Assignment 7: Airport Geometric Design Standards

Date Due: October 27, 2021
Instructor: Trani

Problem 1

a) A new airport is designed with two satellite terminal buildings as shown in Figure 1. The buildings are designed to accommodate aircraft up to the size of an Airbus A350-900. Find the dimensions A through R in Figure 1. Make sure that your design allows pilots entering the gate position to maneuver with steering angles no more than 50 degrees. Assume the service roads have 12-foot wide lanes.

Airbus A350-900 wingspan=212.42 feet length=219.16 feet
AAC: C ADG: V TDG: 5

Note that the concourse A has a dual service road as well. All the dimensions are rounded to the nearest integer.

B=25 feet
D=245 feet (Taxilane centerline to parallel taxilane centerline)
E=138 feet (Taxilane Centerline to Fixed or Movable Object)

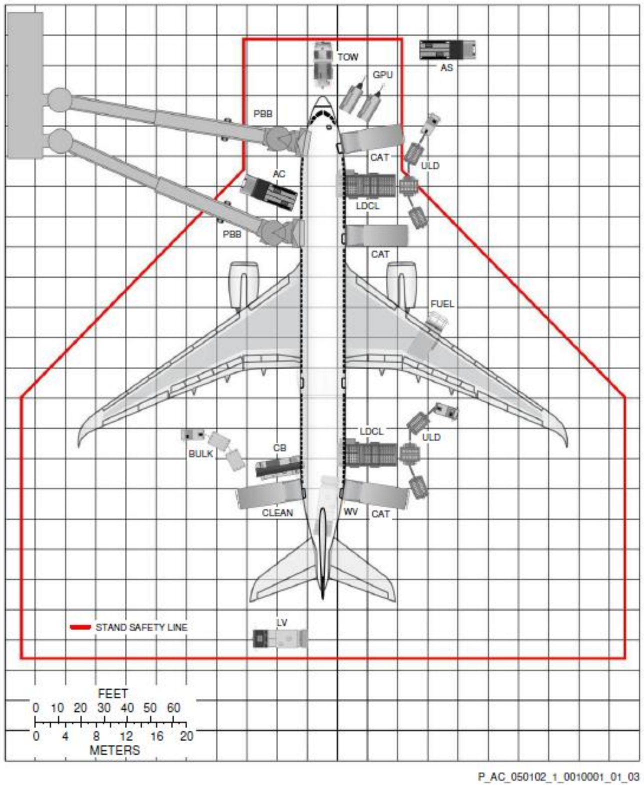
G=2*12=24 feet
H=G+E-0.5*wingspan=56 feet
C=3*4=12 meters=40 feet (see the following picture)
F=C+length=259 feet
A=2*(F+G+E)+D=1087 feet

If we consider the dimension of a two-parallel taxilane design, dimension for D and E can be calculated by the following equation:

D=1.1*wingspan+10=243.662 feet

2*E+D=2.3*wingspan+30=518.566 feet
E=137.452 feet

Note that they are close to what we calculated above.



