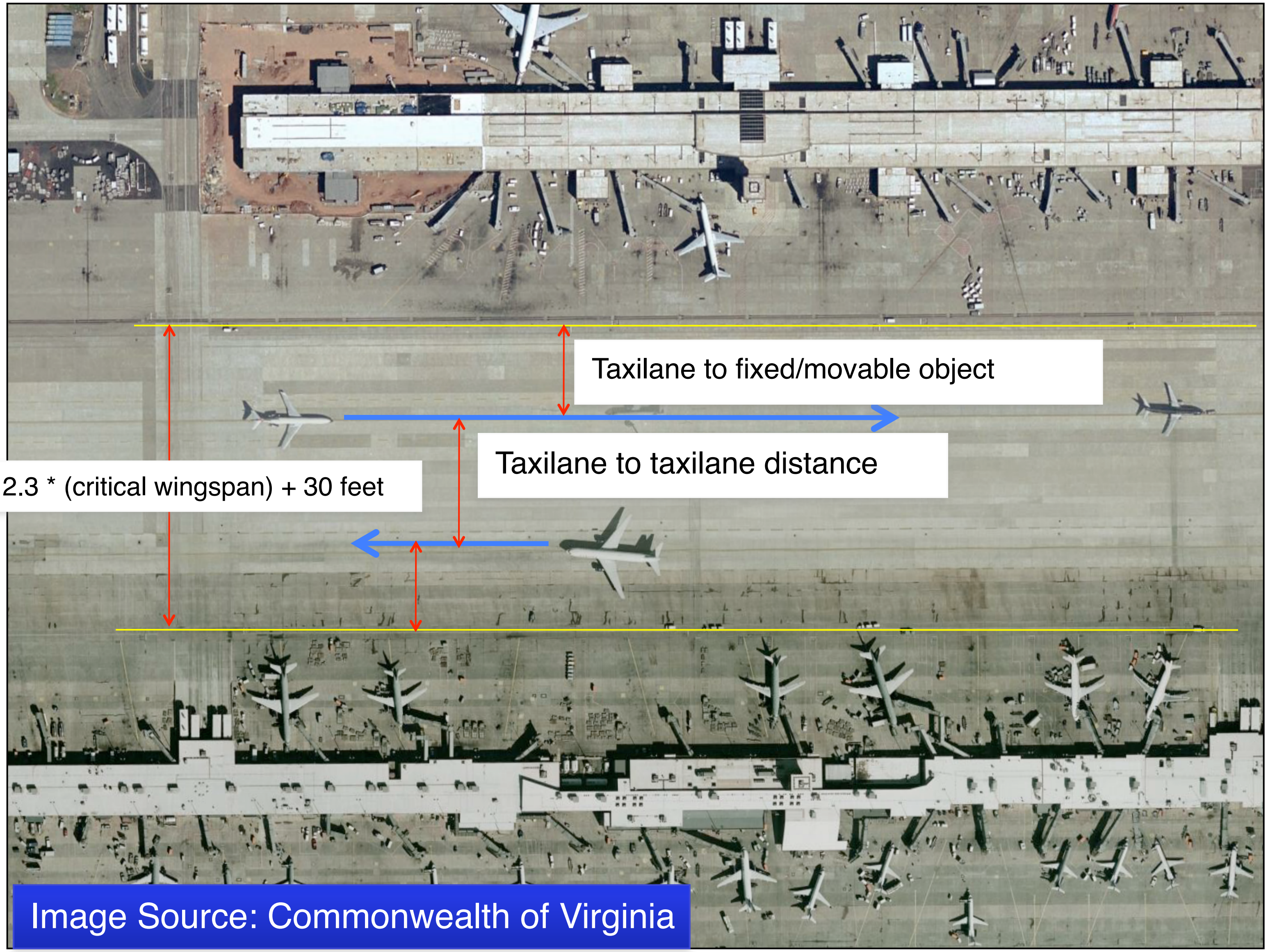
Example: Dual Taxilane Between Two Terminal Buildings (Concourses)



source: FAA AC 150/5300-13B (Figure 4-7)

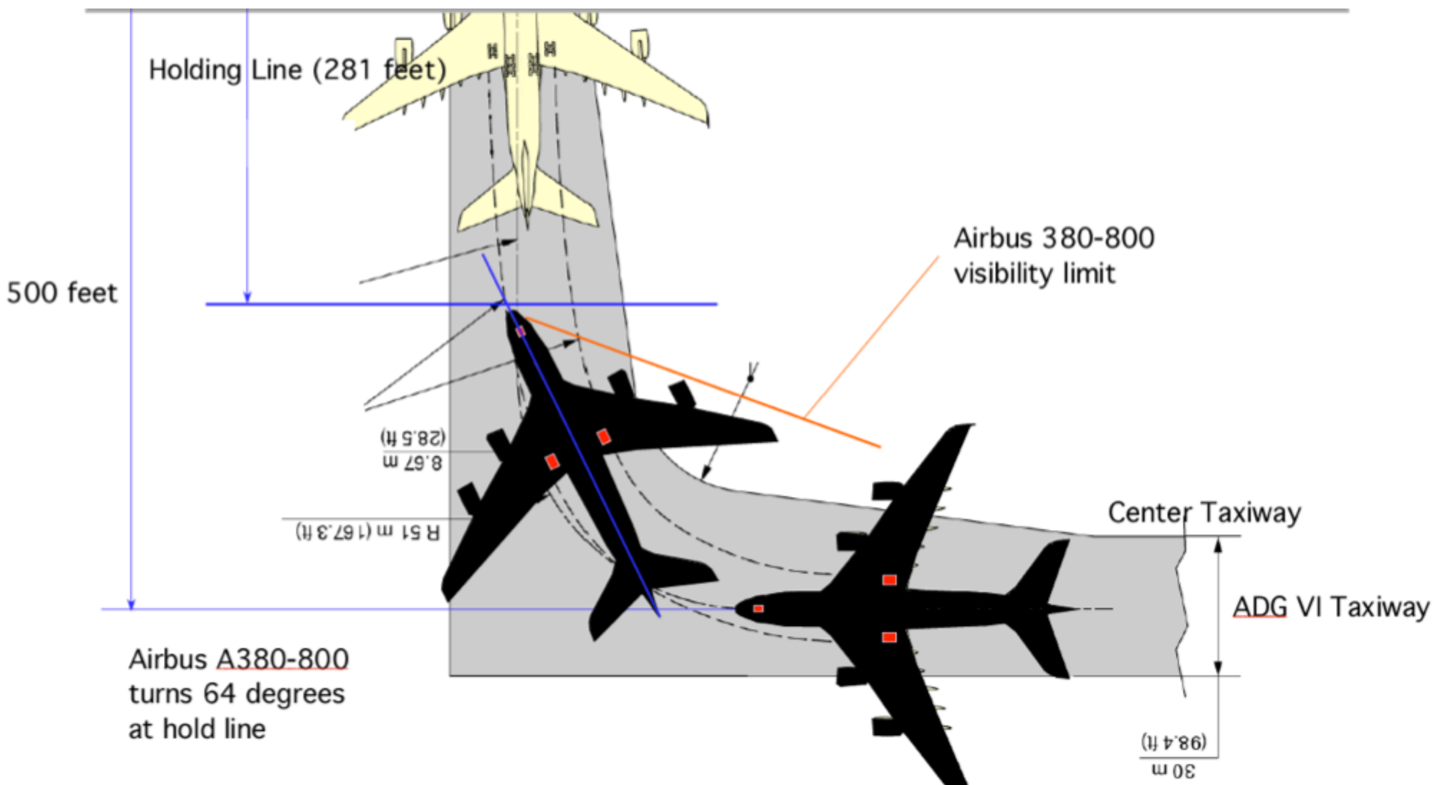


Example Dual Taxilane (IAD)



Detailed Geometric Design of Taxiway Junctions

- Aircraft can have long distances between cockpit and main gear
- Main landing gear tracks inside the centerline followed by the nose gear
- Taxiway fillets are needed to provide safety margins in turns



source: Airbus and the author

FAA Geometric Design Design Philosophy for Intersections

- Use the **cockpit over centerline steering method**
- FAA no longer advocates judgmental oversteering
- Cockpit over centerline steering reduces the risk of pavement excursions
- Design taxiway intersections with **steering angles to 50 degrees or less**

Steering Angle Explanation

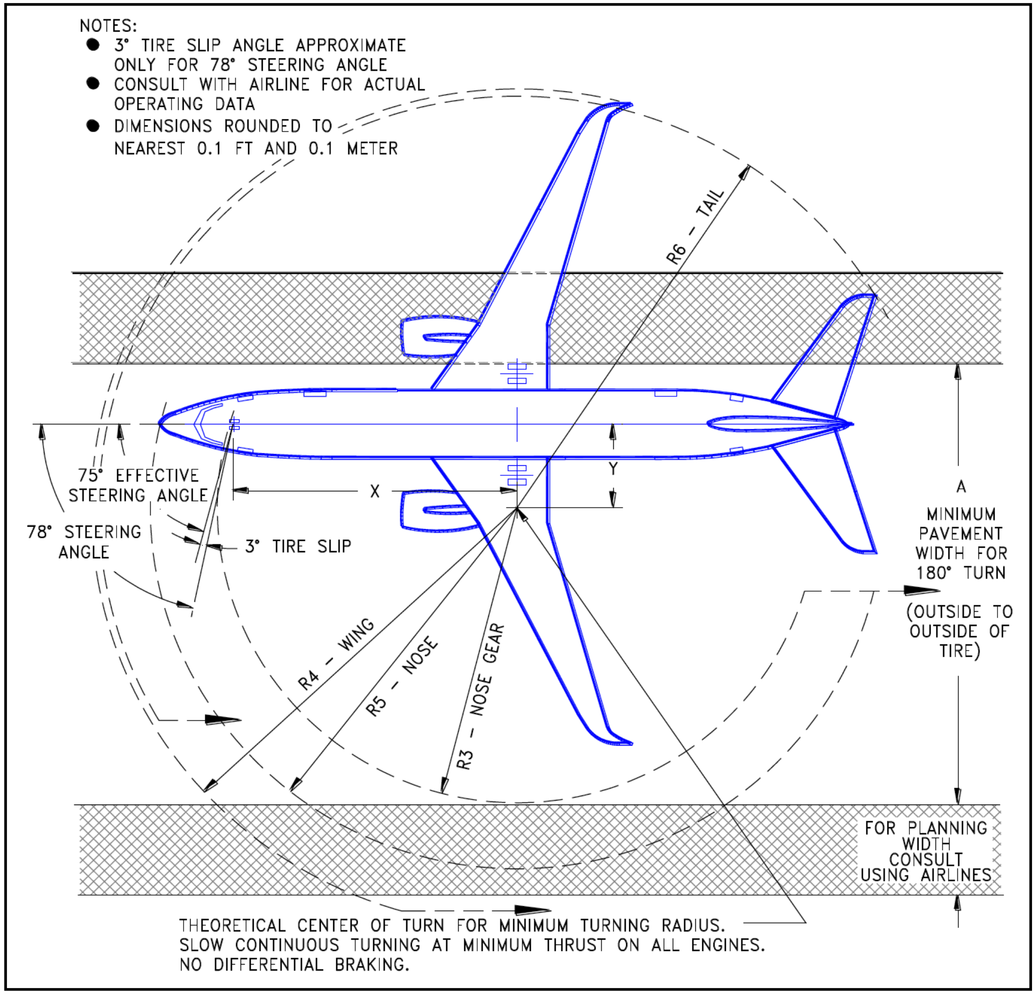
- Modern aircraft nose landing gears are designed to reach steering angles of 70 degrees

Boeing 737-800 (A. Trani)

Gulfstream 550 (A. Trani)

Steering Angle Information

A Boeing 737-800 has a maximum steering angle of 78 degrees (75 degrees effective steering angle)

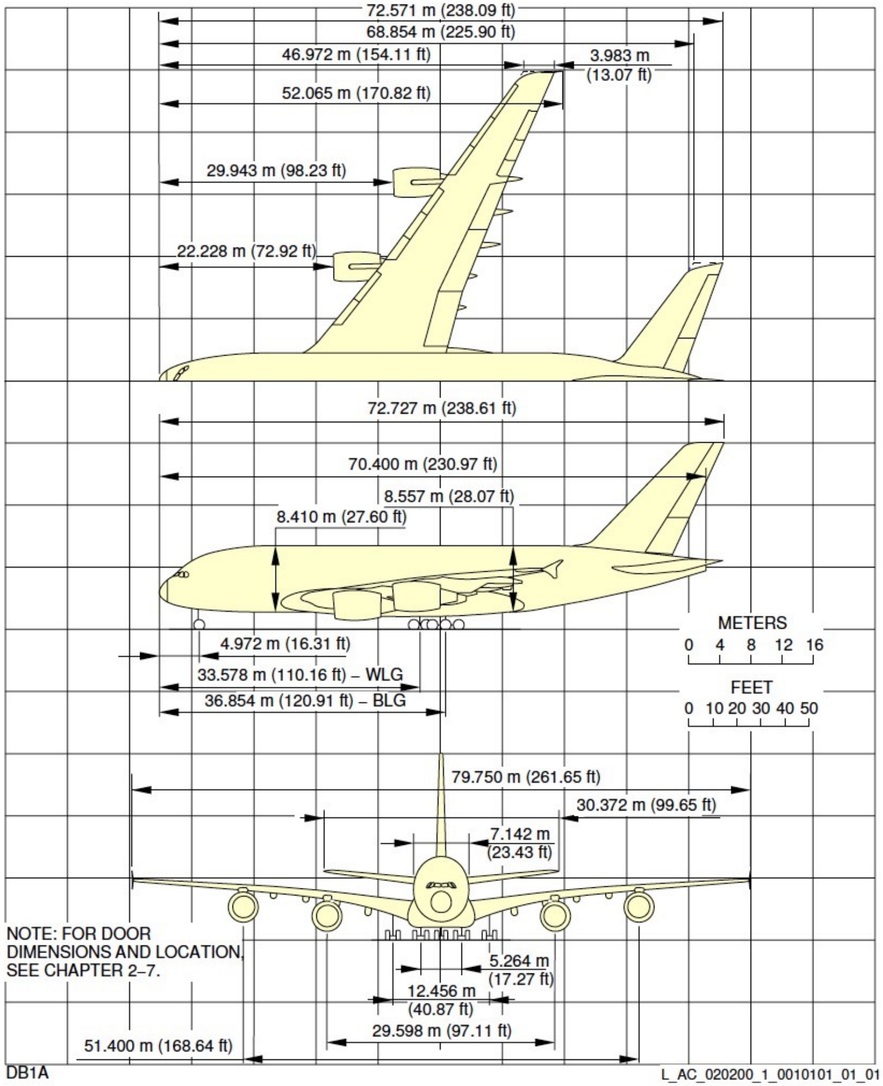


Source: Boeing 737 Airplane Characteristics for Airport Planning (Chapter 4)

Example : Taxiway-Taxiway Fillet Design for an Airbus A380 (ADG VI, TDG 6)

- Design a taxiway-taxiway junction for an Airbus A380 class vehicle using FAA design criteria
- FAA recommends using the cockpit centerline tracking
- Draw the solution to scale and specify the dimensions of the taxiway-taxiway junction
- Compare the solution with the recommendations by Airbus

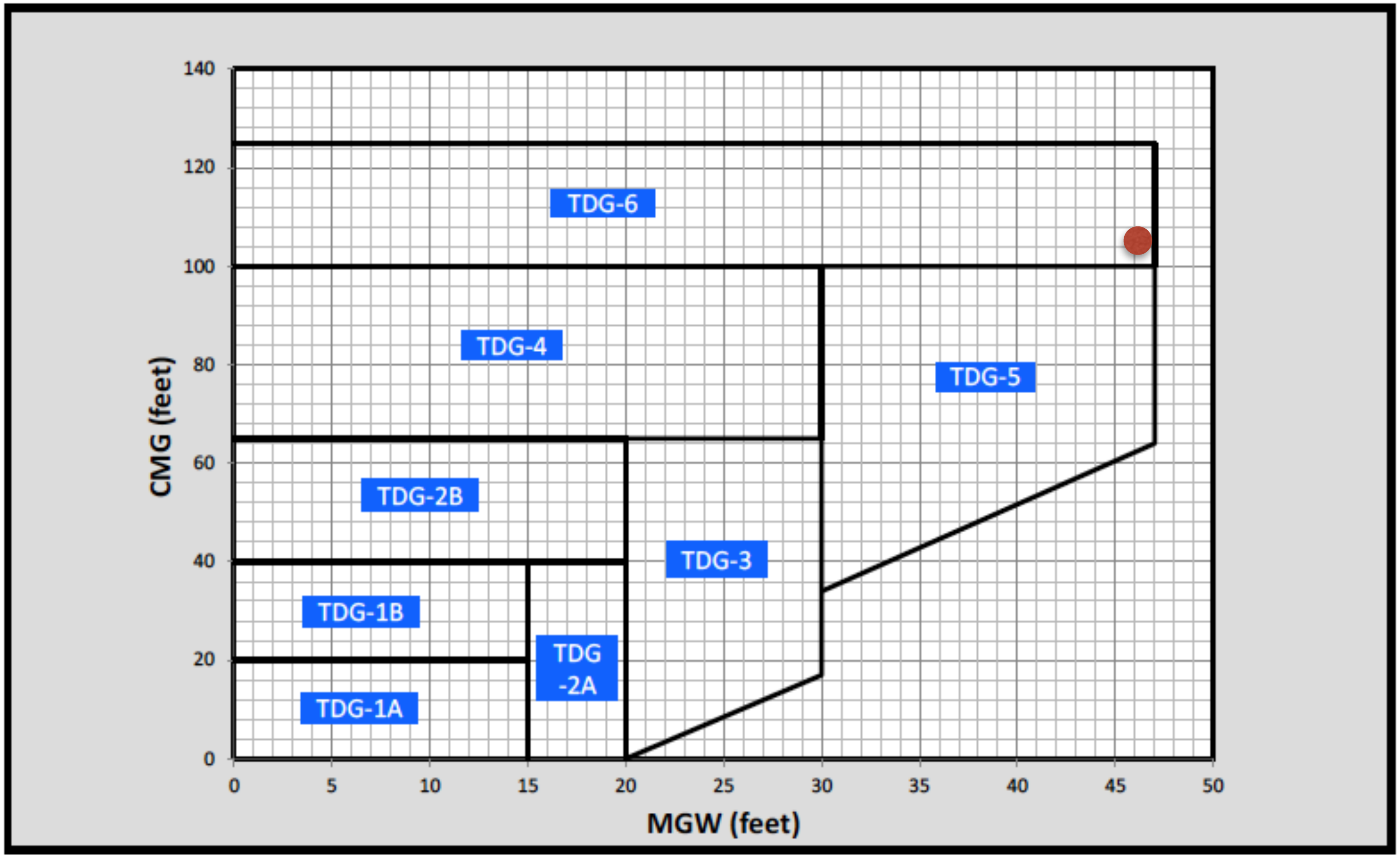
Example : Taxiway-Taxiway Fillet Design for an Airbus A380



