Assignment 6: Obstruction Analysis and Wind Rose Analysis

Solution Set

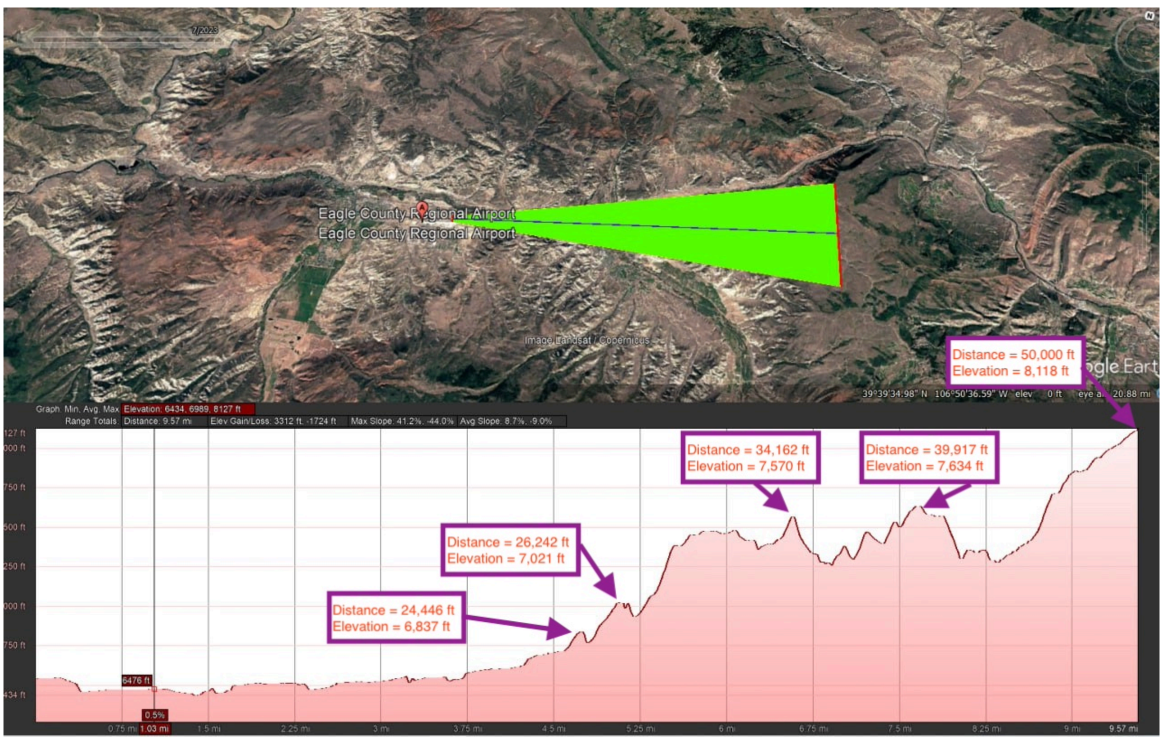
Instructor: Trani

Problem #1

Use the Elevation Profile function in Google Earth to check for obstructions to navigation on the approach to runway 25 at Eagle County Airport (EGE).

a) As demonstrated in class, create a straight path from the runway 25 threshold (to the Northwest). For a precision runway, define the path segment that spans the complete approach surface. For this analysis, ensure the path segment created is aligned with the runway centerline (see Figure 1). **Note: Distances reported by Google Earth in the elevation profiles are in statute miles.**

b) Create an elevation profile using the Google Earth tool and identify the “peaks” of the elevation profile that span the complete approach surface for a precision runway.



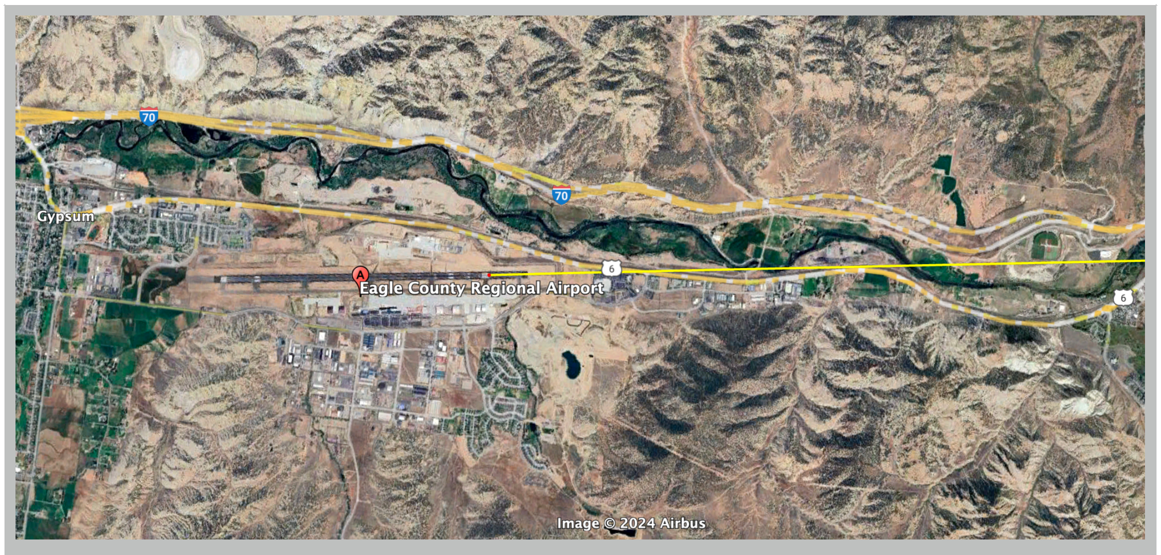


Figure 1. Sample Image in Google Earth Showing Runway 25 Threshold at Eagle County Airport (EGE).

c) Estimate if the “peaks” identified in part (b) constitute natural obstacles to navigation for a **precision runway**. You only need to check the peaks identified in your elevation plot. Use the FAR Part 77 standard to do the analysis.

d) Estimate if the “peaks” identified constitute natural obstacles to navigation for the **precision runway (runway 25)**. You only need to check the peaks identified in your elevation plot. Show your calculations and the slopes required in the approach surface.