Typical Ramp Layout (Gate)
FIGURE-5-1-2-991-001-A01

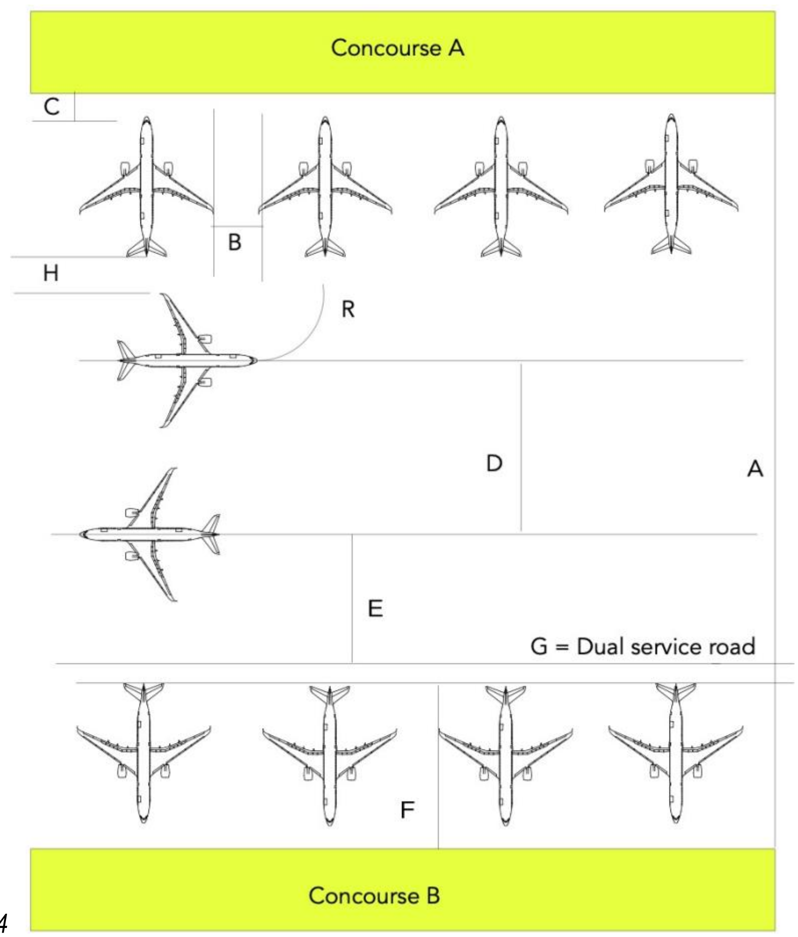


Figure 1. New Terminal Buildings for a Proposed Airport.

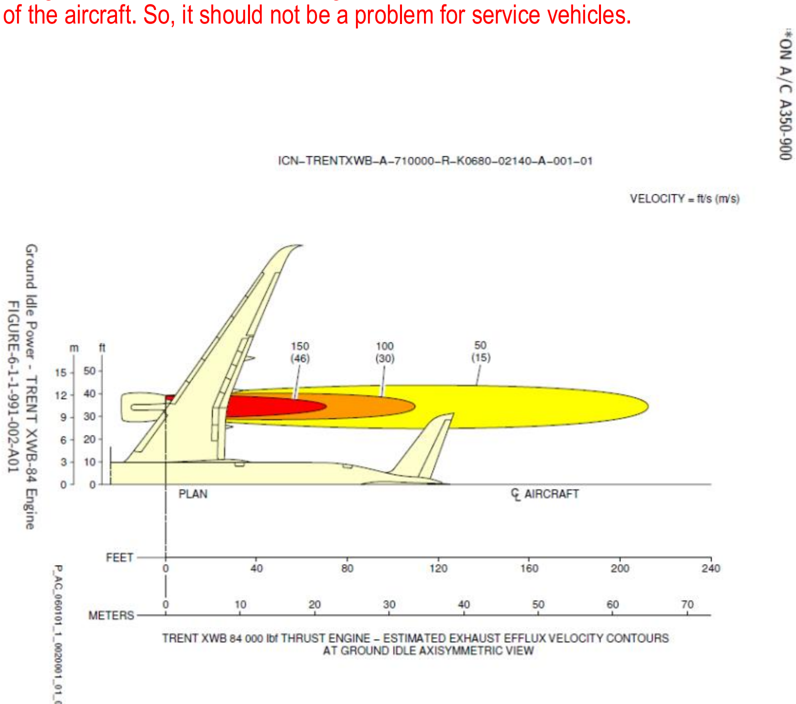
b) Estimate the steering angle and wingtip radius of the Airbus A350-900 for the radius R proposed in your solution. Consult the Airbus A350-900 airport design document.

Given that the steering angles should be no more than 50 degrees, the radius R should be greater than 127 feet. Considering the safety margin, the radius R can be 151 feet with a steering angle of 40 degrees.