Obtain the critical dimensions
for geometric design standards

Consult with the aircraft manufacturer data

Use Taxiway Design Group 6 for A380



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

CMG = 104.6 feet and MG width = 47 feet

FAA Taxiway Fillet Design Tool

United States Department of Transportation

Federal Aviation Administration

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Home / Airports / Engineering, Design, & Construction Standards / Airport Design

- Overview
- Airport Design Technical Video Series
- Runway Design Standards Matrix

Airport Design Tools, Videos and Drawings for Advisory Circular 150/5300-13

Additional Design Technical Videos, Tools, and Drawings

Advisory Circular

- AC 150/5300-13 - Airport Design
- Runway Design Matrix Tool

Source: https://www.faa.gov/airports/engineering/airport_design

Airport Design Tools

- Aircraft Characteristics Database
  For aircraft with a CMG and MGW combination in the TDG 2 category, use the ADG and TDG Classification Tool below to calculate TDG 2A and 2B.
- ADG and TDG Classification Tool **(added 4/4/2022)**
- Acute Angle Exit Tool **(added 8/19/2022)**
- Taxiway Fillet Design Tool (MS Excel) **(added 4/4/2022)**
  - Taxiway Fillet Design Tool User's Guide
  - Taxiway Fillet Design Tool Instructional Video **(added 4/13/2022)**
- Runway Exit Design Interactive Model (REDIM)

Taxiway Fillet Design Geometry

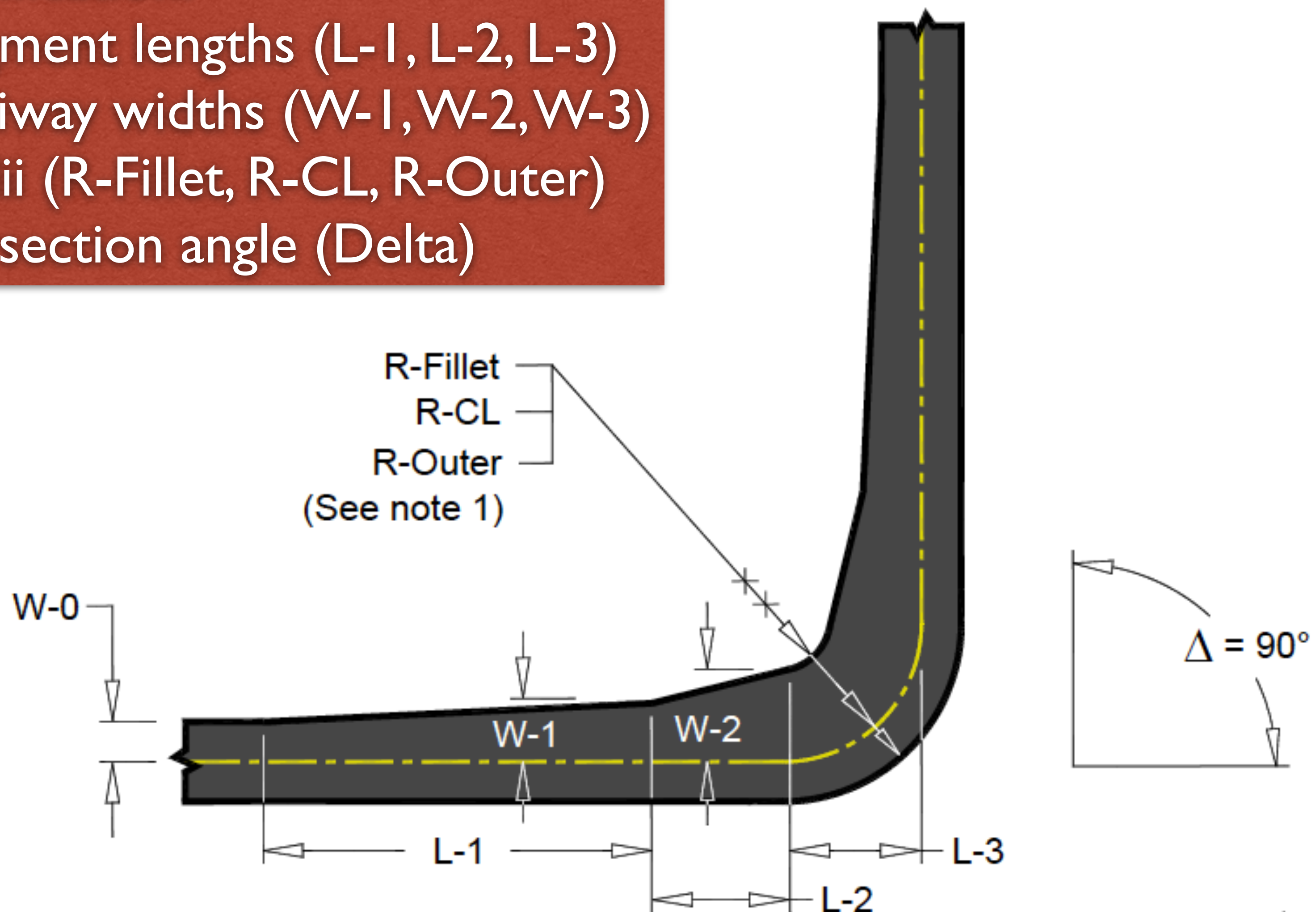
Fillet specification:

Three segment lengths (L-1, L-2, L-3)

Three taxiway widths (W-1, W-2, W-3)

Three radii (R-Fillet, R-CL, R-Outer)

One intersection angle (Delta)

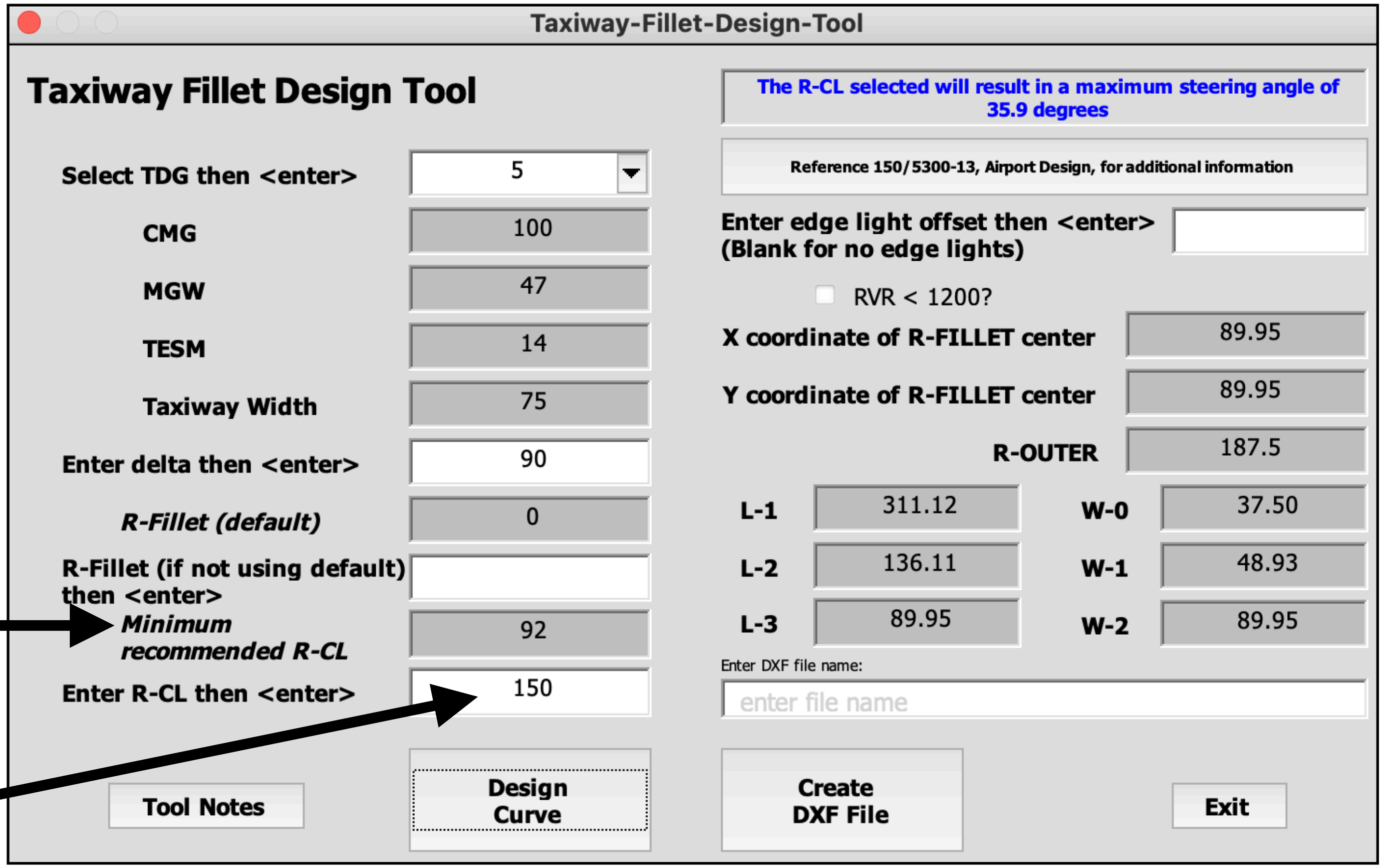


Source: FAA AC 150/5300-13B

Taxiway Fillet Design Tool (FAA)

White fields must be provided by the user
Program calculates Minimum R-CL, and fillet dimensions

Program calculates Minimum R-CL to meet 50 degree steering angle

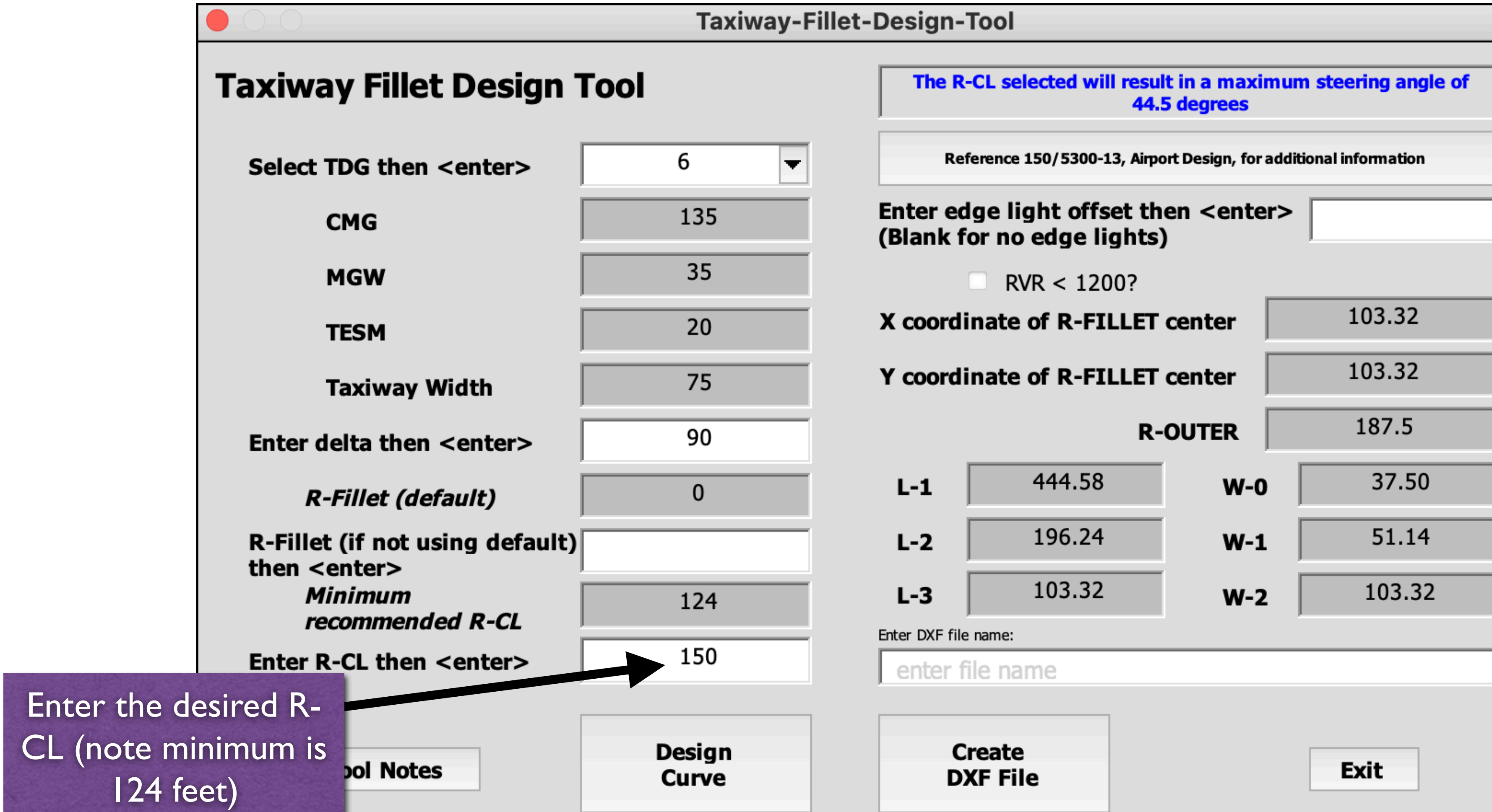


Minimum centerline radius (R-CL) is 92 feet

You can design with higher radii

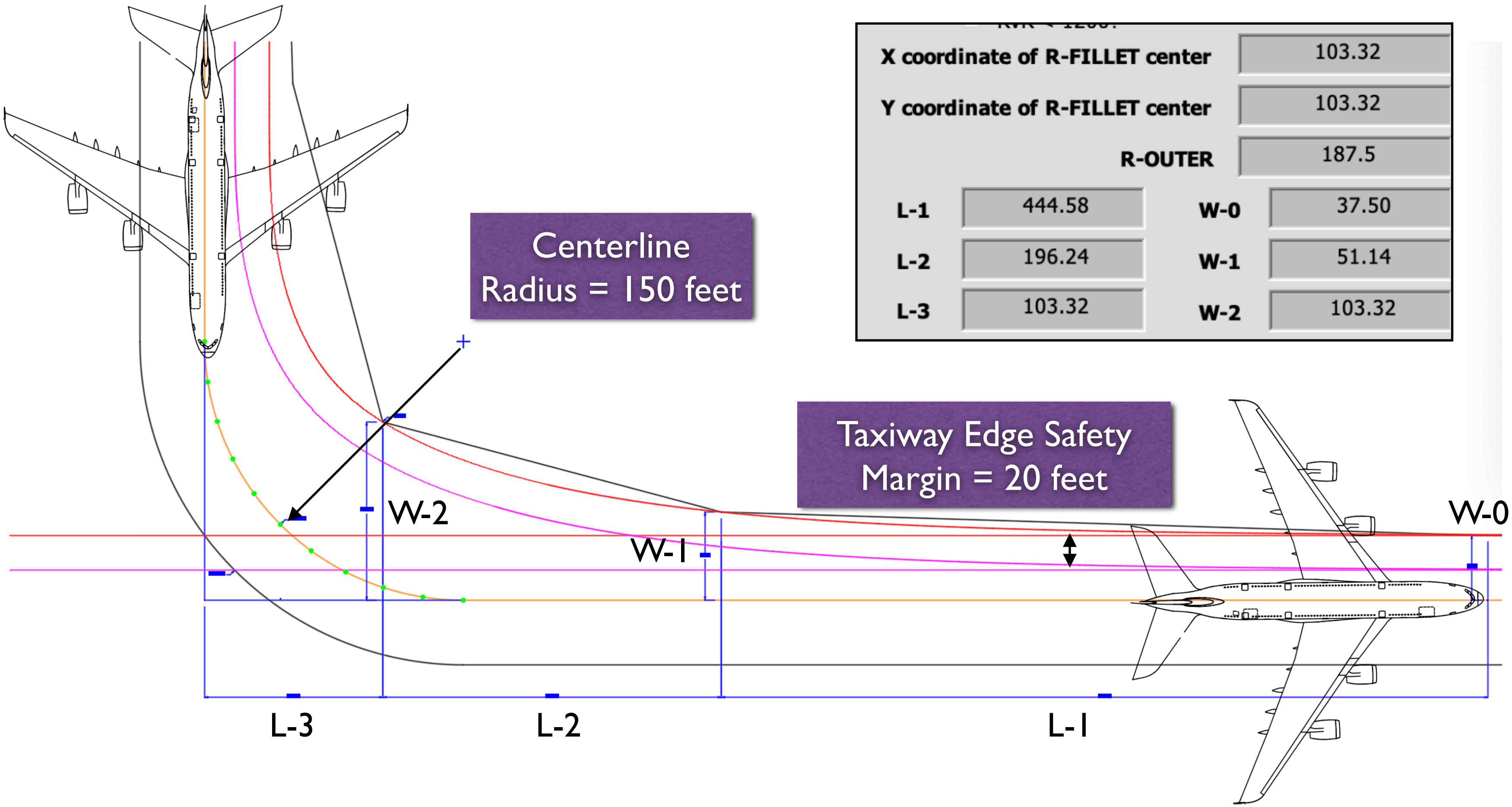
Taxiway Design Tool (FAA) Example

- Design the fillet for 90-degree intersection for the Airbus A380 (TDG-6)
- In the design use a centerline radius of 150 feet (more than the minimum recommended for design)