Comment: The Runway 25 threshold elevation is 6,545 ft from mean sea level.

Peak point 1:

Peak point elevation = 6,837 ft - 6,545 ft = 292 ft

Distance from the end of the inner approach surface = 24,446 ft

Elevation at the end of the outer approach surface = 10,000 ft / 50 = 200 ft

The peak point is located at the outer approach surface.

Elevation of the approach surface at the peak point = ((24,446 ft- 10,000 ft) ft / 40) + 200 ft = 561 ft

Therefore, peak point 1 is not an obstacle to navigation.

Peak point 2:

Peak point elevation = 7,021 ft - 6,545 ft = 476 ft

Distance from the end of the inner approach surface = 26,242 ft

Elevation at the end of the outer approach surface = 10,000 ft / 50 = 200 ft

The peak point is located at the outer approach surface.

Elevation of the approach surface at the peak point = ((26,242 ft- 10,000 ft) ft / 40) + 200 ft = 606 ft

Therefore, peak point 2 is not an obstacle to navigation.

Peak point 3:

Peak point elevation = 7,570 ft - 6,545 ft = 1,025 ft

Distance from the end of the inner approach surface = 34,162 ft

Elevation at the end of the outer approach surface = 10,000 ft / 50 = 200 ft

The peak point is located at the outer approach surface.

Elevation of the approach surface at the peak point = ((34,162 ft - 10,000 ft) ft / 40) + 200 ft = 804 ft

Therefore, peak point 3 is an obstacle to navigation.

Peak point 4:

Peak point elevation = 7,634 ft - 6,545 ft = 1,089 ft

Distance from the end of the inner approach surface = 39,917 ft

Elevation at the end of the outer approach surface = 10,000 ft / 50 = 200 ft

The peak point is located at the outer approach surface.

Elevation of the approach surface at the peak point = ((39,917 ft - 10,000 ft) ft / 40) + 200 ft = 948 ft

Therefore, peak point 4 is an obstacle to navigation.

Peak point 5:

Peak point elevation = 8,118 ft - 6,545 ft = 1,573 ft

Distance from the end of the inner approach surface = 50,000 ft

Elevation at the end of the outer approach surface = 10,000 ft / 50 = 200 ft

The peak point is located at the outer approach surface.

Elevation of the approach surface at the peak point = ((50,000 ft - 10,000 ft) ft / 40) + 200 ft = 1,200 ft

Therefore, peak point 5 is an obstacle to navigation.

e) Using the calculations and your analysis of parts (c-d) to explain the possible reason for a displaced threshold on runway 25.

- Since peak points 3, 4, and 5 are obstacles to navigation, a displaced threshold may have been implemented on runway 25 to provide greater clearance between the approaching aircraft and the terrain. By shifting the landing point on the runway, the displaced threshold improves safety margins over these obstacles during the final approach, ensuring that pilots can safely fly over them. However, the main drawback of a displaced threshold is the reduced usable landing distance for aircraft (LDA).

f) Explain how you would use terrain information to check for obstacles to navigation for the complete approach surface polygon (not just the extended centerline).

- To check for obstacles to navigation across the entire approach surface polygon, not just the extended centerline, terrain information can be analyzed using geographic information system (GIS) tools such as ArcGIS. In ArcGIS, first, we can define the approach surface polygon. Then, using software like ArcGIS we can quickly provide elevation of the terrain peak points and illustrate if they pierce the approach surface polygon.

Problem #2

A new 9400-foot precision runway will be constructed at a new airport (see Figure 2).

a) Use the CAD program of your choice to construct the top view of the five imaginary surfaces. Provide the dimensions of each surface.

b) Study three objects shown in Figure 2 to see if the objects violate any imaginary surface. State the FAR Part 77 imaginary surface applicable to each object.