A350–900 TURNING RADII									
TYPE OF TURN	STEERING ANGLE (deg)	EFFECTIVE STEERING ANGLE (deg)		R1 RMLG	R2 LMLG	R3 NLG	R4 WING	R5 NOSE	R6 TAIL
2	20	19.6	m	76.3	86.9	86.0	113.6	87.1	96.0
			ft	250	285	282	373	286	315
2	25	24.5	m	58.7	69.3	69.6	96.2	71.2	79.7
			ft	193	227	228	316	233	262
2	30	29.4	m	46.7	57.3	58.9	84.3	60.8	69.0
			ft	153	188	193	277	199	226
2	35	34.2	m	38.0	48.6	51.5	75.7	53.7	61.5
			ft	125	159	169	248	176	202
2	40	39.1	m	31.1	41.7	45.9	68.9	48.5	55.9
			ft	102	137	151	226	159	183
2	45	43.8	m	25.7	36.3	41.8	63.7	44.7	51.7
			ft	84	119	137	209	147	170
2	50	48.6	m	21.1	31.7	38.6	59.2	41.8	48.3
			ft	69	104	127	194	137	158
2	55	53.1	m	17.4	28.0	36.2	55.5	39.6	45.7
			ft	57	92	119	182	130	150
2	60	57.5	m	14.1	24.7	34.3	52.4	38.0	43.5
			ft	46	81	113	172	125	143
2	65	61.5	m	11.4	22.0	32.9	49.8	36.7	41.9
			ft	37	72	108	163	121	137
2	70	65.0	m	9.2	19.8	31.9	47.7	35.9	40.6
			ft	30	65	105	156	118	133
2	72 (MAX)	66.1	m	8.5	19.1	31.6	47.0	35.6	40.2
			ft	28	63	104	154	117	132

c) Estimate the size (length) of the 100 feet/second engine exhaust contours for the Airbus A350-900 assuming that the pilot applies engine breakaway power (11% maximum thrust) while parking the aircraft nose-in towards the terminal building. The engine exhaust contours are included in the Airport Planning and Design aircraft documents (see Section 6). Will the 100 ft/s contours pose a problem for service vehicles moving on the opposite size of the dual taxi lane configuration?

The length of the 100 feet/second engine exhaust contours for the Airbus A350-900110 is 110 feet. That length will not exceed the tail of the aircraft. So, it should not be a problem for service vehicles.



Problem 2

The same international airport described in Problem 1 will have a 120 degree taxiway-taxiway connector (see Figure 2). Specify the dimensions of the complete 120-degree taxiway connector. Draw your solution in the CAD application of your choice.

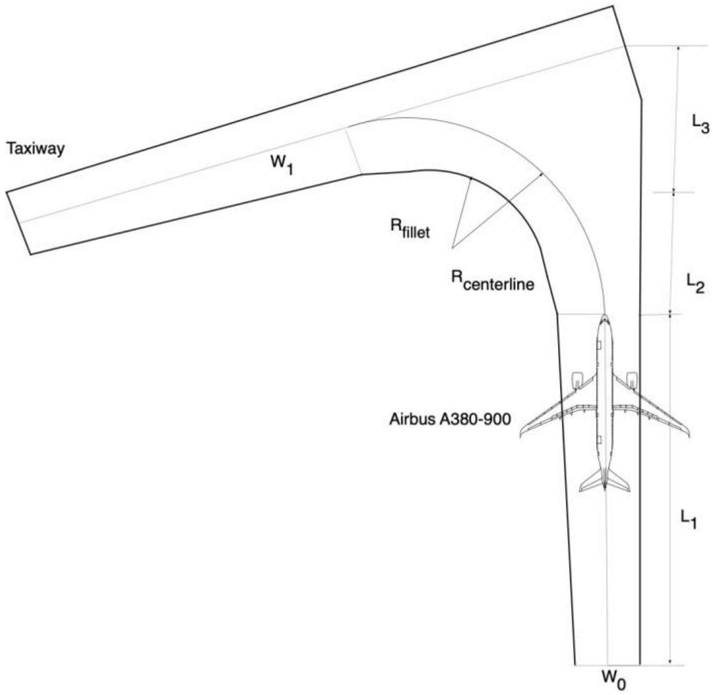
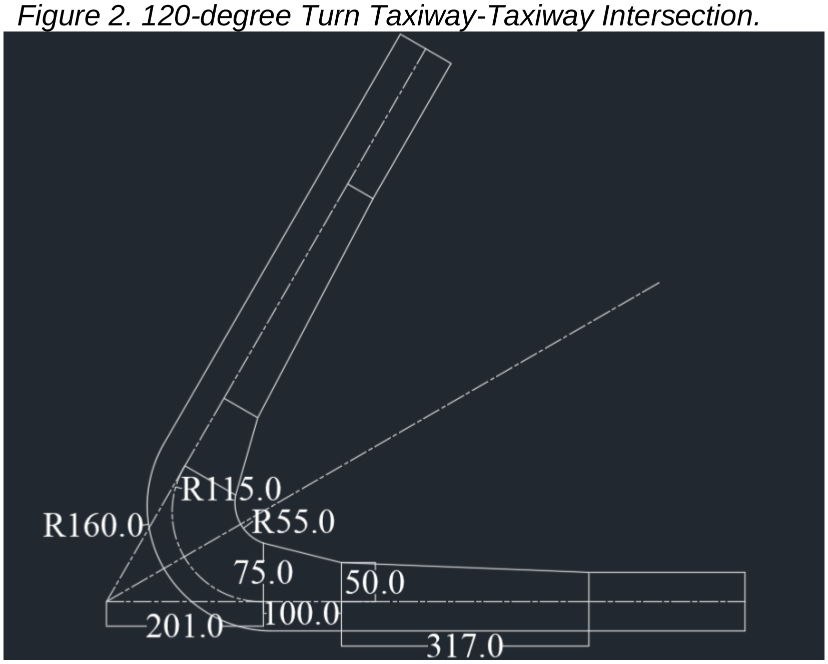