Taxiway Design Tool (FAA) Example

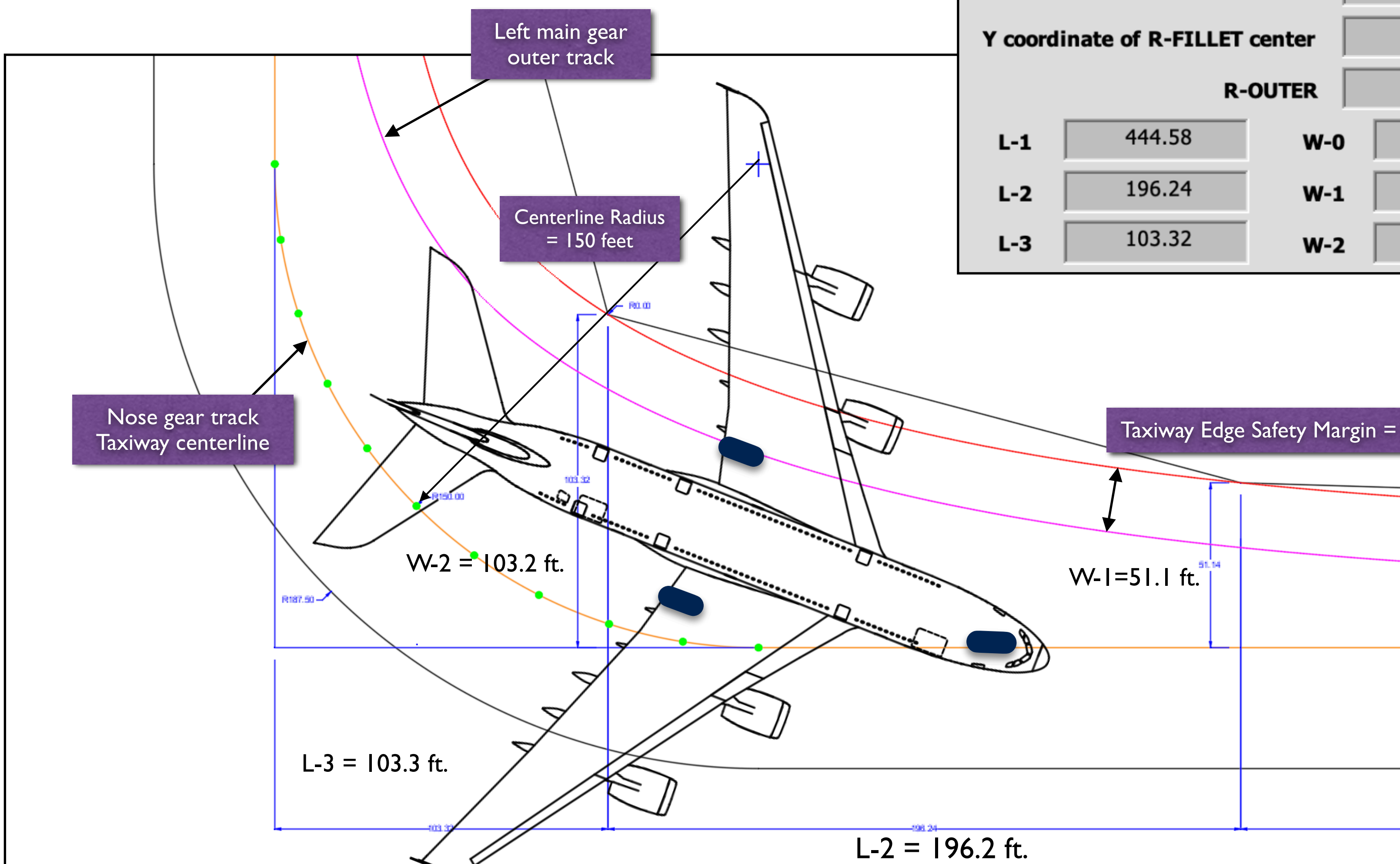
- 90-degree taxiway junction, Airbus A380 (TDG-6)
- Taxiway centerline radius of 150 feet (instead of the 124 foot- minimum radius)



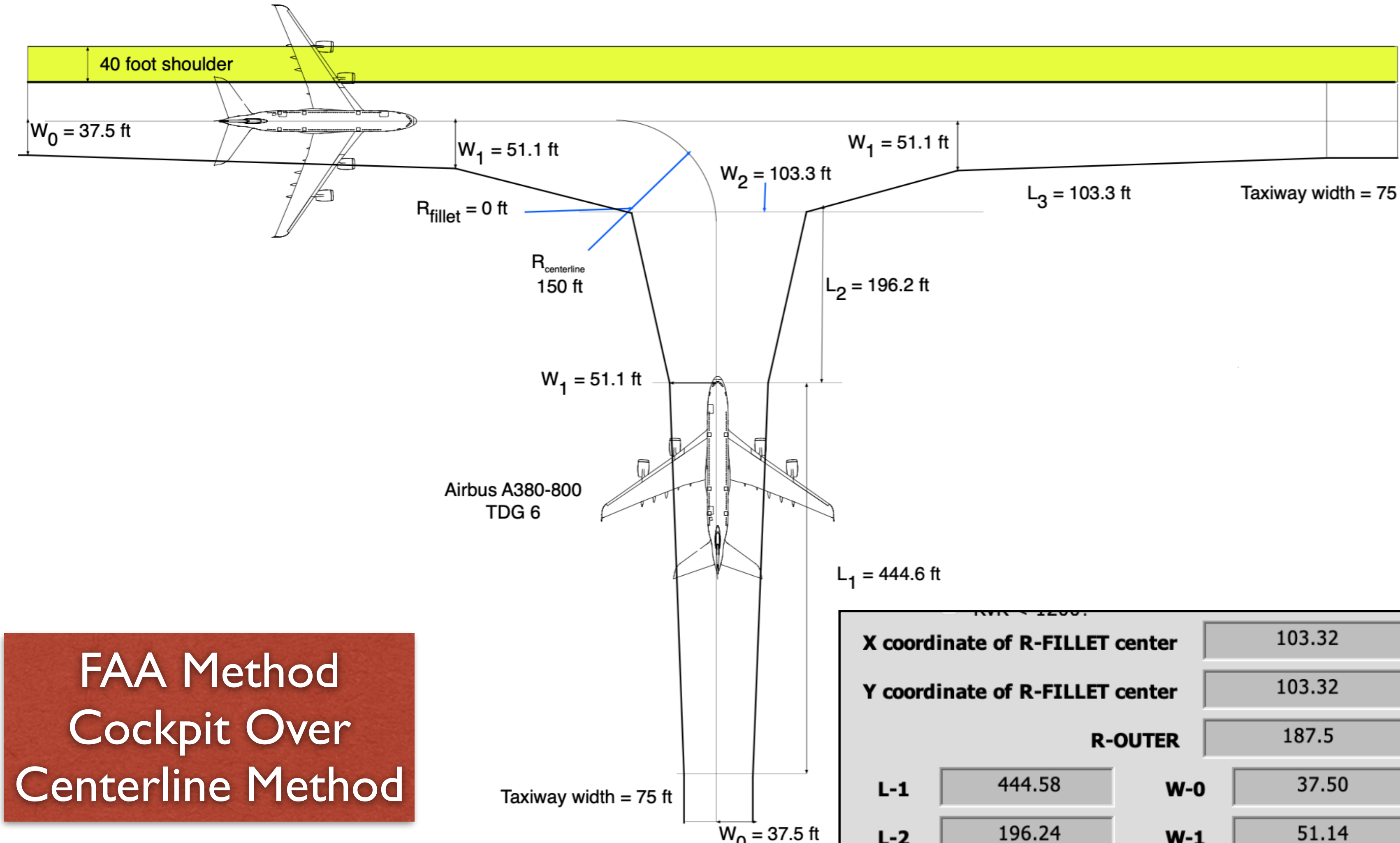
Taxiway Design Tool (FAA) Example

- 90-degree taxiway junction, Airbus A380 (TDG-6)
- Taxiway centerline radius of 150 feet (instead of the 124 foot- minimum radius)

X coordinate of R-FILLET center			103.32
Y coordinate of R-FILLET center			103.32
R-OUTER			187.5
L-1	444.58	W-0	37.50
L-2	196.24	W-1	51.14
L-3	103.32	W-2	103.32



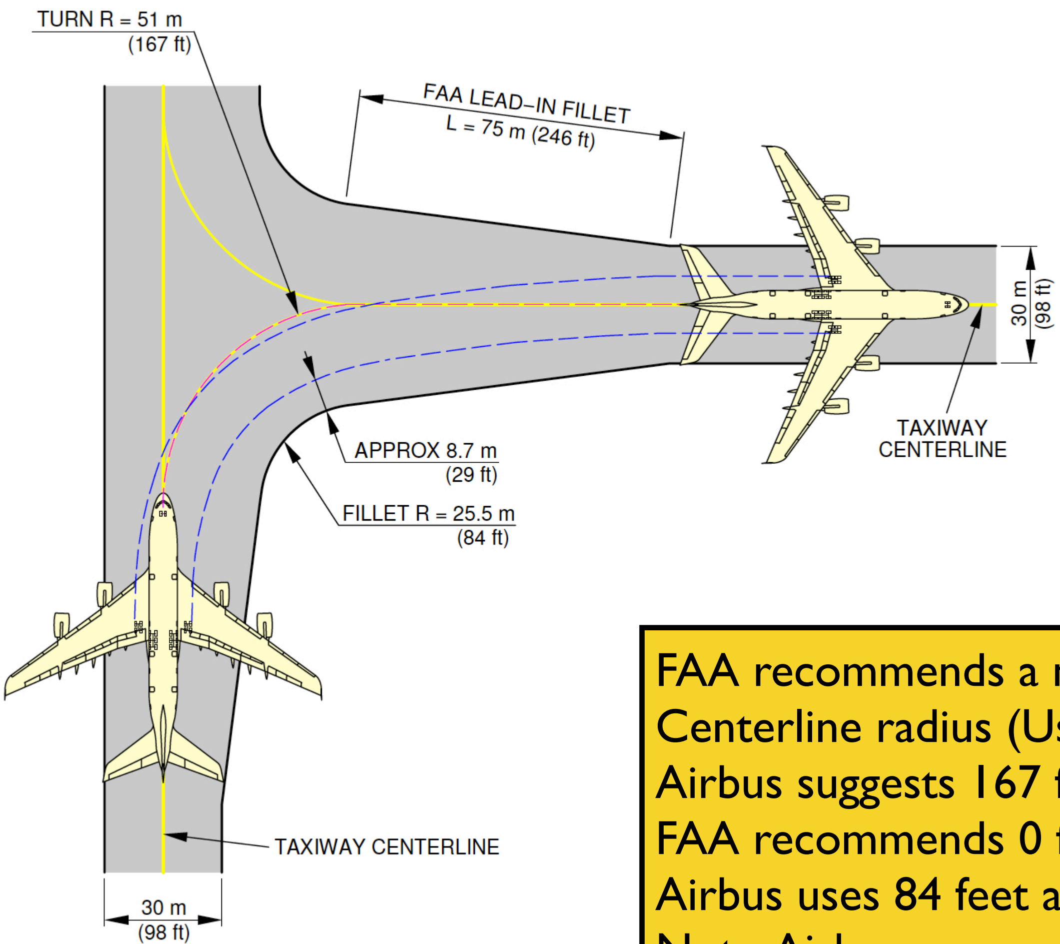
Taxiway-Taxiway Design (Airbus A380)



FAA Method Cockpit Over Centerline Method

X coordinate of R-FILLET center	103.32		
Y coordinate of R-FILLET center	103.32		
R-OUTER	187.5		
L-1	444.58	**W-0**	37.50
L-2	196.24	**W-1**	51.14
L-3	103.32	**W-2**	103.32

Verification with Aircraft Manufacturer Data

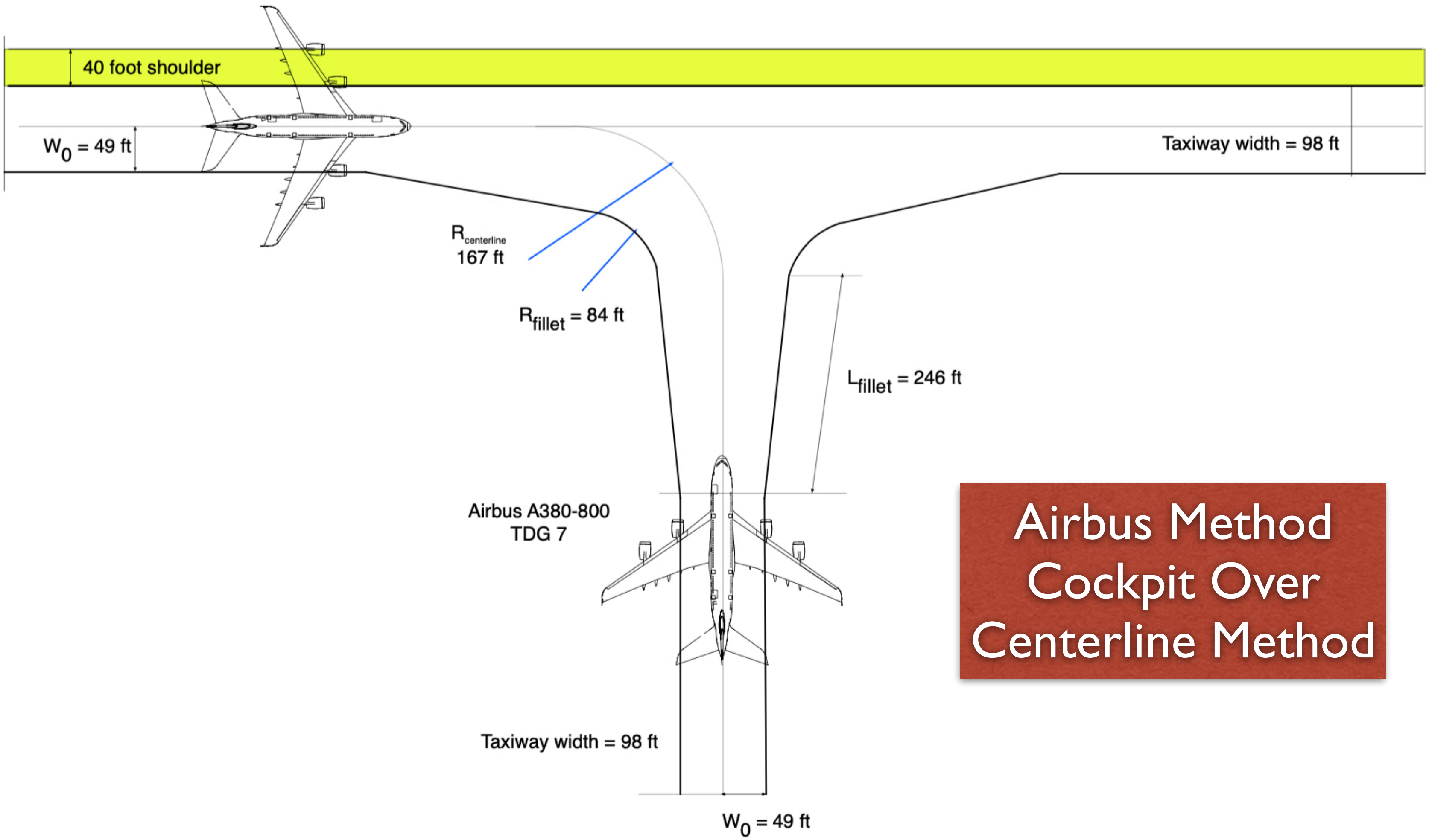


source: Airbus document: Aircraft Characteristics for Airport Planning (November 2020)