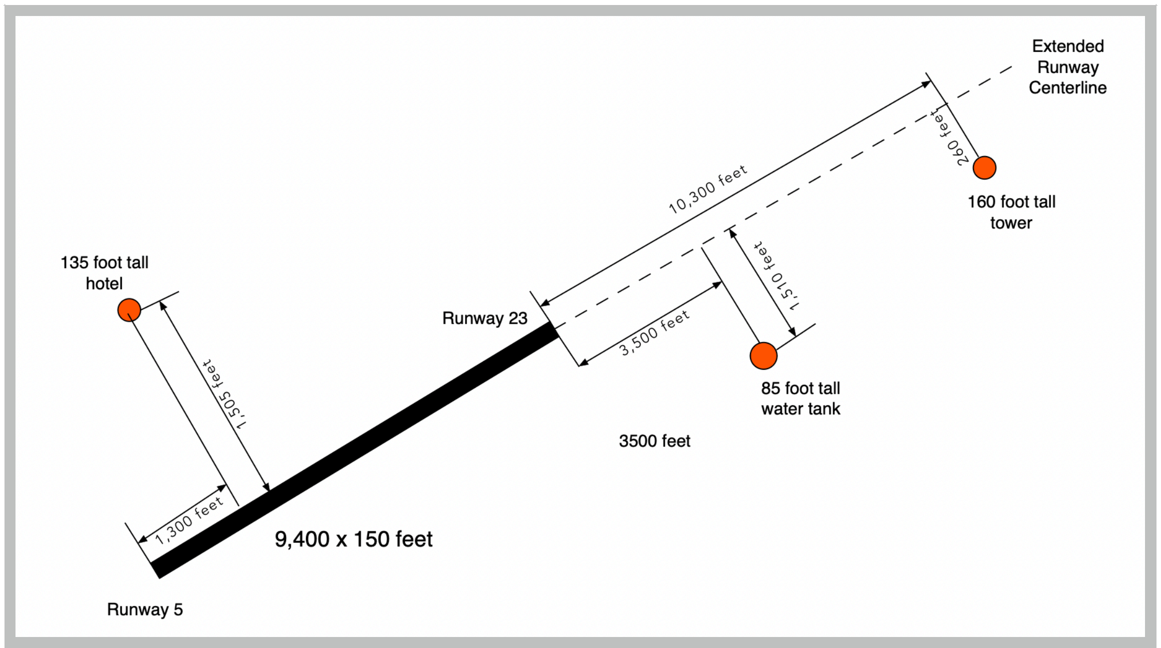


Figure 2. Objects Identified Near a Proposed New Runway. Drawing not to Scale.

Assumptions:

The airplanes approach and land on runway 23.

The reference point (0,0) is on the runway 23 threshold.

- 135 feet tall hotel analysis:

Distance between the hotel and the edge of the primary surface = 1,505 ft + 150/2 ft - 500 ft = 1,380 ft

Distance from the edge of the horizontal surface and the edge of the primary surface

150 ft (horizontal surface elevation) * 7 (transitional surface slope) = 1,050 ft

Therefore, the horizontal surface is applicable.

Horizontal surface elevation at the point of interest = 150 ft is greater than 135 ft (hotel height). Therefore, the hotel is not an obstacle to navigation.

- 85 feet tall water tank analysis:

Distance between the water tank and the edge of the primary surface = 1,510 ft - 500 ft = 1,010 ft

First, we need to determine if the water tank is covered by the approach surface or not:

Coordinates of the two points associated with the bottom side of the approach surface are: (200, -500) (50,200, -8,000)

Therefore its line equation is:

$y=-0.15x-470$

Therefore, the water tank with coordinates (3,500, -1,510) is located below the bottom side of the approach surface (outside the approach surface)

Distance from the edge of the horizontal surface and the edge of the primary surface

150 ft (horizontal surface elevation) * 7 (transitional surface slope) = 1,050 ft

1,010 ft is less than 1,050 ft. Therefore, the water tank is located within the transitional surface.

1,010 ft / 7 = 144.3 ft

Transitional surface elevation at water tank location = 1,010 ft / 7 = 144.3 ft that is greater than 85 ft (water tank height). Therefore, the water tank is not an obstacle to navigation.

- 160 feet tall tower analysis:

First, we need to determine if the tower is covered by the approach surface or not:

The coordinates of the two points associated with the bottom side of the approach surface are: (200, -500) (50,200, -8,000)

Therefore, its line equation is:

$y=-0.15x-470$

Therefore, the tower with coordinates (10,300, -260) is located above the bottom side of the approach surface (inside the approach surface)

The elevation of the inner approach surface at 10,000 far away from the edge of the primary surface = the elevation of the horizontal surface = 150 ft

Distance of tower from the edge of the primary surface = 10,300 ft - 200 ft = 10,100 ft

Therefore, the tower is located inside the transitional surface between the inner and outer approach surfaces.

The elevation of the transitional surface at the tower location = 150 ft + 100 ft / 7 = 150 ft + 14.3 ft = 164.3 ft

164.3 ft is greater than 160 ft (tower height). Therefore, the tower is not an obstacle to navigation.

c) Find if the 160-foot tall tower structure violates the Precision Approach and Departure Surfaces defined in the FAA AC 150/5300-13B (called Surfaces 5, 6, and 7 in the advisory circular) for precision runways.

Precision departure from the runway 05:

Assumption: there is no clearway at the departure end of runway 05.

Length of extended departure surface = 12,152 ft

Distance of tower from the runway 05 departure end = 10,300 ft

Therefore, the runway 05 extended departure surface is applicable.