Figure 2. 120-degree Turn Taxiway-Taxiway Intersection.



Problem 3

Use the FAA/Virginia Tech Landing Events Database to answer the following questions.

a) Find the median (50%) arrival threshold ground speed for Boeing 737-800 landing IAD airport runway 1R. Is the reported speed consistent with the approach speeds reported in the FAA AC 150/5300-13a? Comment.

Landing Events Database - [IAD - Speed Analysis]

ANC
ATL
BDL

Runway: 01R | Exit: | Carrier | Location: Threshold Crossing | Median | 1/ 1/2020 to 1/ 1/2021 | Query

By Aircraft | Distribution | Profiles

Aircraft	Arrivals	Min Speed (kts)	25 Percentile Speed (kts)	Median Speed (kts)
B738	876	118.3	138.3	143.8

arrival threshold ground speed =143.8 kts (01/01/2020-01/01/2021)
the approach speeds reported in the FAA AC 150/5300-13a is 142 kts.
It is consistent

b) Find the median (50%) speed at the Point of Curvature (i.s., start of the turn) for Boeing 737-800 landing at IAD airport runway 1R and using high-speed exit K4.

Landing Events Database - [IAD - Speed Analysis]

ANC
ATL

Runway: 01R | Exit: K4 | Carrier | Location: Point Of Curvature | Median | 1/ 1/2020 to 1/ 1/2021 | Query

B738	248	24.9	42.6	48.7	55.9

48.7 knots

c) Find the median (50%) speed at the Point of Curvature (i.s., start of the turn) for Boeing 737-800 landing at DCA airport runway 19 and using right-angle exit F.
24.4 knots

d) Compare the median speeds of parts (b) and (c). Are the exit speeds different? Comment.
High-speed exits have exit speeds twice as fast as those of right-angle exits.

Problem 4

The purpose of this analysis is to locate **two high-speed exits** for a 2800 meter-long runway at an airport with a fleet mix shown in Table 1. The critical aircraft is a Boeing 737-800. The runway designed to be 2,800 meters long. Use the Three-Point Method Matlab computer program provided in class (http://128.173.204.63/courses/cee4674/cee4674_pub/ThreePointMethod_stochastic.m). In your design consider the typical operational exit speeds recommended in class. In your design, select the runway locations to accommodate 85% of the landings simulated. The data shown in Table 1 has been collected by Virginia Tech Air Transportation Lab at several airports in the country.