Airbus uses the old 250-foot lead-in fillet

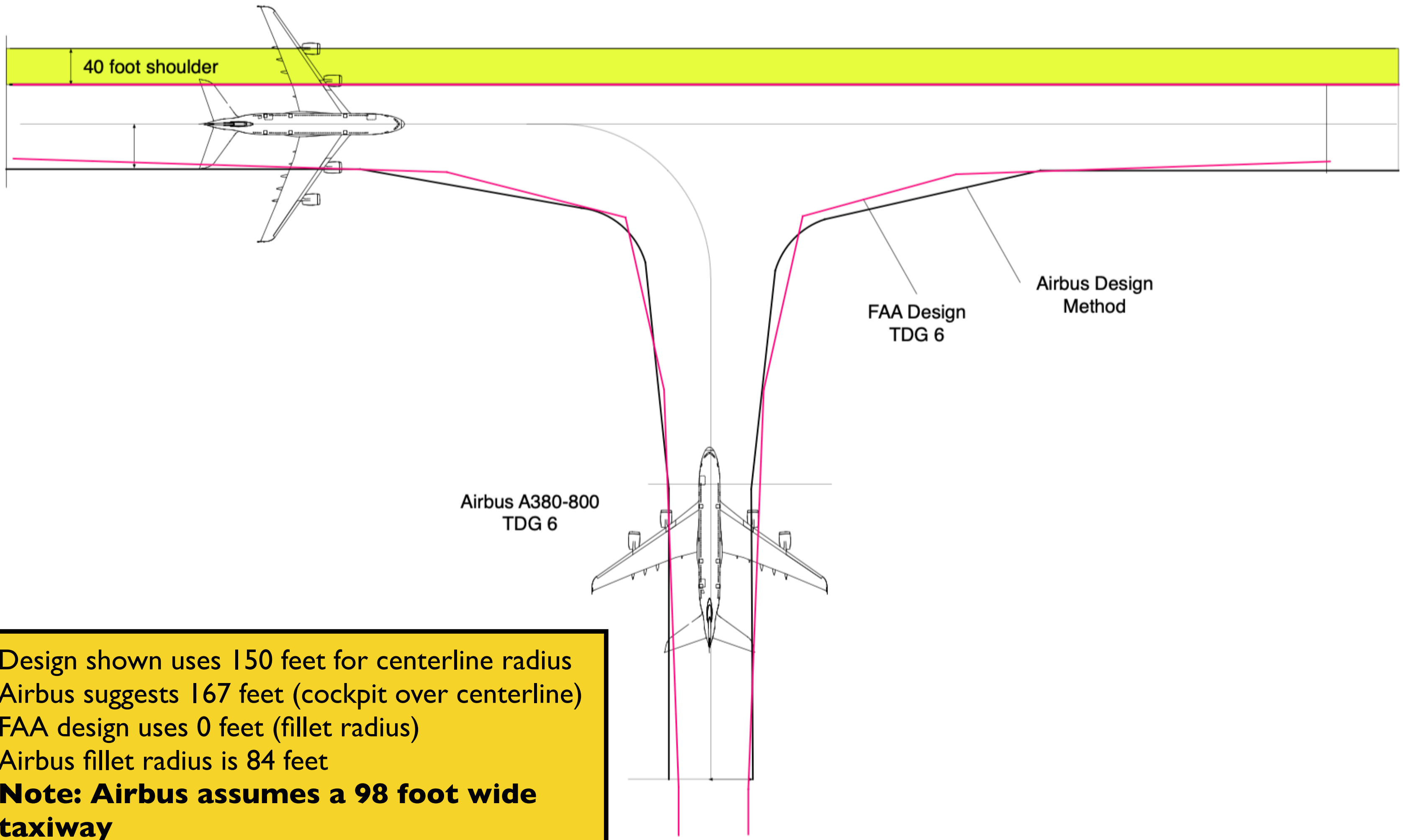
FAA recommends a minimum of 124 feet Centerline radius (Used 150 feet for the example)
Airbus suggests 167 feet (cockpit over centerline)
FAA recommends 0 feet (fillet radius)
Airbus uses 84 feet as fillet radius
Note: Airbus assumes a 98 foot wide taxiway

Taxiway-Taxiway Junction Design for Airbus A380 (Airbus Fillet Design in Airport Planning Documents)



Airbus Method
Cockpit Over
Centerline Method

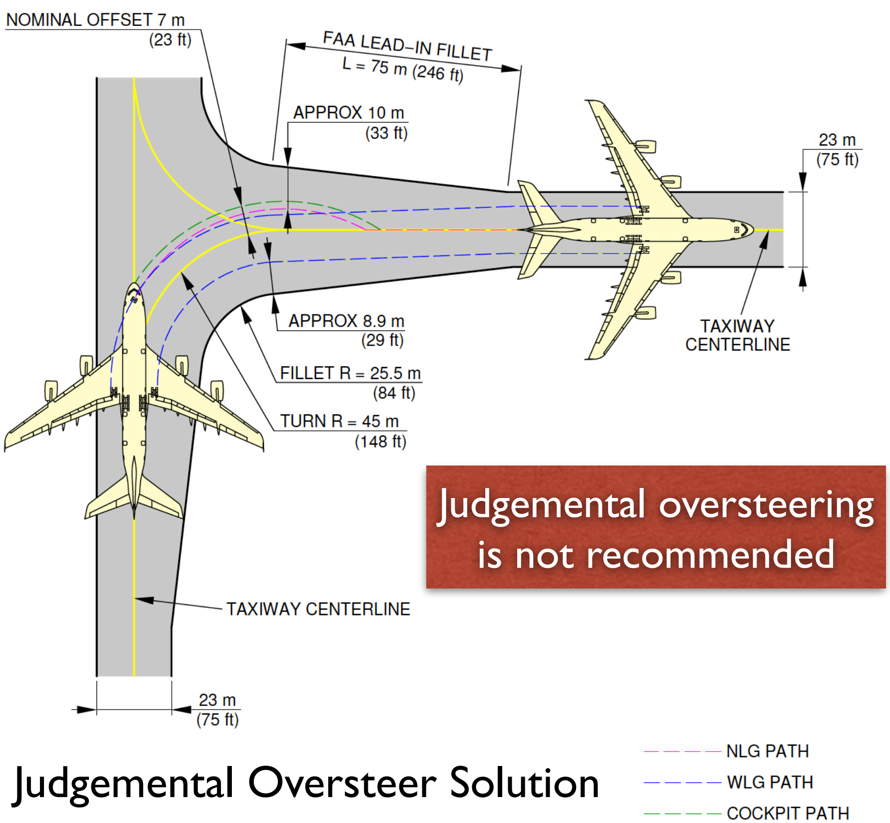
Taxiway-Taxiway Junction Designs Compared



Design shown uses 150 feet for centerline radius
Airbus suggests 167 feet (cockpit over centerline)
FAA design uses 0 feet (fillet radius)
Airbus fillet radius is 84 feet
Note: Airbus assumes a 98 foot wide taxiway

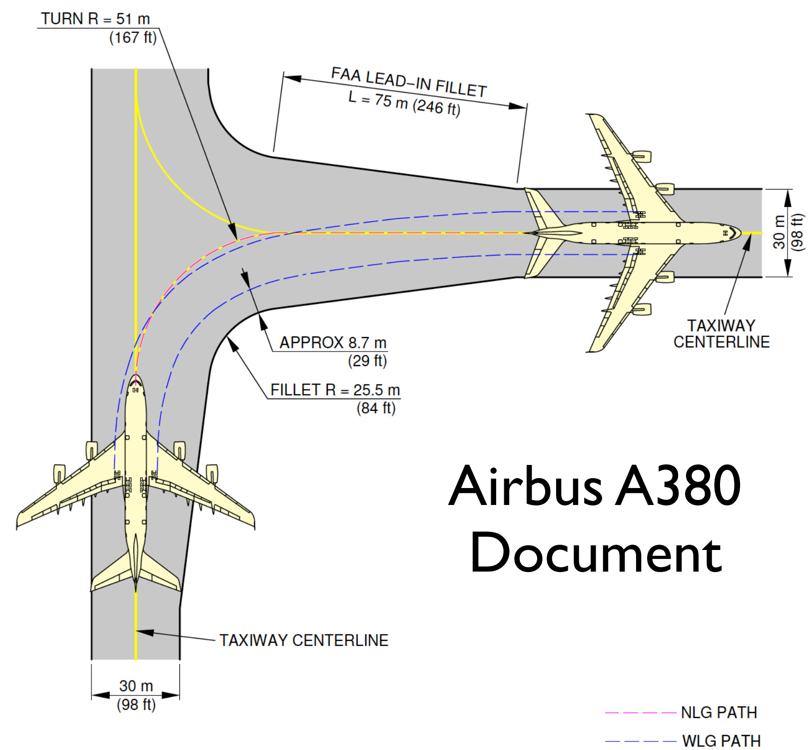
Consult with the Aircraft Manufacturer to Verify your Geometric Design Solution

- These documents contain example taxiway-taxiway and runway-taxiway designs to help you compare your analysis
- See Chapter 4 (Section 4) on both Airbus and Boeing documents



Judgemental oversteering is not recommended

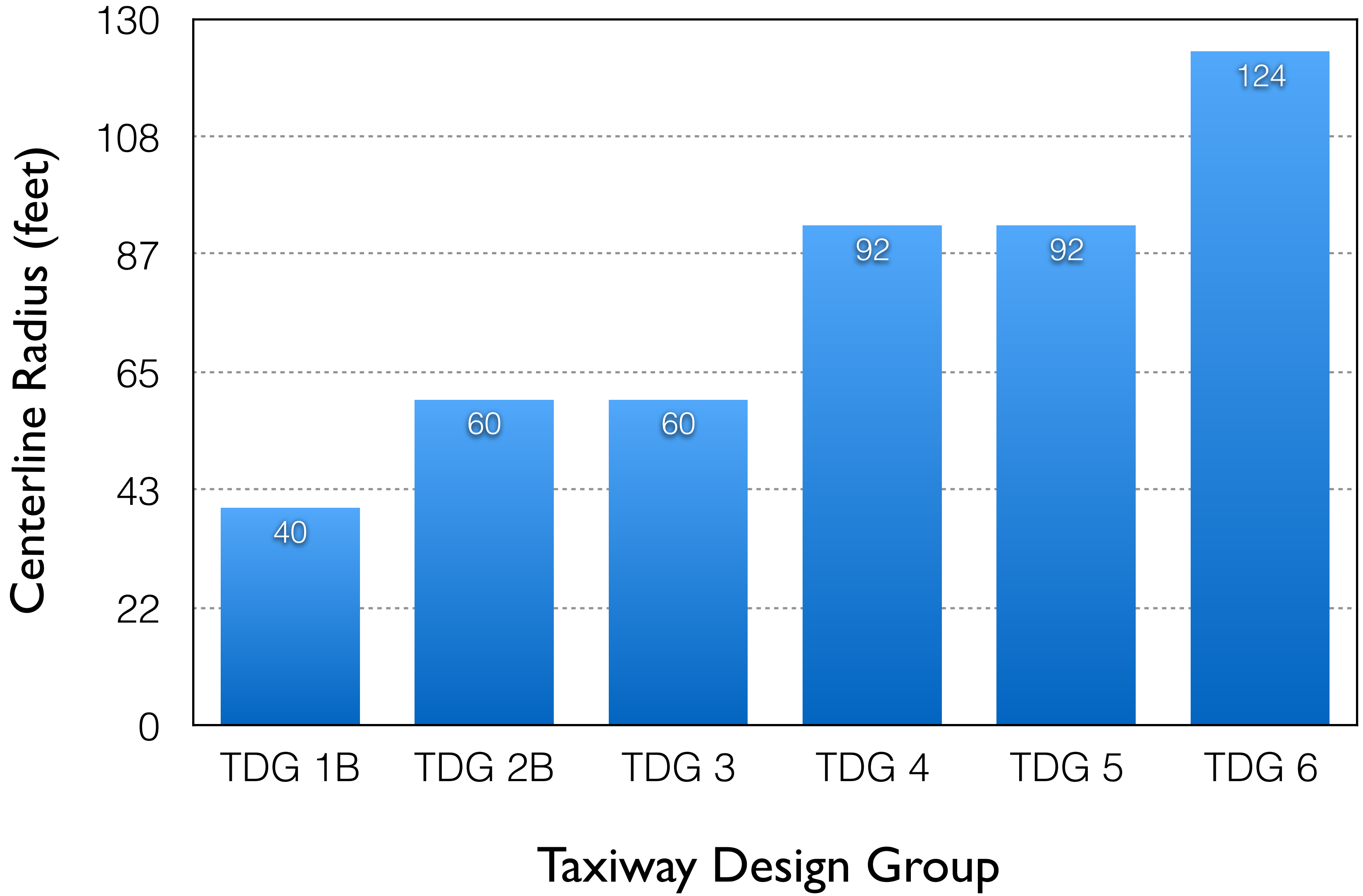
Judgemental Oversteer Solution



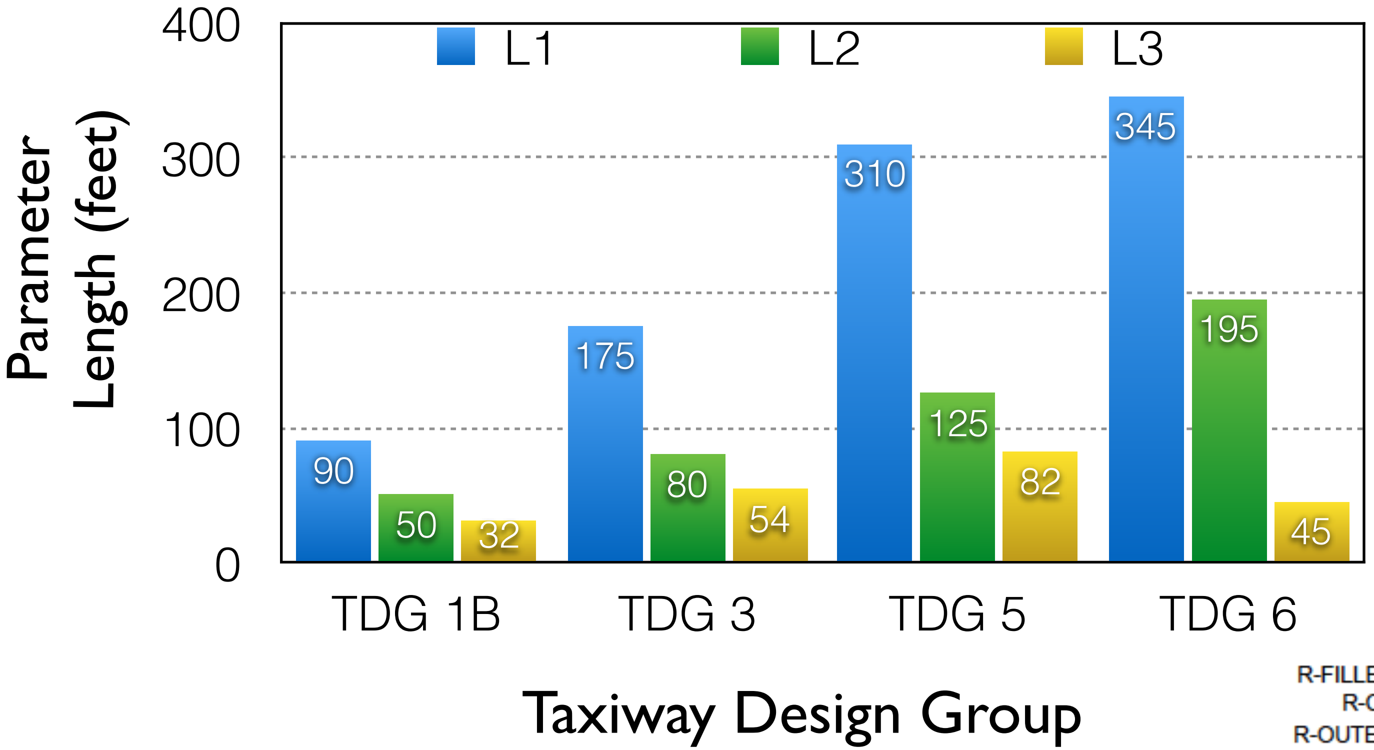
Airbus A380 Document

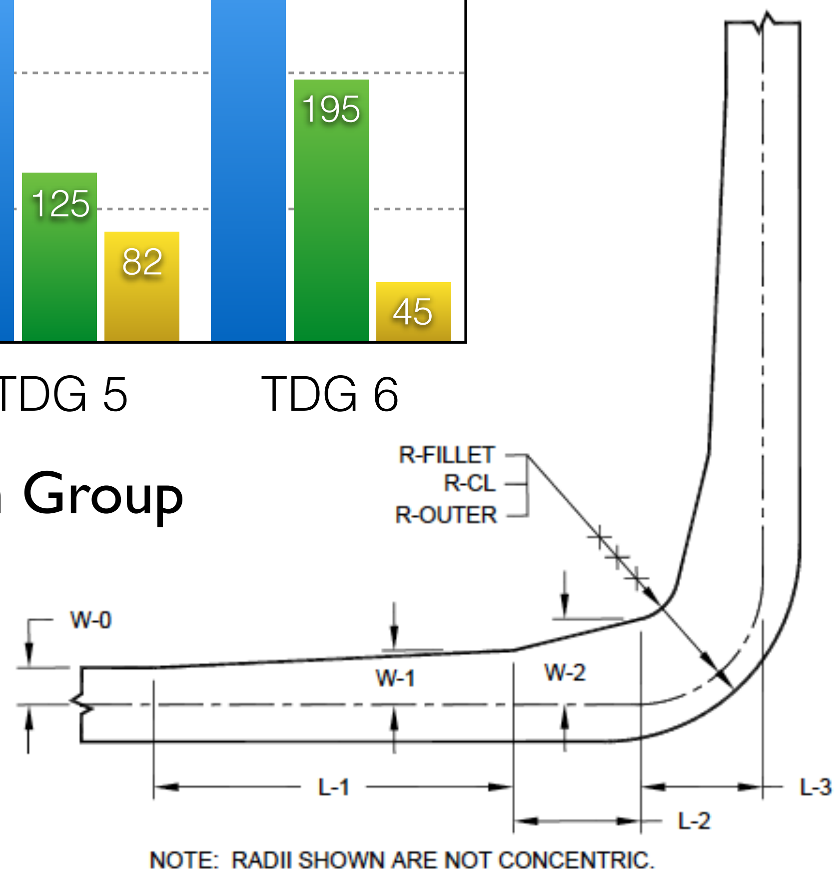
Cockpit Tracks Centerline

Minimum Centerline Radii Suggested by FAA Taxiway Fillet Design Tool (90 Degree Taxiway Turn)