Extended departure surface slope = 40:1

Elevation of the extended departure surface at the tower location = 10,300 ft / 40 = 257.5 ft

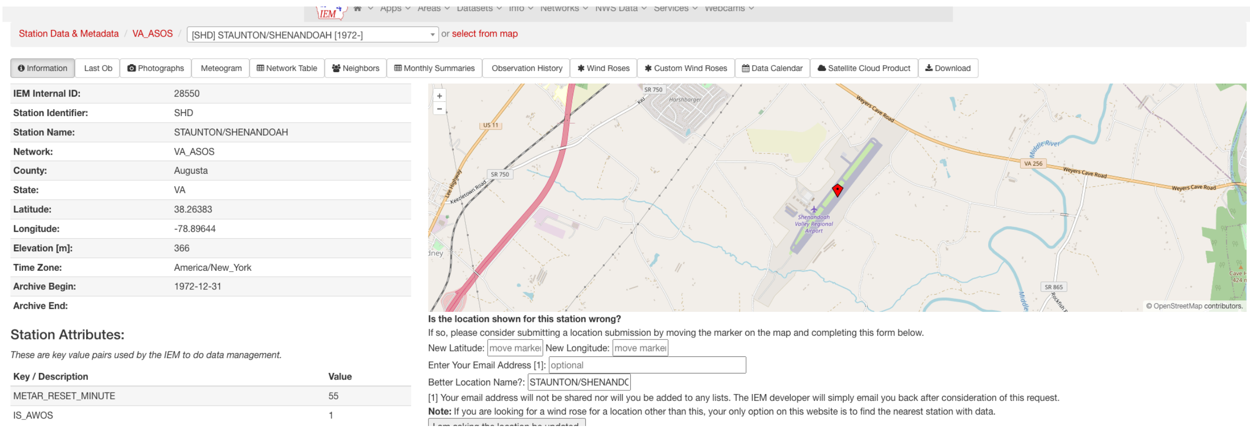
Tower height = 160 ft

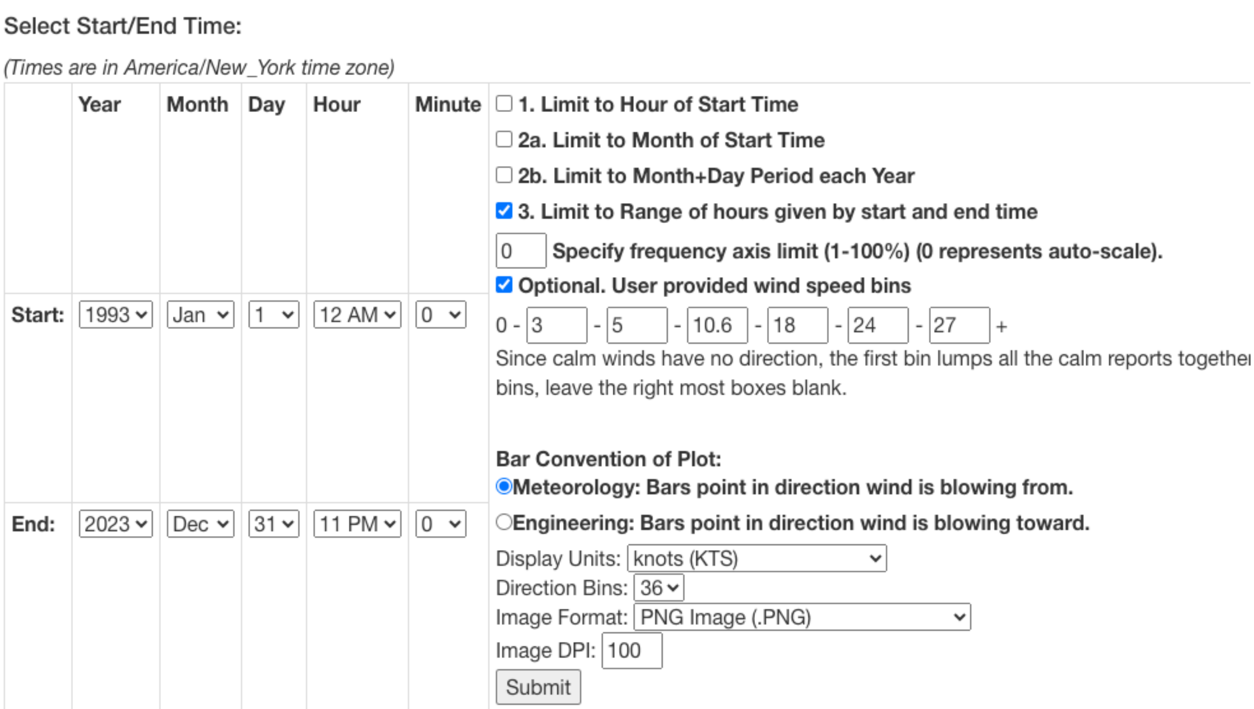
Therefore, the tower is not a violation for the departure operations from runway 05.