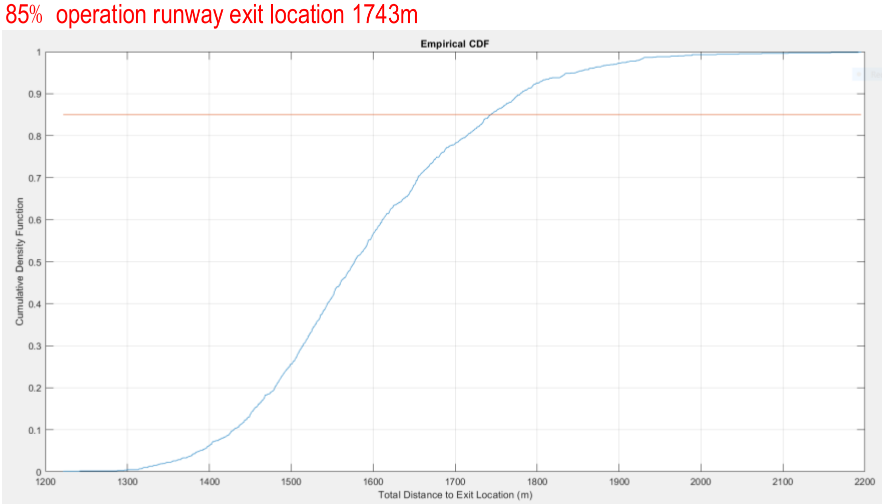
Table 1. Estimated Aircraft Landing Roll Characteristics for Runway Exit Design.

Aircraft	Landing Technical Characteristics
Boeing 737-800 	Mean approach speed = 142 knots Approach speed std deviation = 3.0 knots Free roll time = 2.0 seconds Mean touchdown distance = 545 m Std. Dev. Touchdown distance = 65 m Mean braking rate = -2.05 m/s-s Std. Dev. braking rate = 0.25 m/s-s Transition segment deceleration = 0.35 m/s-s
Cessna 750 	Mean approach speed = 129 knots Approach speed std deviation = 2.4 knots Free roll time = 2.0 seconds Mean touchdown distance = 520 m Std. Dev. Touchdown distance = 55 m Mean braking rate = -1.95 m/s-s Std. Dev. braking rate = 0.25 m/s-s Transition segment deceleration = 0.4 m/s-s
Bombardier Q400 	Mean approach speed = 115 knots Approach speed std deviation = 2.3 knots Free roll time = 2.0 seconds Mean touchdown distance = 428 m Std. Dev. Touchdown distance = 53 m Mean braking rate = -1.72 m/s-s Std. Dev. braking rate = 0.25 m/s-s Transition segment deceleration = 0.4 m/s-s

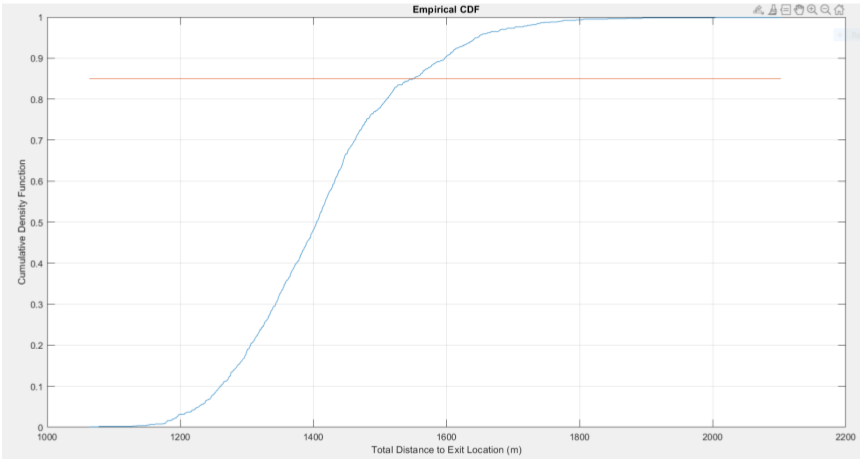
a) Plot the Three Cumulative Exit Distance curves (one for each aircraft) and clearly state the selected runway exit locations (i.e., the distance from the runway threshold to the point of curvature of each runway exit).

Note that this is a stochastic model. The exit location varies from person to person.