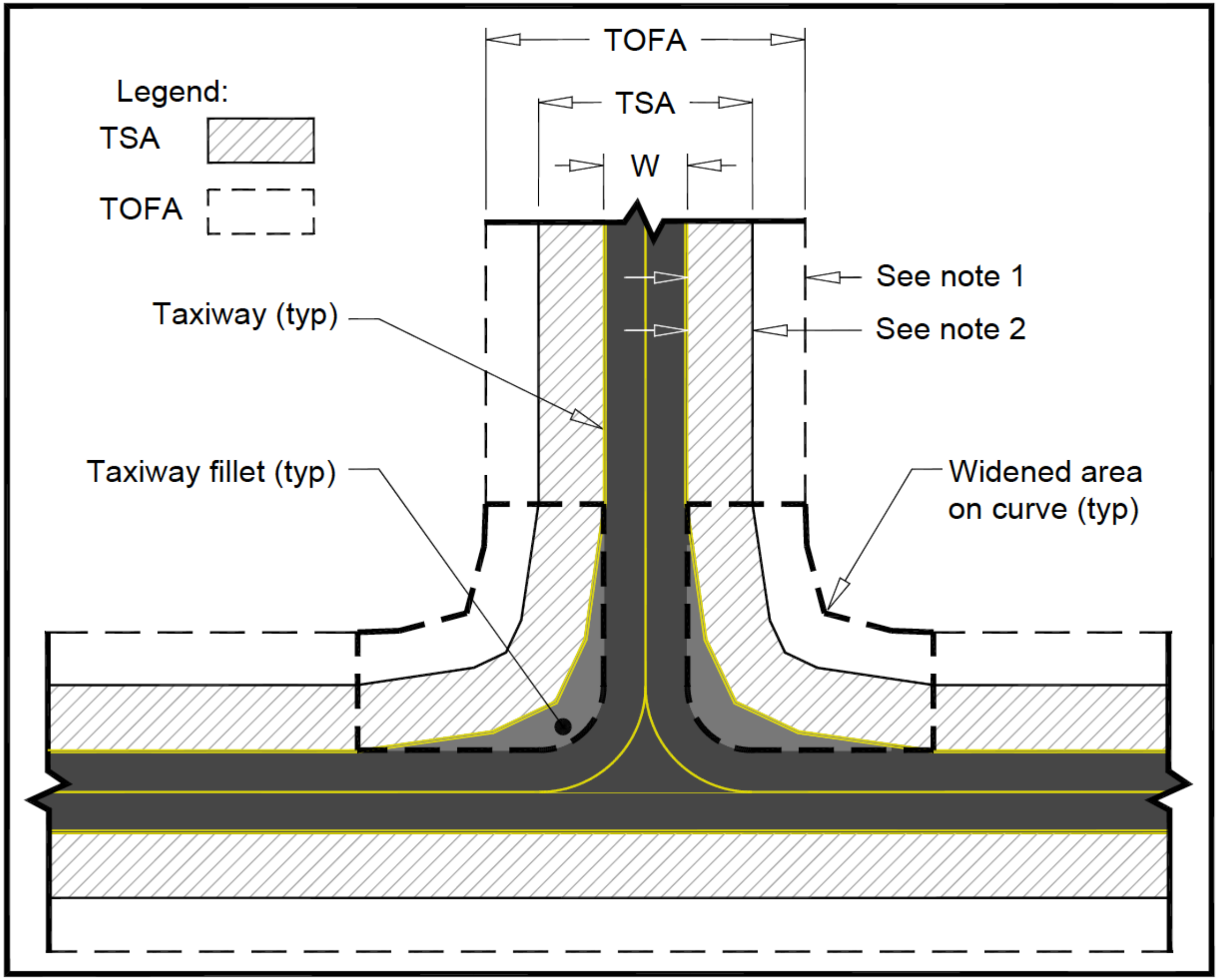


Taxiway Fillet Dimensions Increase with Aircraft Size (TDG Group)





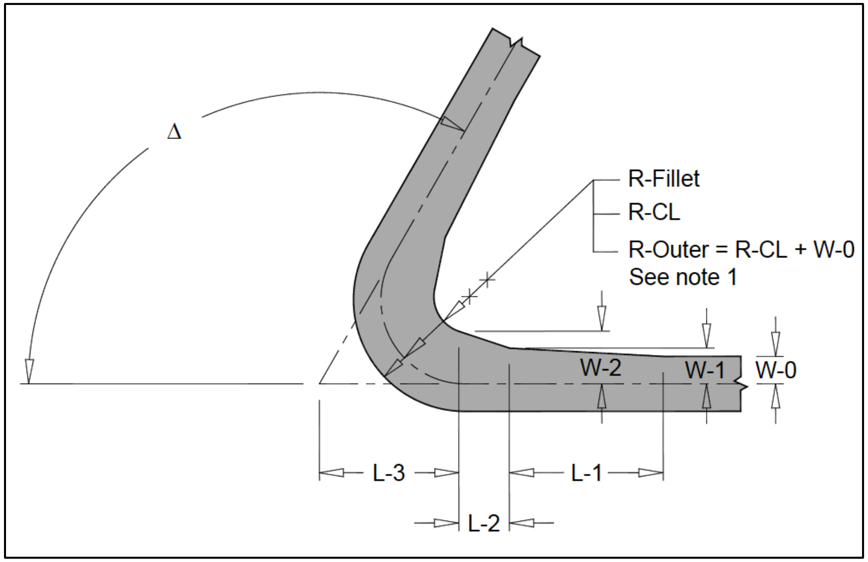
Taxiway Safety Area and Taxiway OFA



Note 1: (TOFA Width - W)/2
Note 2: (TSA Width - W)/2
Note 3: See paragraph 4.5.3.1 and paragraph 4.5.4.1 for increased width of TSA and TOFA, respectively.

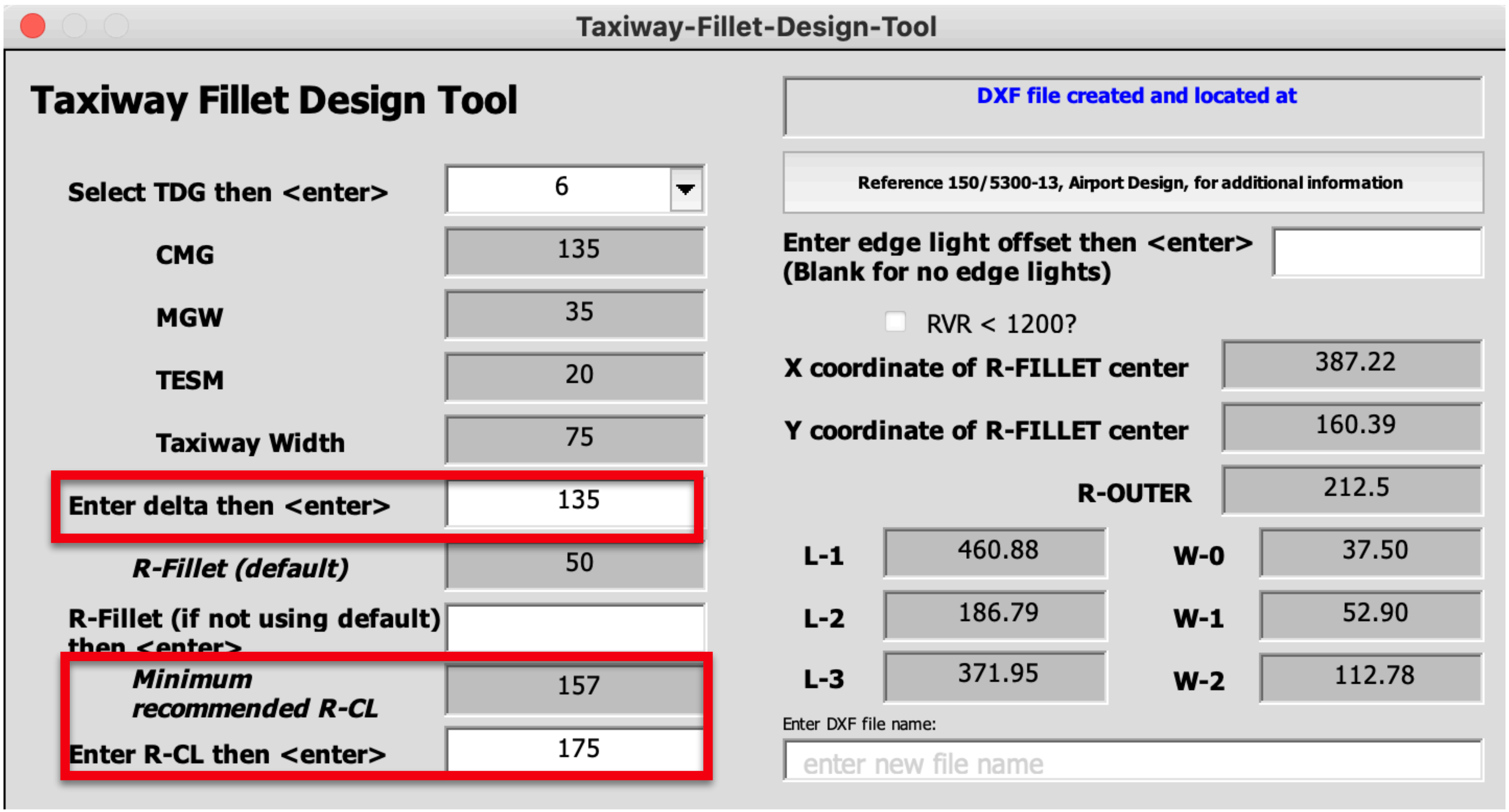
Example : Taxiway-Taxiway Fillet Design for an Airbus A380 (ADG VI, TDG 6)

- Design a taxiway-taxiway junction for an Airbus A380 class vehicle using FAA design criteria
- Taxiway-Taxiway angle (delta) - 135 degrees
- Draw the solution to scale and specify the dimensions of the taxiway-taxiway junction



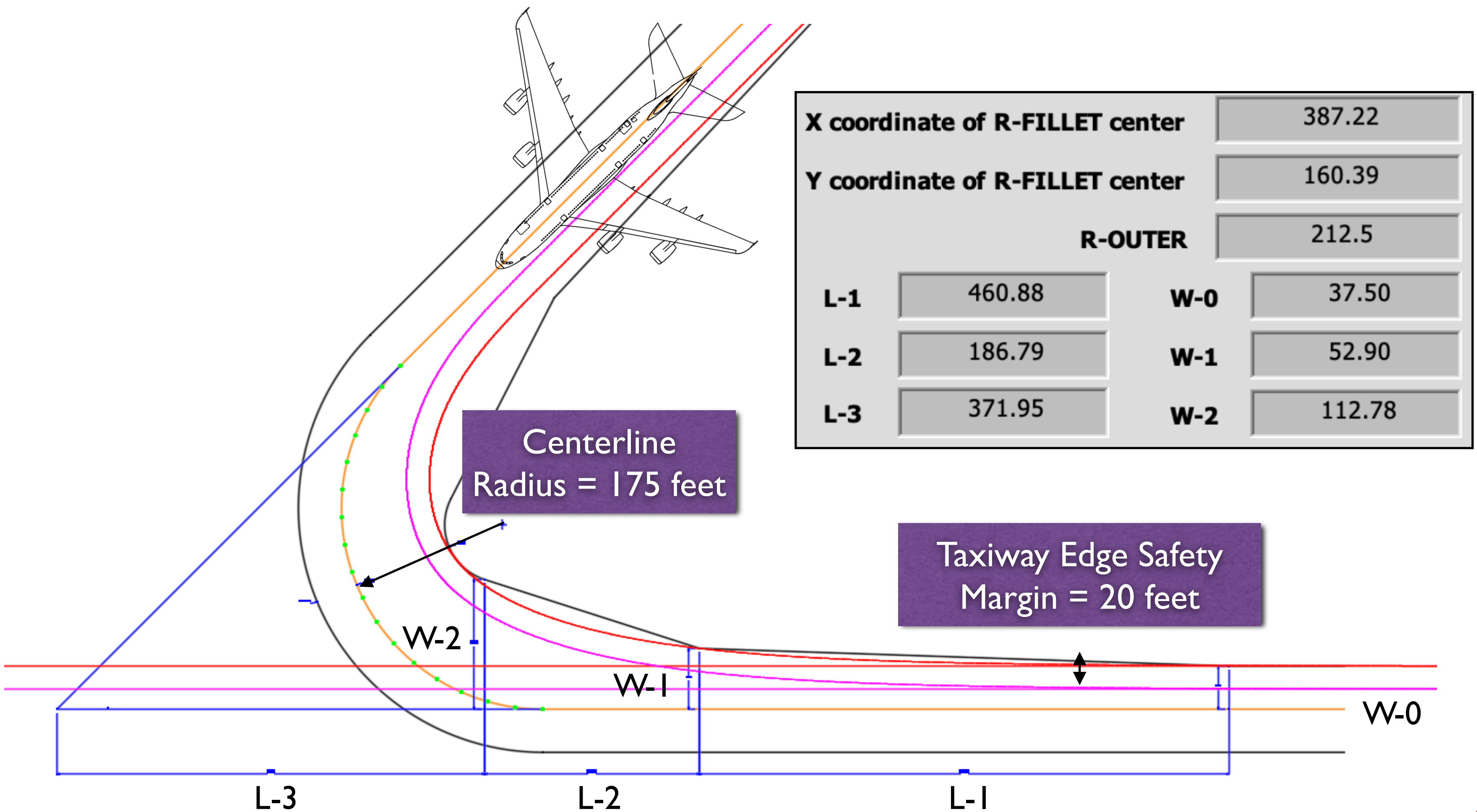
Taxiway Design Tool (FAA)

- 135 degree intersection for the Airbus A380 (TDG-6)
- In the design use a centerline radius of 175 feet (more than the minimum recommended for design)



Taxiway Design Tool (FAA) Example

- 135-degree taxiway junction, Airbus A380 (TDG-6)
- Taxiway centerline radius of 175 feet (instead of the 157 foot- minimum radius)