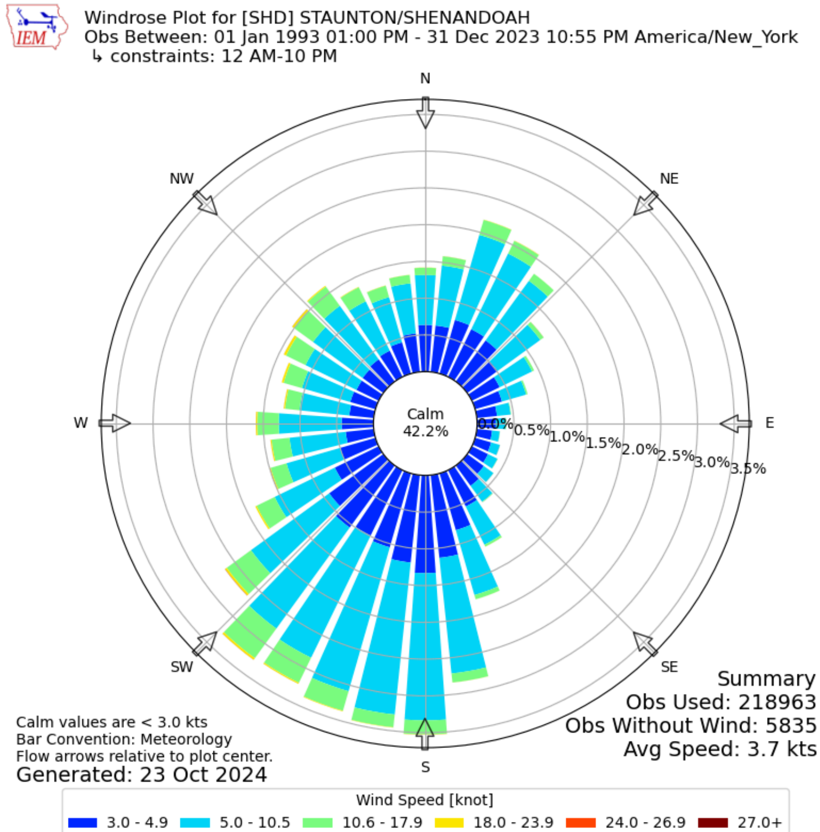
Problem #3

Use the Iowa State Mesonet model data to construct a Wind Rose for Staunton/Shenandoah Airport (SHD). Specifically, wind data for the airport (SHD) will be collected using the Automated Surface Observing Systems (ASOS) for Shenandoah, as demonstrated in class.

(a) Collect the data and **create a custom wind rose that contains 36 direction bins** and the following wind speeds (knots). Find the predominant orientation of the wind.







Comment: the predominant orientation of the wind is from south/southwest towards north/northeast.

(b) Find the percent of the time the **wind speed exceeds 18 knots** at SHD (from all azimuth directions).

Comment: the percent of the time the wind speed exceeds 18 knots at SHD is 0.3%.

Direction	Calm	3.0 4.9	5.0 10.5	10.6 17.9	18.0 23.9	24.0 26.9	27.0+	
355-004	42.21	0.636	0.679	0.099	0.002	0	0	
005-014		0.635	0.82	0.128	0.001	0	0	
015-024		0.76	1.204	0.213	0.004	0	0	
025-034		0.722	1.145	0.191	0.004	0	0	
035-044		0.693	1.002	0.118	0	0	0	
045-054		0.511	0.718	0.055	0.001	0	0	
055-064		0.421	0.49	0.031	0	0	0	
065-074		0.381	0.343	0.021	0	0	0	
075-084		0.276	0.186	0.007	0	0	0	
085-094		0.256	0.134	0.008	0	0	0	
095-104		0.209	0.105	0.003	0	0	0	
105-114		0.228	0.123	0.001	0	0	0.001	
115-124		0.245	0.143	0.003	0	0	0	
125-134		0.28	0.161	0.002	0	0	0	
135-144		0.343	0.267	0.008	0	0	0	
145-154		0.551	0.578	0.029	0.001	0	0	
155-164		0.804	0.918	0.06	0.001	0	0	
165-174		1.132	1.583	0.123	0.001	0	0	
175-184		1.33	2.002	0.191	0.004	0	0	
185-194		1.196	2.079	0.175	0.004	0	0	
195-204		1.047	2.037	0.277	0.008	0	0	
205-214		0.991	1.849	0.379	0.016	0	0	
215-224		1.044	1.699	0.498	0.027	0	0.001	
225-234		0.911	1.316	0.408	0.028	0.002	0.002	
235-244		0.665	0.91	0.274	0.019	0	0	
245-254		0.498	0.762	0.224	0.016	0	0	
255-264		0.383	0.769	0.246	0.014	0.001	0	
265-274		0.433	0.857	0.293	0.018	0.001	0	
275-284		0.334	0.682	0.198	0.016	0	0	
285-294		0.356	0.685	0.26	0.025	0	0	
295-304		0.337	0.771	0.296	0.032	0	0	
305-314		0.349	0.833	0.323	0.027	0	0.001	
315-324		0.374	0.9	0.322	0.014	0	0	
325-334		0.397	0.747	0.213	0.006	0	0	
335-344		0.443	0.64	0.162	0.003	0	0	
345-354		0.526	0.685	0.116	0.002	0	0	
					0.294	0.004	0.005	0.303

(c) Find the critical crosswind wind speed used in the wind rose analysis for the Embraer 145 (see Figure 4).

RDC: AAC-ADG

Embraer 145 RDC: C-II

Table B-1. Allowable Crosswind Component per Runway Design Code (RDC)