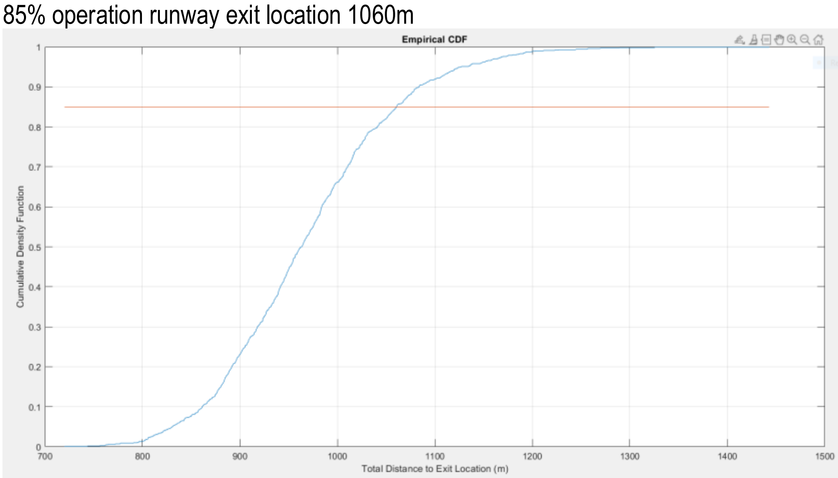
Boeing 737-800
85% operation runway exit location 1743m



Cessna 750
85% operation runway exit location 1549m



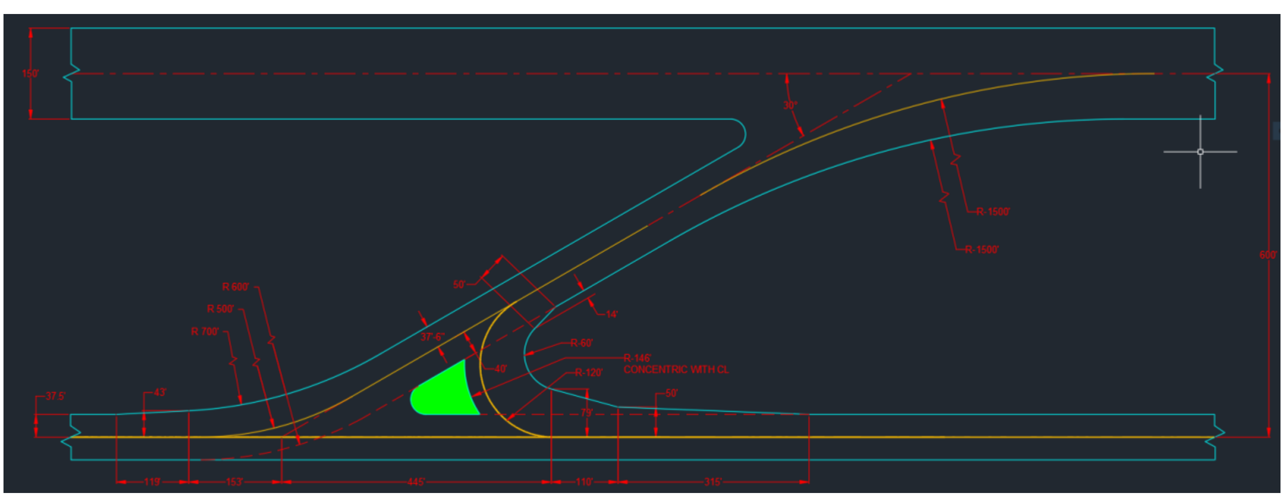
Bombardier Q400
85% operation runway exit location 1060m



Note that 85% of the operations runway exit location for Boeing 737-800 and the Cessna 750 are close. So, the two high-speed exits locations should be 1743m and 1060m to serve all three aircraft groups.

b) Use the FAA airport design templates and draw the high-speed runway exit geometry assuming the runway-taxiway centerline distance is 600 feet. State the Taxiway Design Group used in the analysis.

Taxiway Design Group is 5. The following figure sources from https://www.faa.gov/airports/engineering/airport_design/



c) Tell me the percent of Boeing 737-800 aircraft that could take the first and the second high-speed exits selected.
   The first exit: 0%
   The second exit: 85%
   Note that the remaining 15% would use the exit at the end of runway.

Bonus Point (3 points of 20 total in homework). Draw the runway taxiway entrance taxiway for the problem.