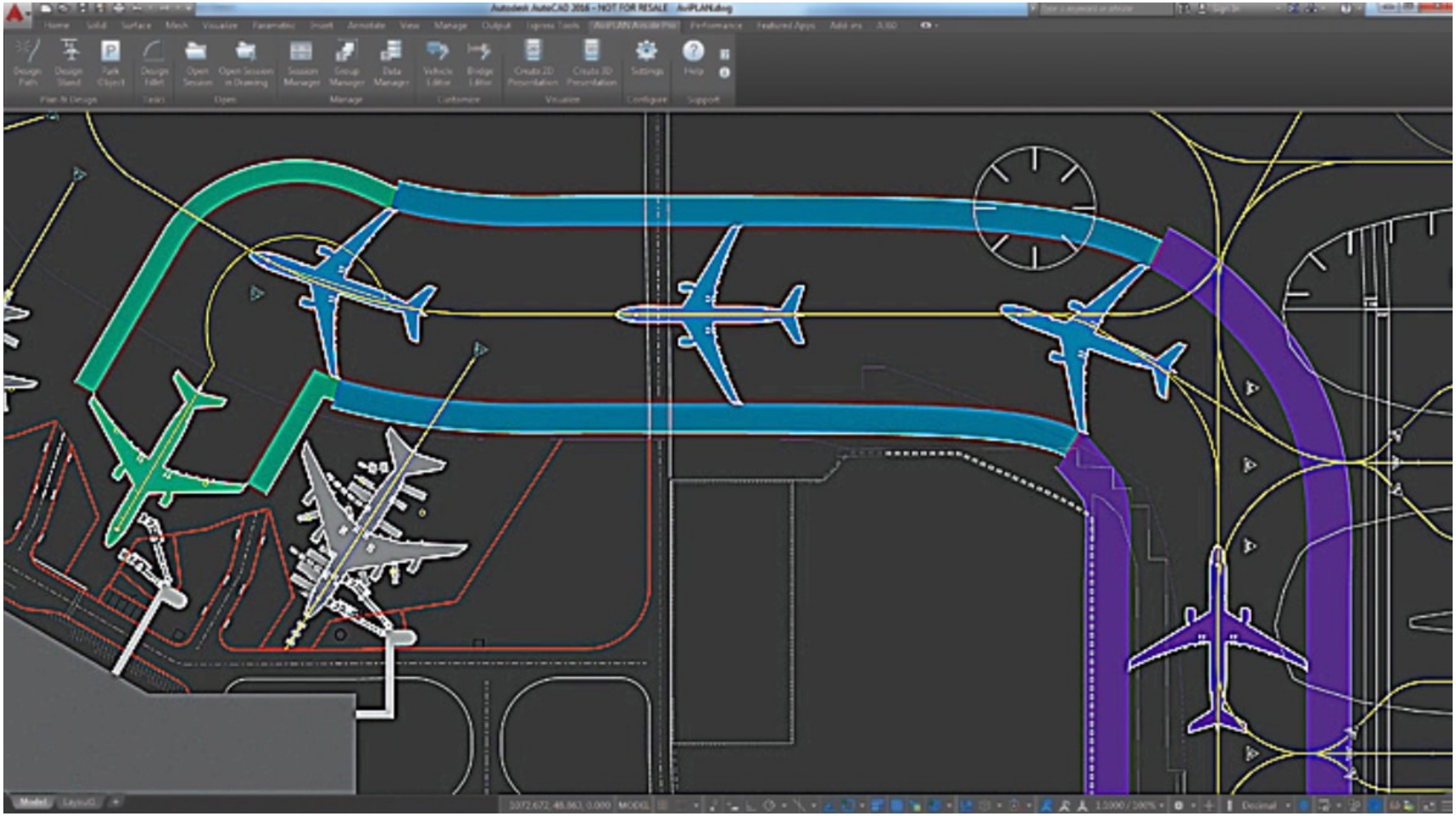


Sample **Old** Taxiway Fillet Design

Use of Specialized Software

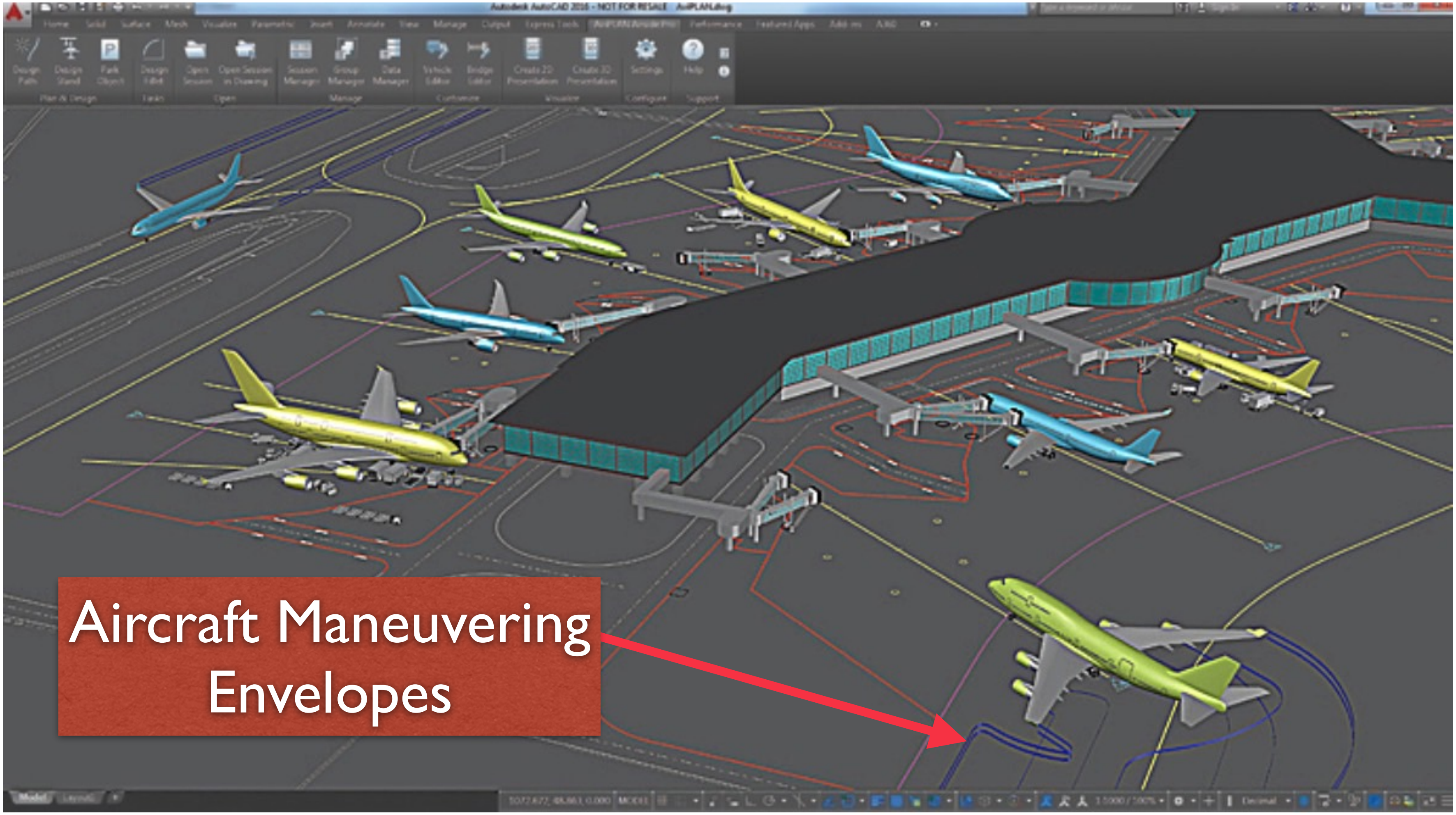
- Several computer design software have been developed to facilitate geometric design of airports
- AviPLAN Turn and AviPlan Turn Pro are a family of products designed to help designers simulate and verify airport designs
- Software are add-ons to AutoCad
- Designers select a path to be tested and the software performs a kinematic simulation to verify the design

Gate Parking Maneuver Simulated in AviPLAN Turn Pro



source: Transoft Solutions

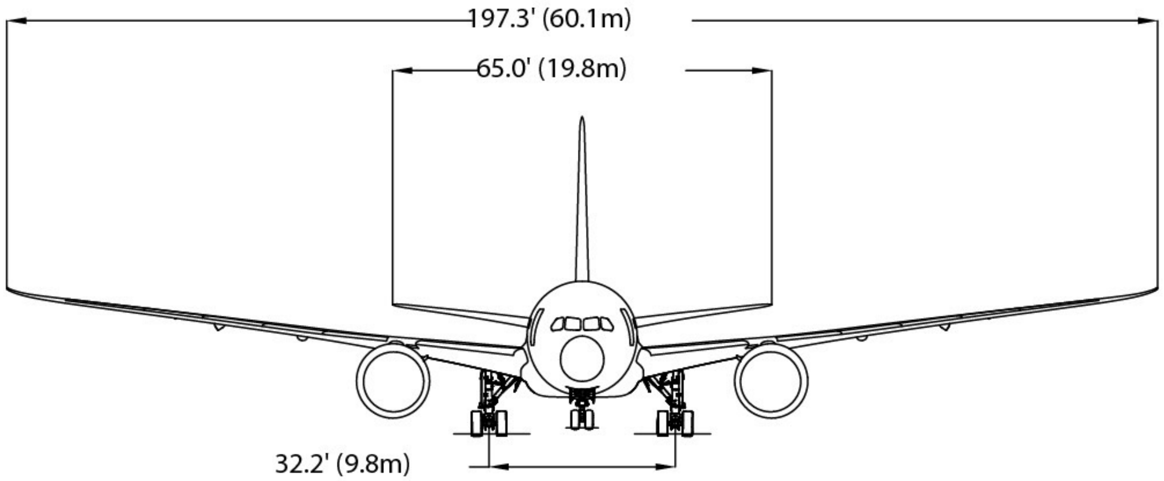
3D Visualization in AviPLAN Turn Pro



source: Transoft Solutions

Other Important Sources to Help Your do Airport Geometric Design

- Consult aircraft manufacturer web sites to obtain 3D drawings of aircraft
- Airbus aircraft (http://www.airbus.com/support/maintenance-engineering/technical-data/autocad-3-view-drawings-of-airbus-aircraft/)
- Boeing aircraft (http://www.boeing.com/commercial/airports/3_view.page)



Boeing 787-8
source: Boeing

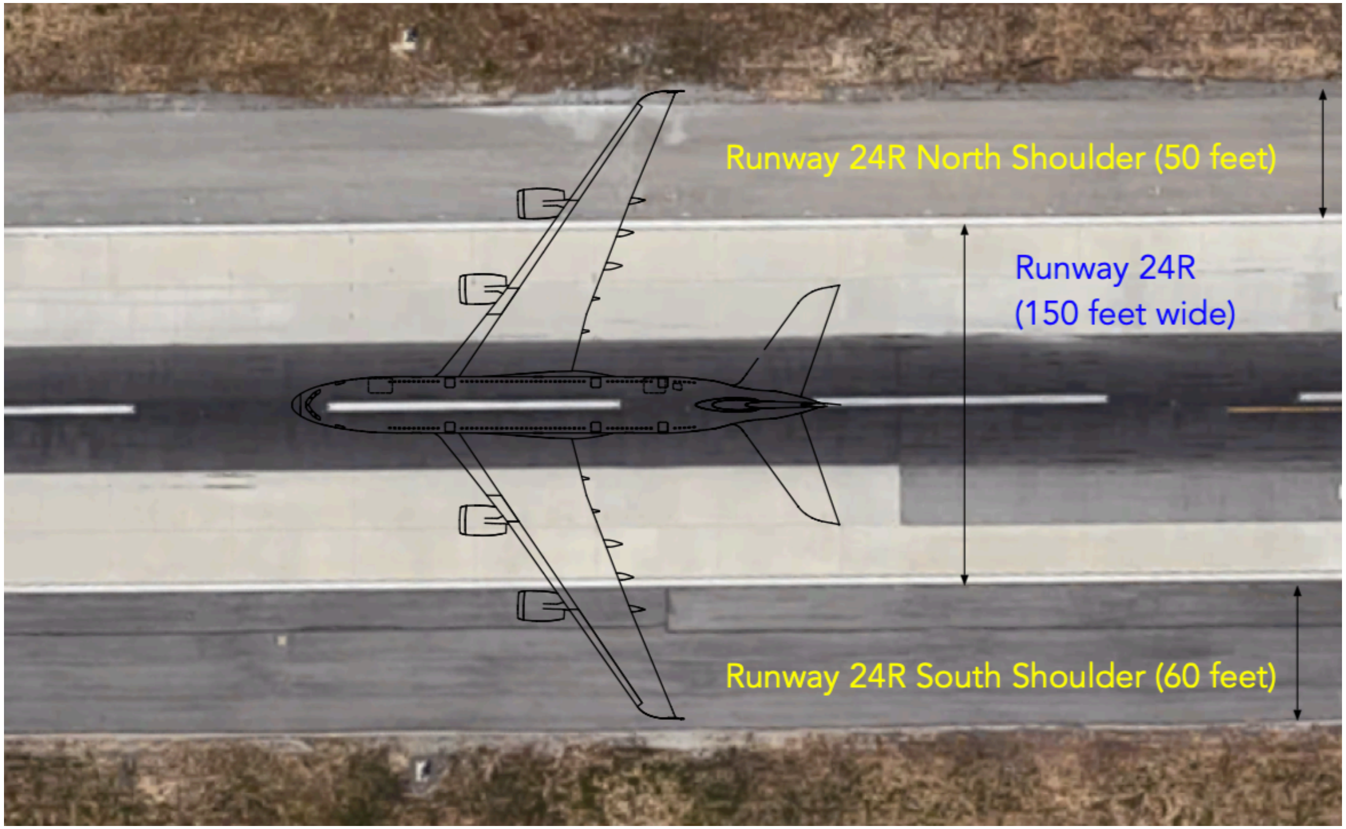
Legacy Airports
Modification of Standards

Legacy Design Standards and Old Airports

- Many airports in the U.S. were designed and constructed before the current design standards were developed
- Consequently many times we find that current geometric design standards are not met
- These airports require **Modification of Standards (MOS)**
- MOS are approved by FAA on a one-to-one basis
- For example, the Airbus A380 requires a 200 foot wide runway (see ADG VI standards)
- The FAA and ICAO have provided a MOS procedure whereby the A380 can operate from 150 foot runways with 50 foot stabilized shoulders

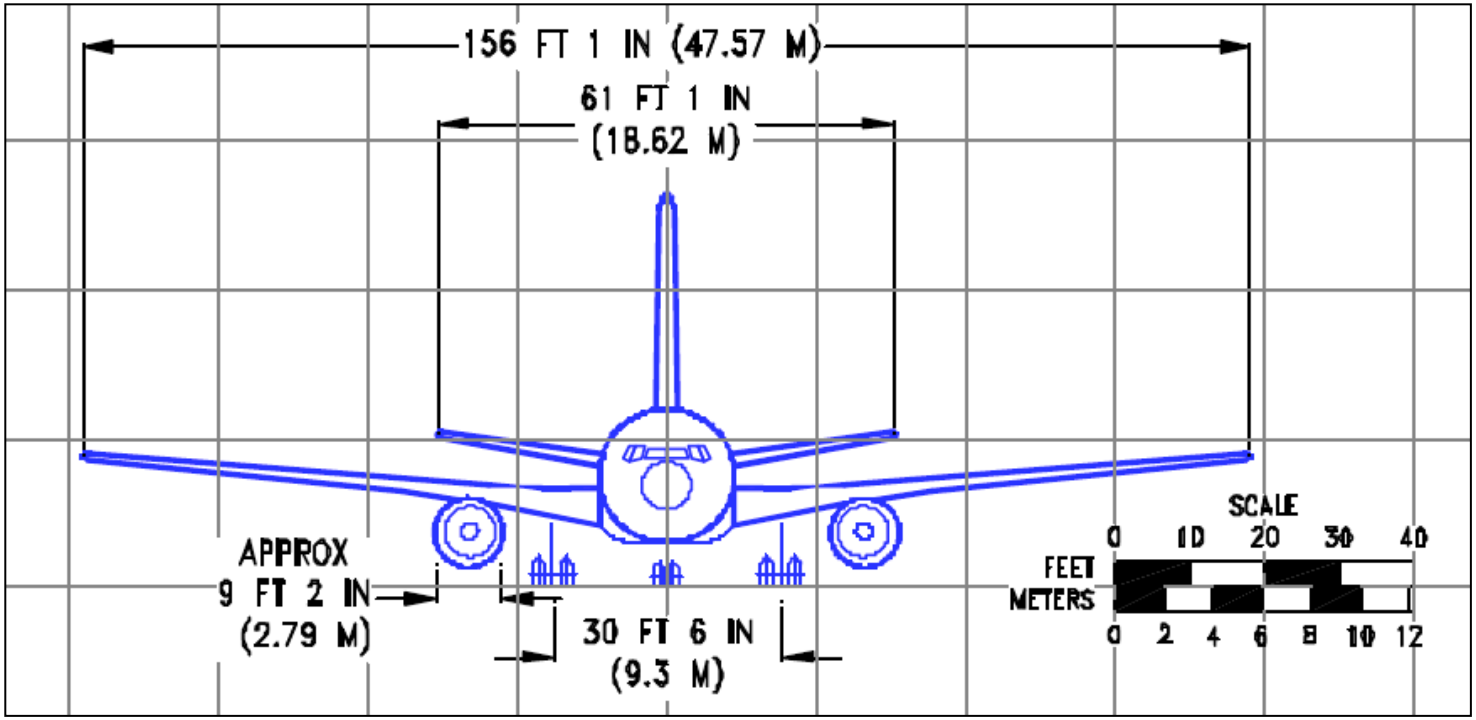
Example: MOS at LAX Runway 24R

- Standard width for ADG VI is 200 feet. Shoulder width is 40 feet.
- MOS allows Airbus A380 landings on runway 24R (150-foot wide runway with 50/60 foot shoulder widths)

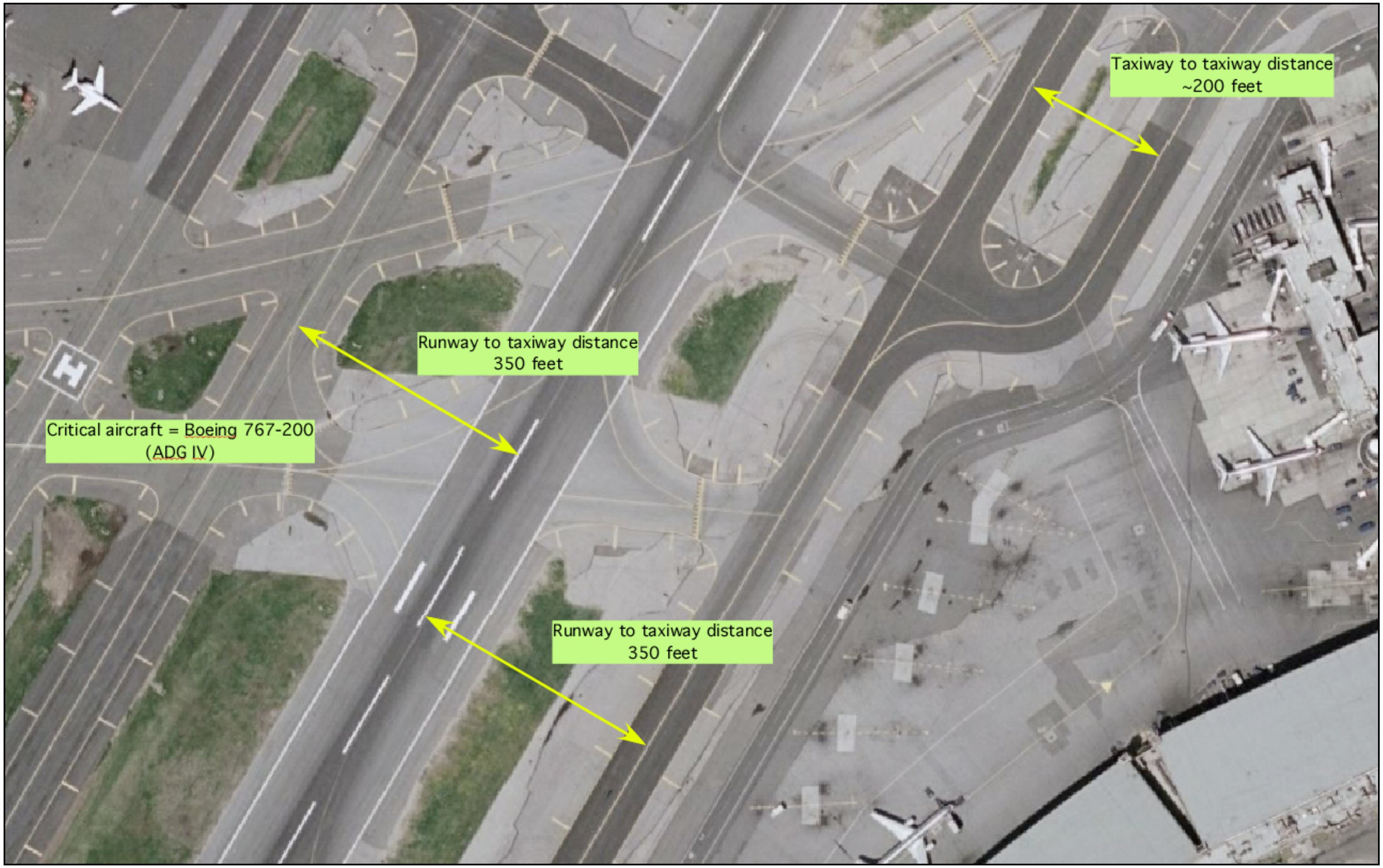


Example of a Legacy Airport
The Following Example Applies to LGA

- Delta Airlines operates Boeing 767-300 into LGA
- The critical aircraft wingspan is 156.08 feet (ADG IV)