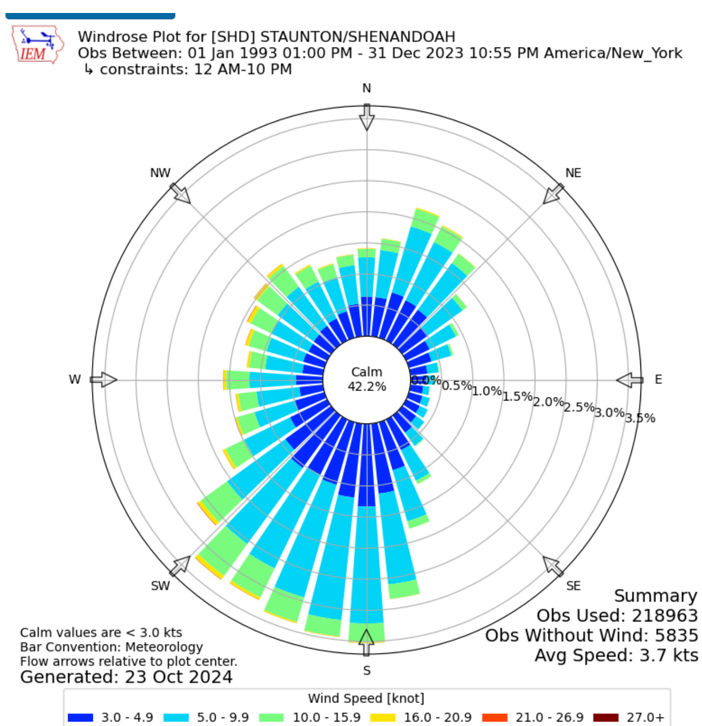
RDC	Allowable Crosswind Component
A-I and B-I *	10.5 knots
A-II and B-II	13 knots
A-III, B-III, C-I through D-III D-I through D-III	16 knots
A-IV and B-IV, C-IV through C-VI, D-IV through D-VI	20 knots
E-I through E-VI	20 knots

Note: * Includes A-I and B-I small aircraft.

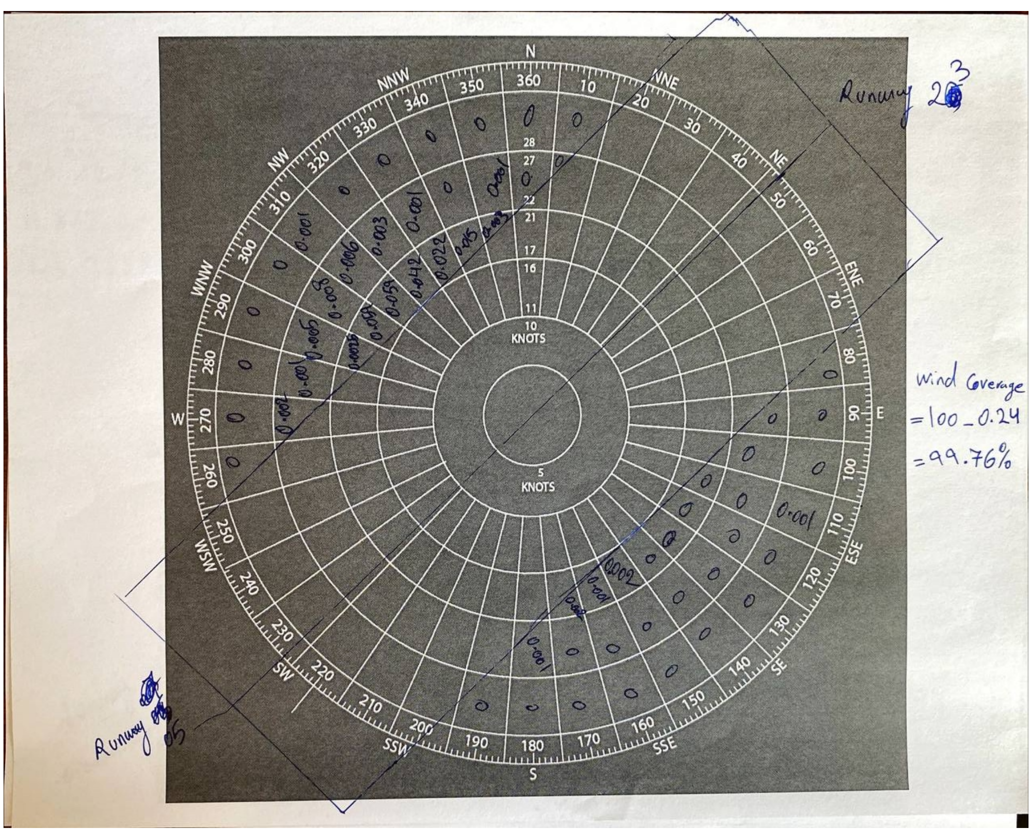
Comment: the maximum allowable crosswind for Embraer 145 is 16 knots.

(d) The critical aircraft is the Embraer 145 (Figure 4). Determine if the runway's **current orientation** satisfies the FAA criteria for crosswind coverage. Remember that ASOS stations report wind according to the **magnetic north**. Tell me the actual coverage of the runway (assuming both runway ends are used).

Note: Runway 5/23 magnetic headings are 047/227. (Reference: https://www.airnav.com/airport/KSHD)
Note: We changed the wind threshold in the Iowa State Mesonet model data to be consistent with the wind speed thresholds in the FAA-approved wind rose diagram as shown below.