Current Situation (LGA)



Runway Design Standards (Boeing 767 D-IV)

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		C/D/E - IV			
ITEM	**DIM** [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 316*			
Holding Position [8, 9]		250 ft	250 ft	250 ft	250 ft
Parallel taxiway/taxilane centerline [2]	D	400 ft	400 ft	400 ft	400 ft
Aircraft parking area	G	500 ft	500 ft	500 ft	500 ft
Helicopter touchdown pad		*Refer to AC 150/5390-2*			

Required runway to taxiway = 400 feet
Available runway to taxiway = 350 feet
A Modification of Standard is needed from the FAA

Sample Modification of Standards (MOS)

- Taxiway centerline to parallel taxiway/taxilane centerline require **1.2 times airplane wingspan** plus 10 feet (3 m)
- Required for limiting ADG IV aircraft (171 foot wingspan) = 215 feet
- Rule for Modification of Standards (MOS) = 1.2 * critical wingspan + 10 feet
- Distance = 2 (156.08) + 10 feet = 197 feet
- Airport has 200 feet between parallel taxiways
- Boeing 767-300 was operated from LGA some years ago

Runway Surface Gradient Design Standards

Runway and Surface Gradients

- Located in FAA AC 150/5300-13B, Chapter 3
- Includes vertical profile limits for runways and taxiways
- Important to maintain line-of-sight in the operations
- Pilot to pilot
- ATC controller to aircraft

Surface Gradient Standards
Chapter 3 in AC 150/5300-13B

3.16.1.2 **Aircraft Approach Categories C, D, and E.**

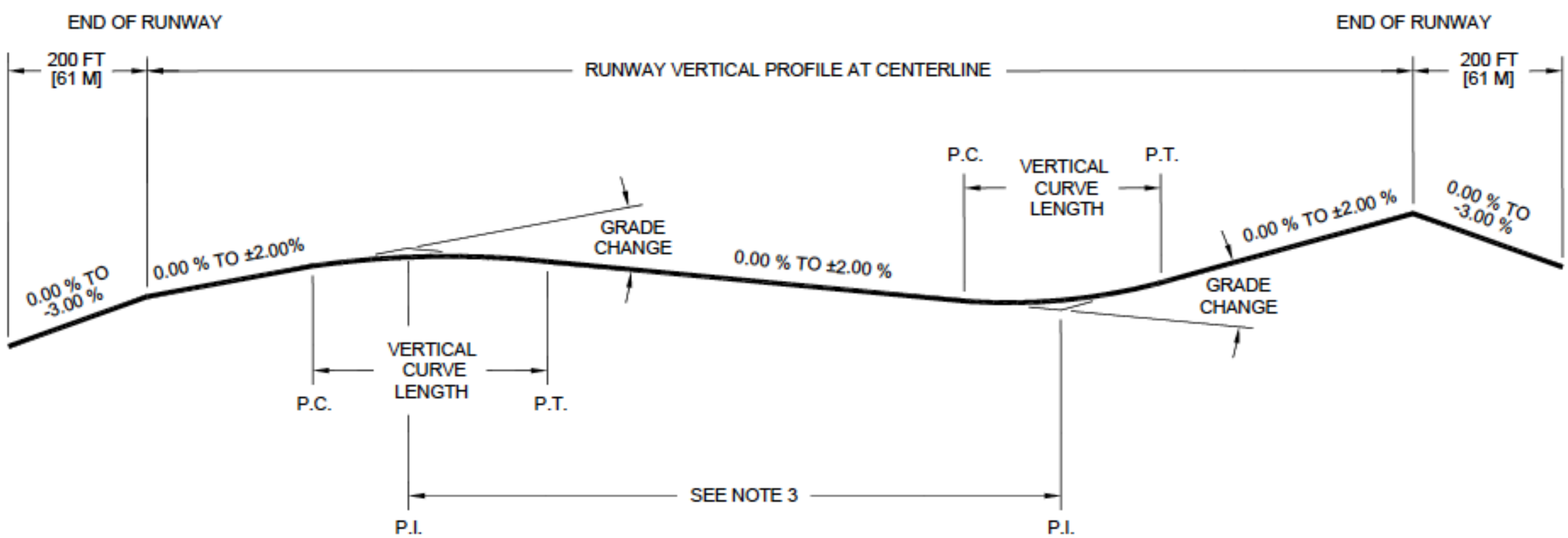
Refer to Figure 3-33 and the following, for standards applicable to Aircraft Approach Categories C, D, and E.

1. The maximum allowable longitudinal grade is ±1.50 percent; however, longitudinal grades exceeding ±0.80 percent are not acceptable within the lesser of the following criteria:
   a. in the first and last quarter of the physical runway length, or
   b. the first and last 2,500 feet (762 m) of the physical runway length.
2. The maximum allowable grade change is ±1.50 percent; however, runway grade changes are not acceptable within the lesser of the following criteria:
   a. the first and last quarter of the physical runway length, or
   b. the first and last 2,500 feet (762 m) of the physical runway length.
3. Vertical curves for longitudinal grade changes are parabolic. The length of the vertical curve is a minimum of 1,000 feet (305 m) for each 1.0 percent of change.

Longitudinal Runway Grades

- 1.5 % maximum for runways serving transport aircraft
  - 0.8% maximum in the first and last quarter of the runway (or first and last 2500 feet of the runway length)
- Up to 2% for general utility runways (Groups A and B)
- 1.5 % transverse from crest (groups C, D. and E)
- **Maximum gradient change 1.5 % for groups C,D, and E.** Use 2% for groups A and B
- **Vertical curve length (1000 x grade change in feet for** groups C, D, and E). Use 300 x grade change for groups A and B.
- **Minimum distance between points of intersection** (1000 ft. for each 1% grade change for groups C,D, and E)

Longitudinal Grades
Approach Speed Groups A and B

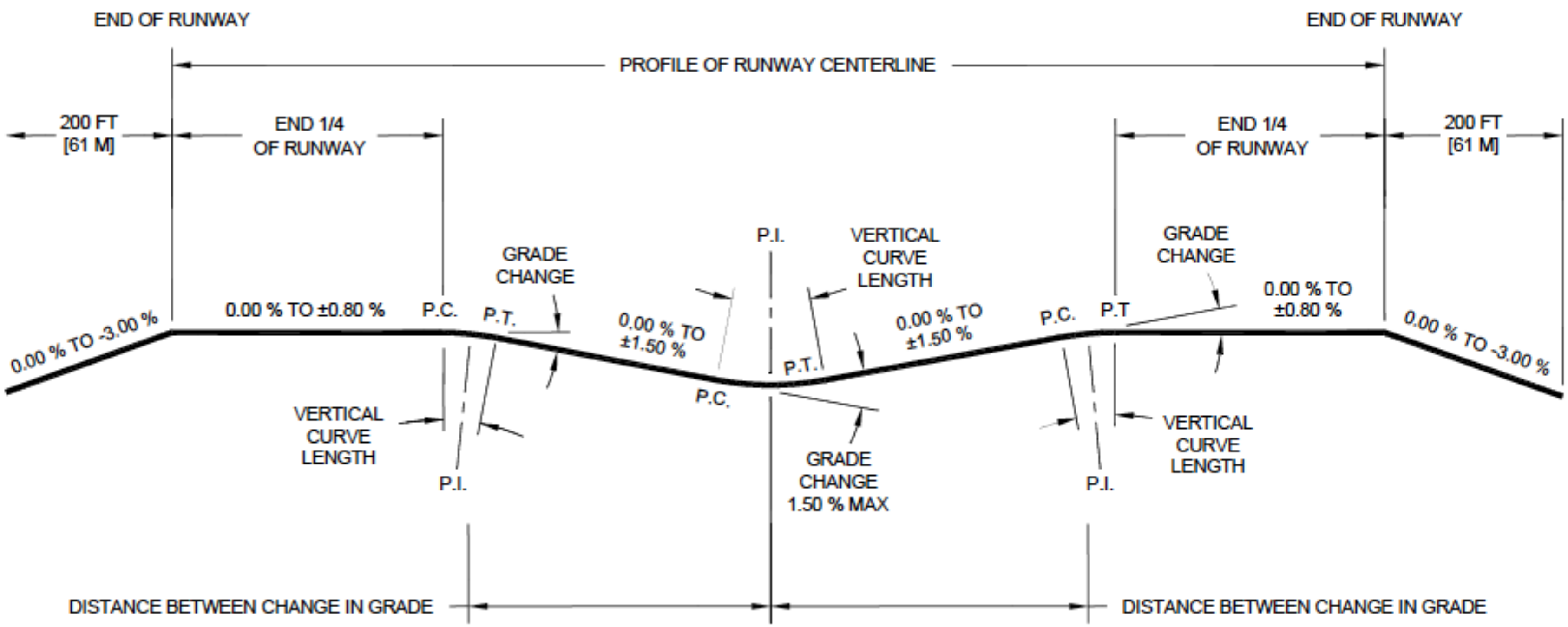


Source: FAA AC 5300-13B

NOTES:

1. LENGTH OF VERTICAL CURVES WILL NOT BE LESS THAN 300 FT [91 M] FOR EACH 1% GRADE CHANGE, EXCEPT THAT NO VERTICAL CURVE WILL BE REQUIRED WHEN GRADE CHANGE IS LESS THAN 0.4%.
2. MAXIMUM GRADE CHANGE AT VERTICAL CURVES SHOULD NOT EXCEED 2.00 %.
3. MINIMUM DISTANCE BETWEEN POINTS OF VERTICAL INTERSECTION SHOULD BE 250 FT [76 M] x SUM OF ABSOLUTE GRADE CHANGES.

Longitudinal Grades Approach Speed Groups C and D

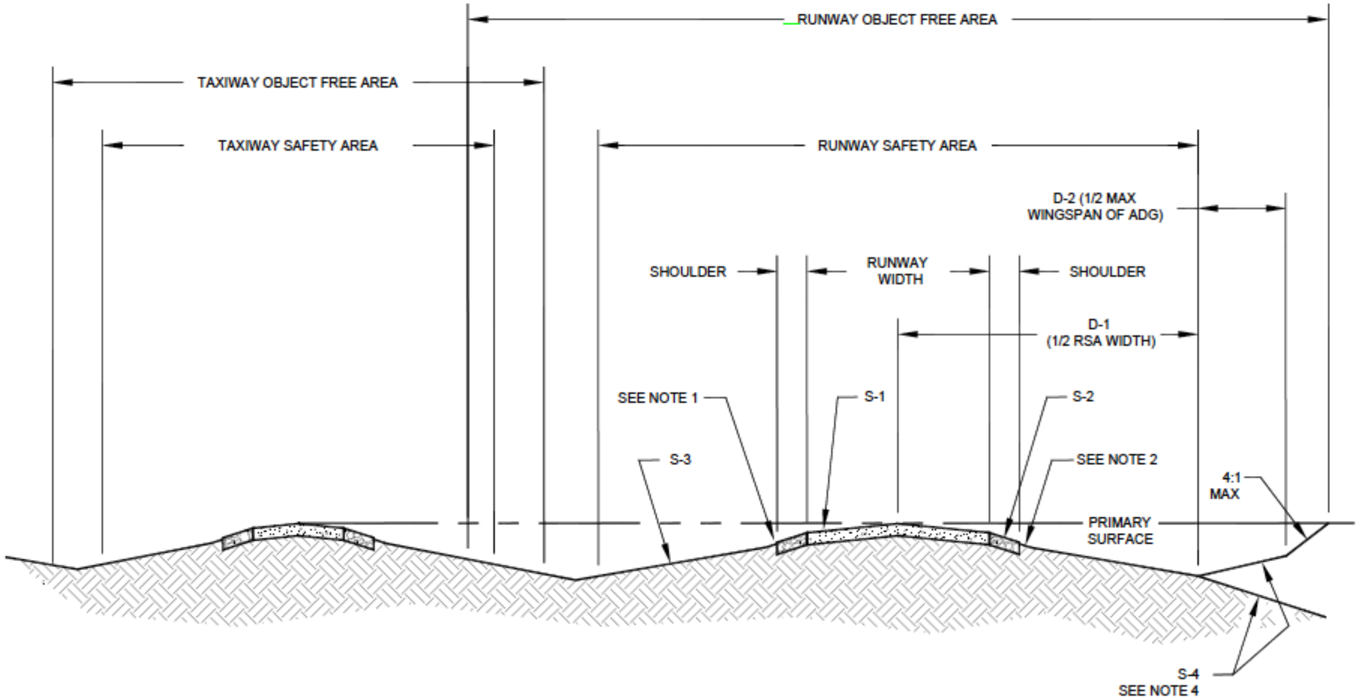


Source: FAA AC 5300-13 – Figure 3-22

NOTES:

1. MINIMUM LENGTH OF VERTICAL CURVES = 1,000 FT [305 M] x GRADE CHANGE (IN %).
2. THE MINIMUM VERTICAL CURVE LENGTH IS EQUAL TO 1,000 FT [305 M] x GRADE CHANGE.
3. THE MINIMUM DISTANCE BETWEEN POINTS OF VERTICAL INTERSECTION MUST BE 1,000 FT [305 M] x SUM OF THE ABSOLUTE GRADE CHANGES.

Transverse Grades for Approach Speed Groups A/B and C/D/E



NOTES:

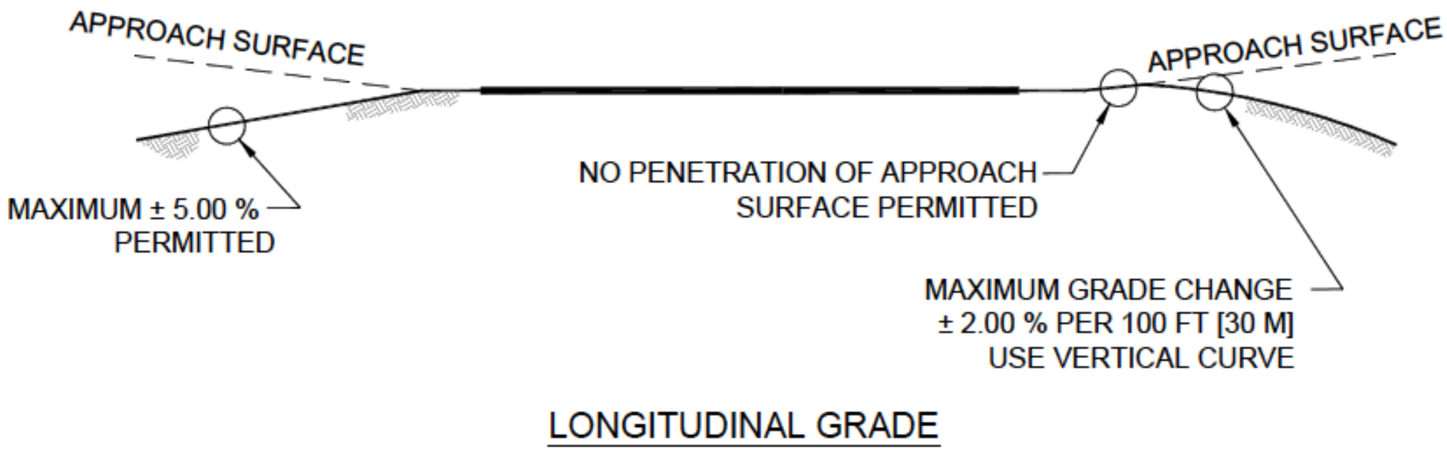
1. CONSTRUCT A 1.5 IN [4 cm] DROP BETWEEN PAVED AND UNPAVED SURFACES.
2. MAINTAIN A -5.0 % GRADE FOR 10 FEET OF UNPAVED SURFACE ADJACENT TO THE PAVED SURFACE.
3. S-2 APPLIES WHEN SHOULDERS ARE PROVIDED.
4. S-4 SHOULD BE 0% OR NEGATIVE (UNLIMITED) TO THE EDGE OF THE RUNWAY OFA IF PRACTICABLE. ALLOWABLE POSITIVE SLOPE BASED ON AIRPLANE DESIGN GROUP.
5. REFER TO FIGURE 4-35 FOR TAXIWAY TRANSVERSE GRADES.