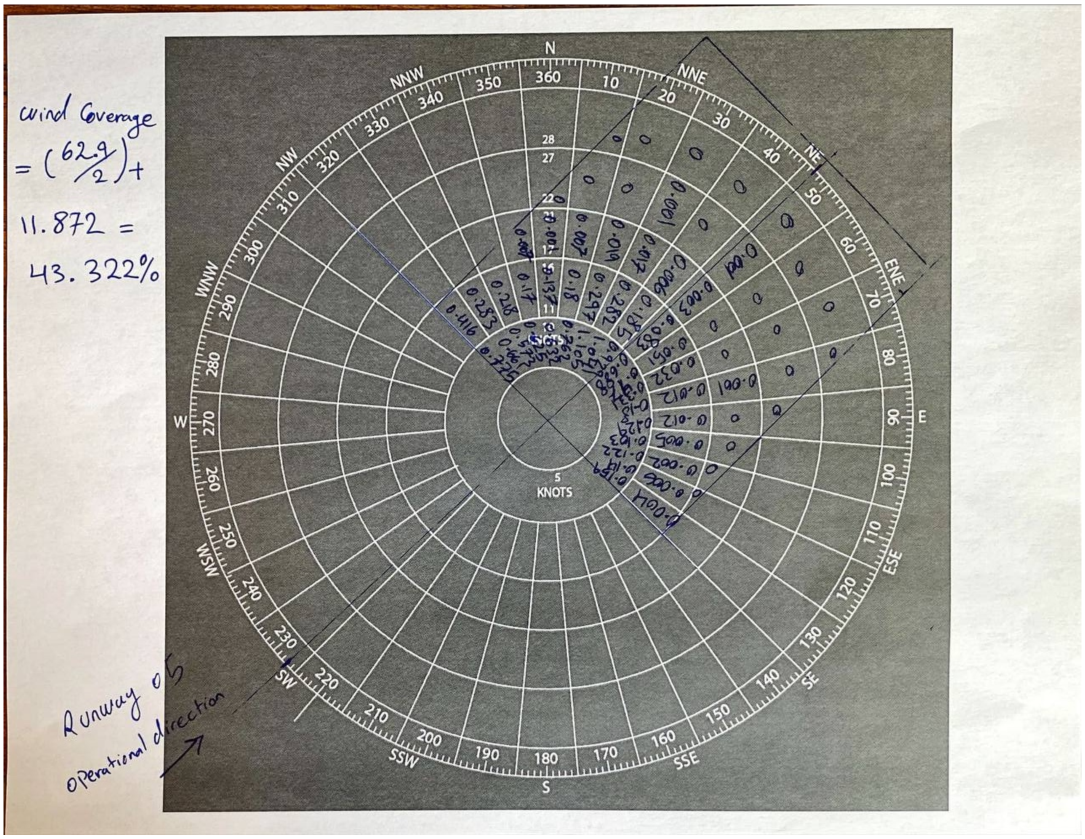


1	Direction	Calm	3.0 4.9	5.0 9.9	10.0 15.9	16.0 20.9	21.0 26.9	27.0+
2	355-004	42.21	0.636	0.632	0.137	0.01	0	0
3	005-014		0.635	0.762	0.18	0.007	0	0
4	015-024		0.76	1.105	0.297	0.019	0	0
5	025-034		0.722	1.041	0.282	0.017	0.001	0
6	035-044		0.693	0.929	0.185	0.006	0	0
7	045-054		0.511	0.688	0.083	0.003	0.001	0
8	055-064		0.421	0.47	0.051	0	0	0
9	065-074		0.381	0.331	0.032	0	0	0
10	075-084		0.276	0.18	0.012	0.001	0	0
11	085-094		0.256	0.129	0.012	0	0	0
12	095-104		0.209	0.103	0.005	0	0	0
13	105-114		0.228	0.122	0.002	0	0	0.001
14	115-124		0.245	0.14	0.006	0	0	0
15	125-134		0.28	0.159	0.004	0	0	0
16	135-144		0.343	0.261	0.015	0	0	0
17	145-154		0.551	0.548	0.059	0.002	0	0
18	155-164		0.804	0.855	0.122	0.001	0	0
19	165-174		1.132	1.47	0.233	0.003	0.001	0
20	175-184		1.33	1.881	0.305	0.011	0.001	0
21	185-194		1.196	1.982	0.266	0.009	0.001	0
22	195-204		1.047	1.889	0.41	0.022	0.001	0
23	205-214		0.991	1.676	0.52	0.044	0.004	0
24	215-224		1.044	1.512	0.634	0.073	0.006	0.001
25	225-234		0.911	1.157	0.523	0.067	0.007	0.002
26	235-244		0.665	0.822	0.333	0.046	0.003	0
27	245-254		0.498	0.671	0.29	0.038	0.004	0
28	255-264		0.383	0.692	0.292	0.042	0.004	0
29	265-274		0.433	0.746	0.374	0.044	0.004	0
30	275-284		0.334	0.601	0.258	0.037	0.001	0
31	285-294		0.356	0.614	0.297	0.054	0.005	0
32	295-304		0.337	0.671	0.362	0.059	0.008	0
33	305-314		0.349	0.716	0.404	0.059	0.006	0.001
34	315-324		0.374	0.775	0.416	0.042	0.003	0
35	325-334		0.397	0.661	0.283	0.022	0.001	0
36	335-344		0.443	0.573	0.218	0.015	0	0
37	345-354		0.526	0.625	0.17	0.007	0.001	0
38								

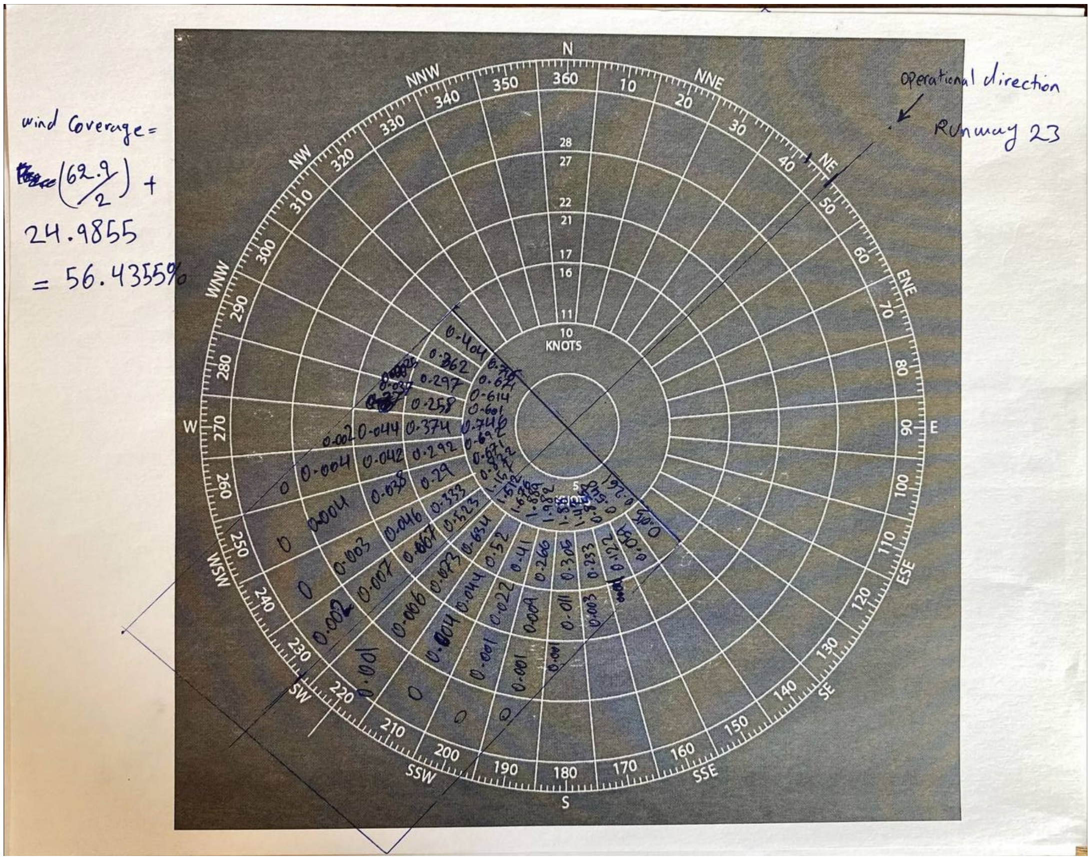


Comment:

(e) Find the percent of time the airport could operate runway 5 based on wind conditions. In the analysis, assume zero tailwinds.



(f) Find the percent of time the airport could operate runway 23 based on wind conditions. In the analysis, assume zero tailwinds.



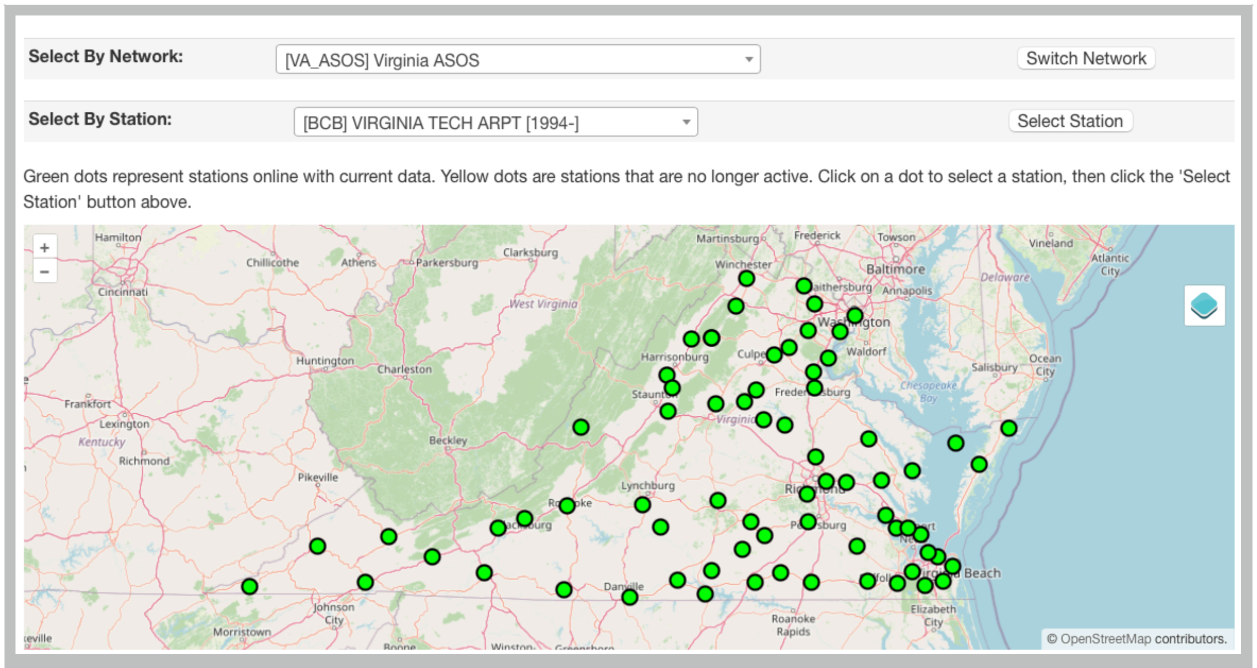


Figure 3.Iowa State Wind Data Site for Virginia ASOS Sites.

Figure 4. Embraer 145 (A.A. Trani).