APPROACH CATEGORY	A & B	C, D, AND E
S-1	1.0% TO 2.0%	1.0% TO 1.5%
S-2 (≥S-1)	1.5% TO 5.0%	1.5% TO 5.0%
S-3	1.5% TO 5.0%	1.5% TO 3.0%

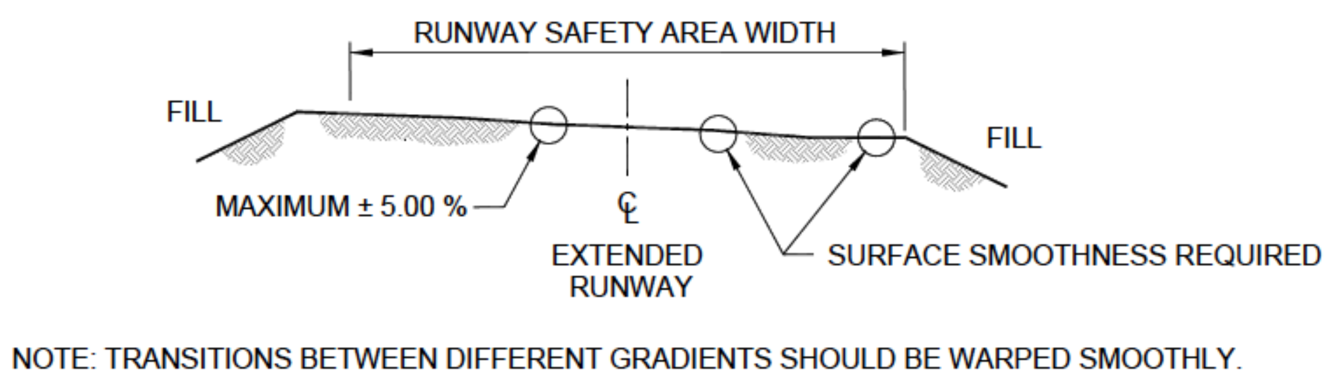
ADG	I	II	III	IV	V	VI
D-1	SEE TABLE 3-8					
D-2	25	40	59	86	107	131
S-4 (MAXIMUM)	8:1		10:1		16:1	

Source: FAA AC 5300-13 – Figure 3-23

Longitudinal and Transverse Grades of Runway Safety Areas



Source: FAA AC 5300-13 – Figure 3-24



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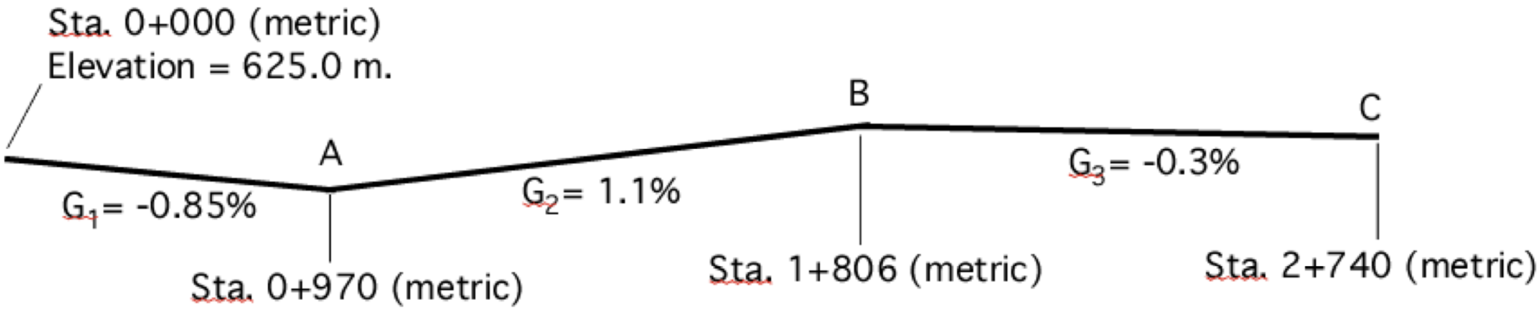
Example Problem

- You are conducting a study for an existing airport. The airport wants to handle air carrier operations with airlines flying the Canadair CRJ-700 aircraft (regional jet)

- Determine the suitability of the runway to conduct air carrier operations. If the runway is not suitable for carrier operations suggest modifications to do it

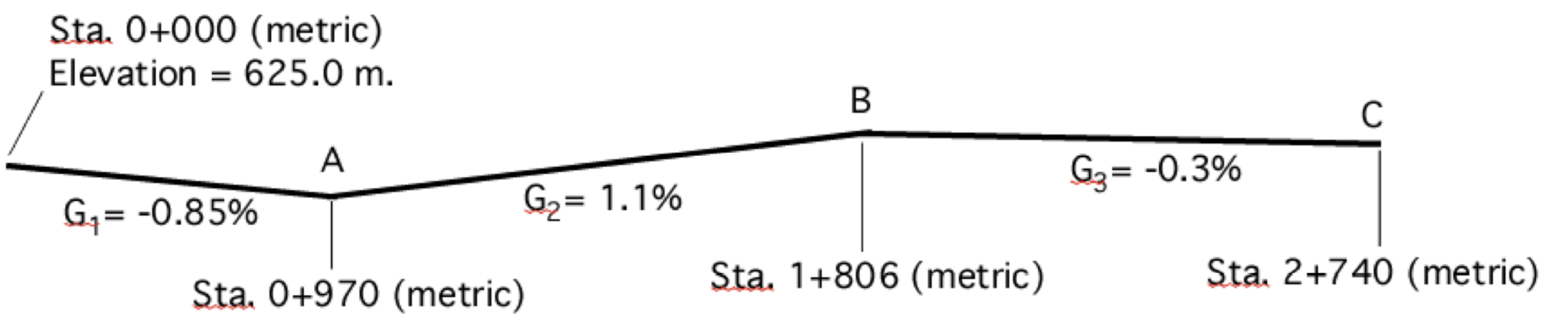


Example Problem: Solution (1)

- The Bombardier CRJ-700 is an interesting aircraft because is a boundary case between Approach speeds B and C. The aircraft has the following geometric characteristics:

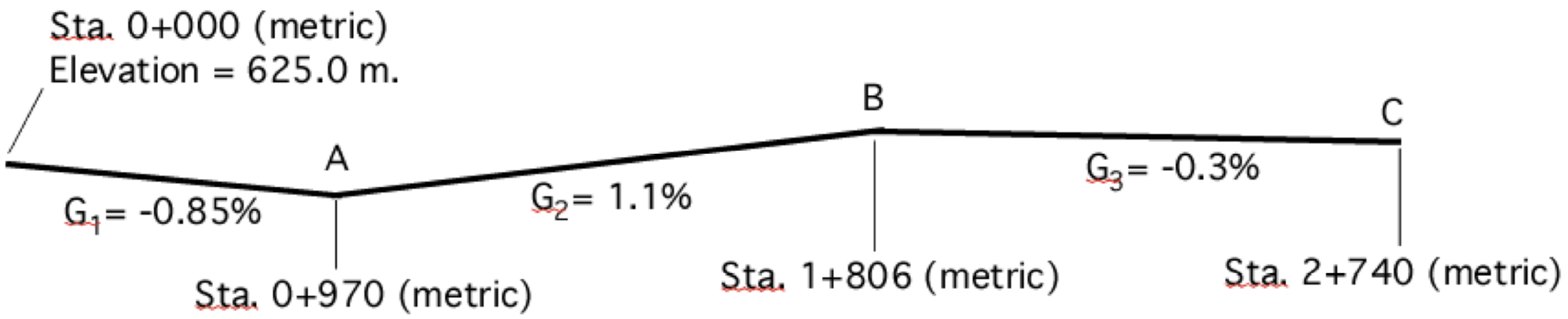
- Table 1. Bombardier CRJ-700 Information (source: Bombardier Aircraft).

External:		
Length overall	106 ft 8 in	32.51 m
Wingspan	76 ft 3 in	23.24 m
Wing area (net)	760 ft^2	70.61 m^2



- The maximum grade allowed is 1.5%. The runway satisfies this criteria.
- The maximum grade change is 1.5%. This criterion is violated at point A.
- The required 0.8% grade for the first ¼ of the runway is not met by the runway.
- The transitional curve lengths are 1,985 feet for point A and 1,400 for point B

Example Problem



- Design the two transition curves at points A and B in the vertical profile shown in the figure. Find the curve length and the elevation of the points on the transition curve at points A and B.

Sample Matlab Code

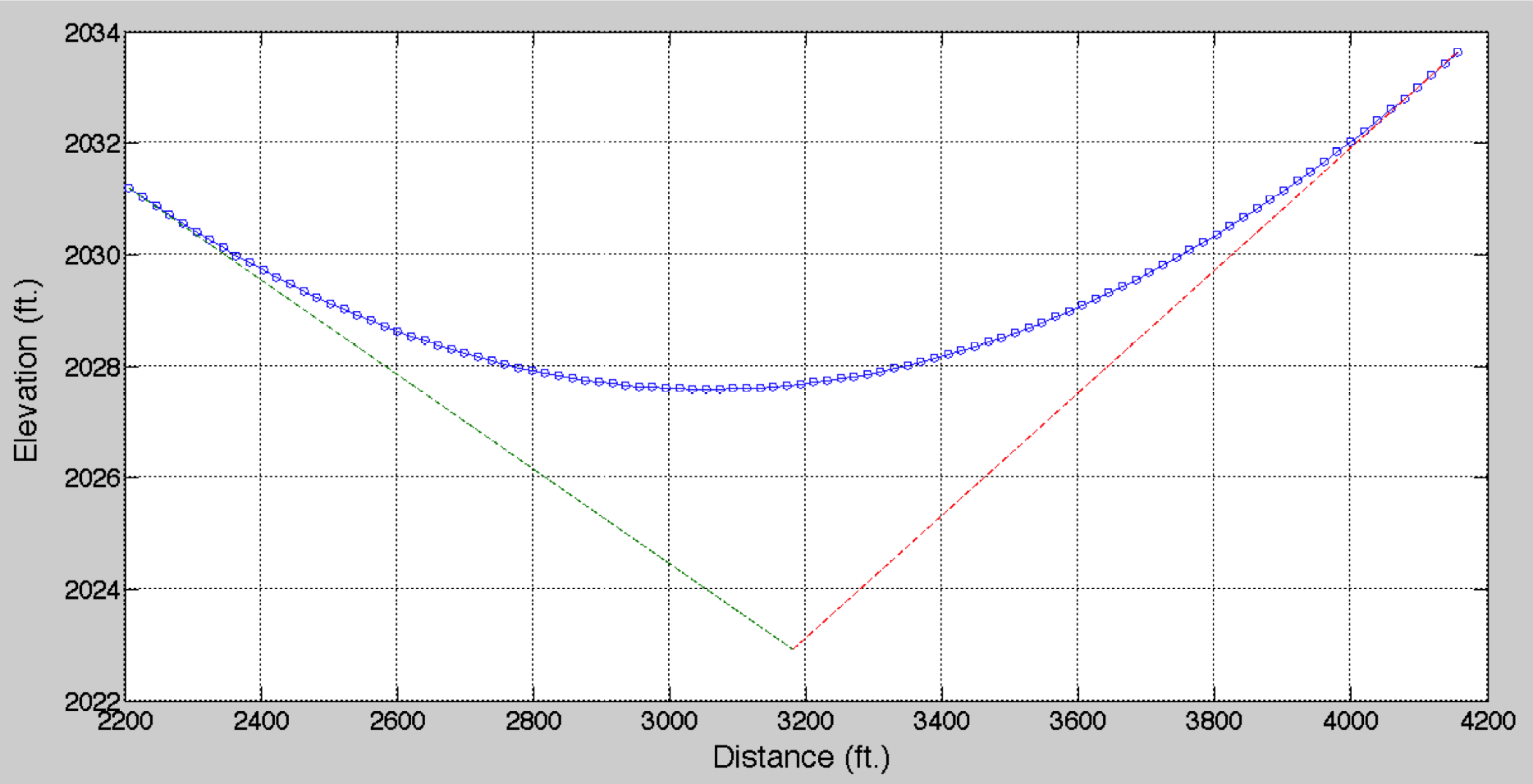
- The equation of a symmetric parabola used as transition curve is given by the following Matlab equations:

```
% G1 = grade of first tangent (%)

% G2 = grade of second tangent (%)

% L = length of transition curve (feet)

% x = station along the horizontal axis defining the transition curve
```

Vertical Curve Solution for Point A

- The transition curve with point of intersection at A (1950 feet long) is shown below
- The Point of Intersection (PI) (point A is located 2207 feet from the runway threshold)
- This is obtained as 970 meters (3182 feet) minus half of the curve length (1950 feet)
- The elevation of the curve is 2050 feet minus the drop in runway elevation between the runway threshold and the point of the curve (0.85/100 * 2207 feet)
- The elevation of the Point of the Vertical Curve is 2031.2 feet.

Vertical Curve Solution

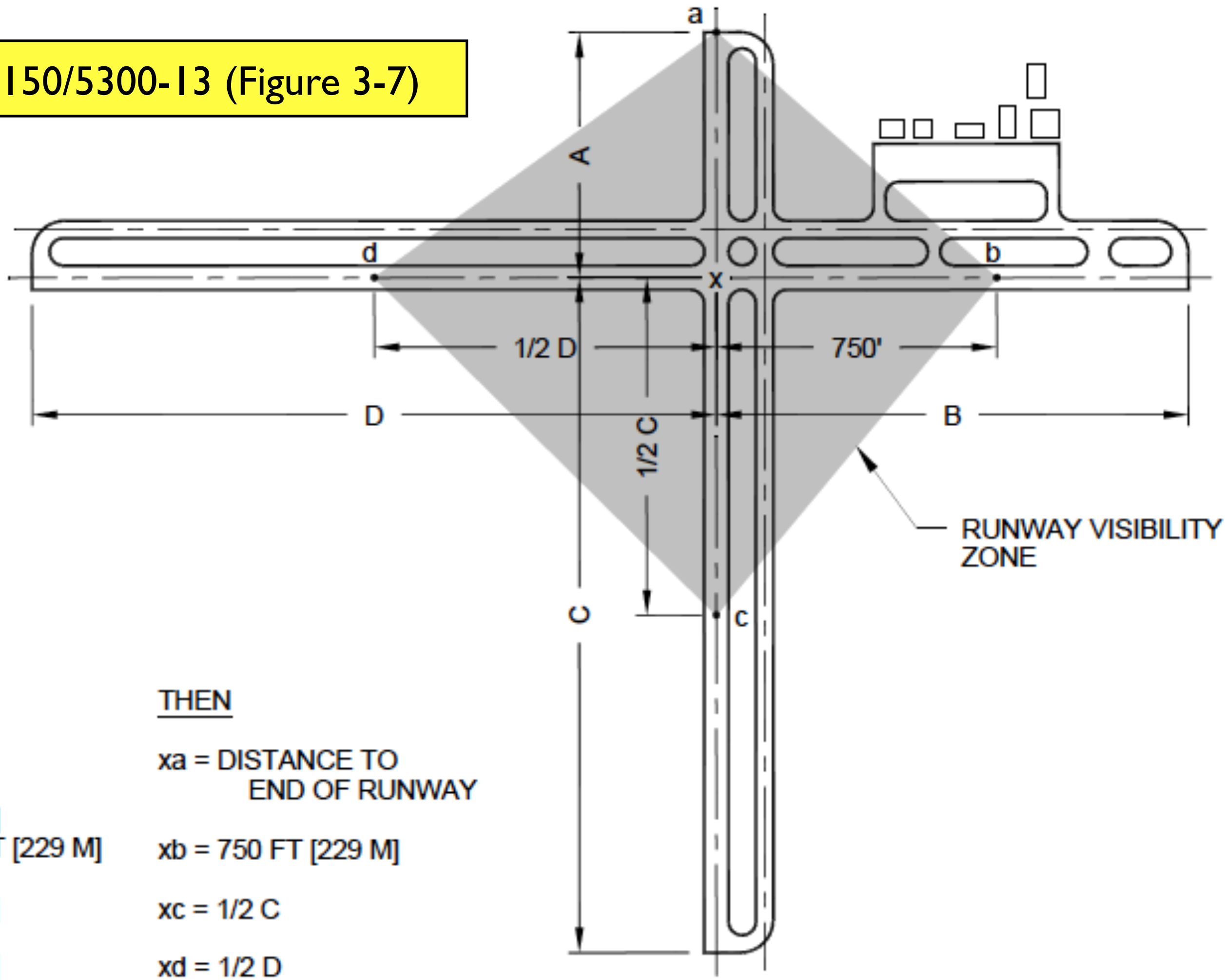


Line of Sight Standards (Paragraph 418 in FAA AC 150/5300-13)

- Along runways
  - Two points 5 feet above the runway should be mutually visible for the entire runway
- Between intersecting runways
  - Two points 5 feet above the runway should be mutually visible inside the runway visibility zone (polygon)
  - Three distance rules are used in the creation of the visibility zone: 1) < 750 feet, 2) 750-1500 feet and 3) >1500 feet
  - See diagram (next slide taken from FAA AC 5300-13)

Runway Visibility Requirements

source: FAA AC 150/5300-13 (Figure 3-7)



WHEN	THEN
A ≤ 750 FT [229 M]	xa = DISTANCE TO END OF RUNWAY
B < 1500 FT [457 M] BUT > 750 FT [229 M]	xb = 750 FT [229 M]
C ≥ 1500 FT [457 M]	xc = 1/2 C
D ≥ 1500 FT [457 M]	xd = 1/2 D

Runway Visibility Polygon (LGA)