Assignment 6: Obstruction Analysis and Wind Rose Analysis

Solution

Instructor: Trani

Problem #1

Use the Iowa State Mesonet model data for Roanoke-Blacksburg Airport (ROA). Specifically, collect 30 years of wind data for ROA using the Automated Surface Observing Systems (ASOS) as demonstrated in class.

(a) Collect the data using the Iowa State Mesonet model (look at the Virginia ASOS network) and **create a custom wind rose that contains 36 direction bins** and the following wind speeds (knots). Show me the Iowa State Mesonet Wind Rose.

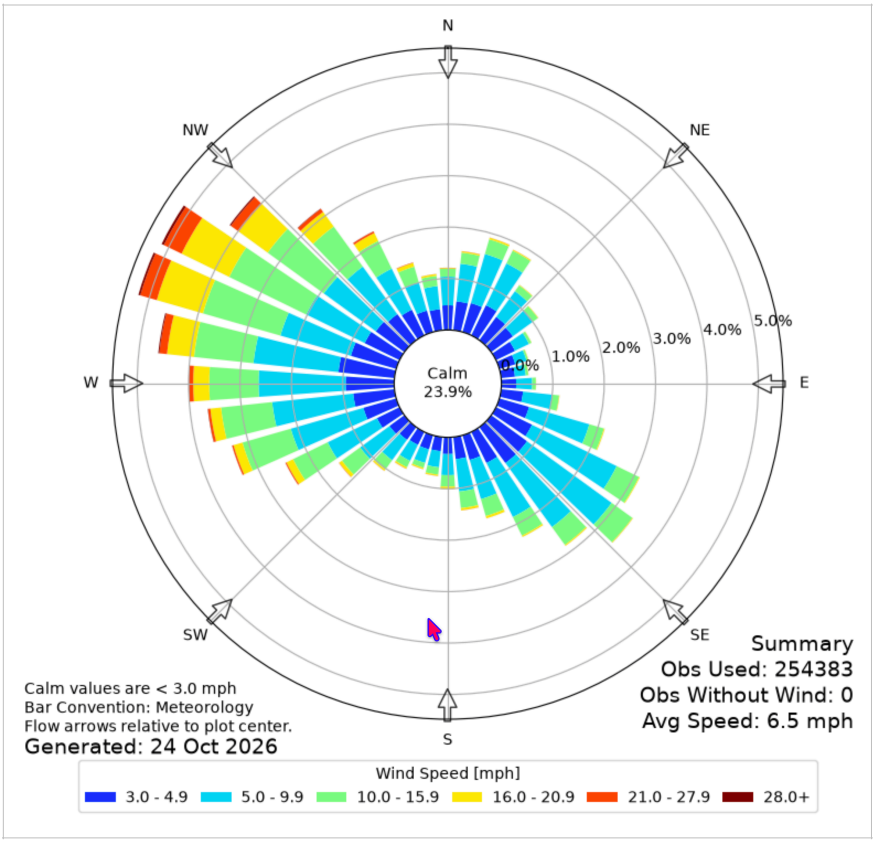
☑ Optional. User provided wind speed bins

0 - 3 - 5 - 10 - 16 - 21 - 28 +

(b) Show the IEM model wind rose and find the predominant orientation of the wind.

The IEM model wind rose is presented below. Note that for 30 years of data, there are 254,383 records. According to the data, 23.9% of the wind records are reported as calm winds in the IEM data (wind speeds less than 3 knots). The FAA considers calm wind conditions winds below 5 knots.

It is clear that the prevailing winds come from the NorthWest. According to the wind data, runway 16/34 at ROA would be preferred.



Wind Rose for ROA Using the IEM Mesonet Model. 30 Years of Data (Jan/ 1/1996 to Jan/1/2026)

(c) Collect the raw data used to generate the Iowa State Mesonet wind rose and bring the data using Excel.

	A	B	C	D	E	F	G	H
1		Wind Speed (knots)						
2	Direction (deg)	Calm	3.0 4.9	5.0 9.9	10.0 15.9	16.0 20.9	21.0 27.9	28.0+
3	355-004	23.93	0.48	0.558	0.154	0.014	0.004	0.001
4	005-014		0.564	0.738	0.217	0.025	0.003	0.001
5	015-024		0.585	0.995	0.295	0.034	0.002	0
6	025-034		0.652	0.908	0.274	0.019	0.002	0
7	035-044		0.56	0.621	0.138	0.01	0	0
8	045-054		0.522	0.489	0.115	0.008	0.001	0
9	055-064		0.41	0.305	0.051	0.004	0	0
10	065-074		0.323	0.23	0.034	0.006	0	0
11	075-084		0.27	0.212	0.05	0.005	0.001	0
12	085-094		0.287	0.313	0.07	0.004	0	0
13	095-104		0.429	0.573	0.132	0.007	0.001	0
14	105-114		0.601	1.221	0.296	0.015	0.001	0
15	115-124		0.779	1.836	0.482	0.015	0	0

	A	B	C	D	E	F	G	H
31	275-284		1.095	1.665	1.161	0.53	0.15	0.02
32	285-294		0.918	1.428	1.567	0.935	0.334	0.038
33	295-304		0.754	1.269	1.666	1.031	0.384	0.047
34	305-314		0.687	1.253	1.349	0.696	0.192	0.025
35	315-324		0.627	1.145	0.961	0.35	0.074	0.008
36	325-334		0.555	0.892	0.598	0.171	0.033	0.004
37	335-344		0.433	0.572	0.318	0.075	0.009	0
38	345-354		0.411	0.454	0.199	0.035	0.002	0
39	Subtotal	23.93	20	32.237	17.061	5.21	1.392	0.161

Wind Rose for ROA Using the IEM Mesonet Model.

(d) Find the percent of time, the wind is stronger than 16 knots at ROA (from any direction).

6.76% of the time wind speeds log more than 16 knots. There number is calculated adding the wind fractions in the table above for wind speed speeds above 16 knots (adding cells in columns F,G, and H).

(e) Find the percent of time the airport has calm winds (< 5 knots).

The FAA considers calm wind conditions winds below 5 knots. Adding the subtotals for columns B and C provides the answer.

Calm Winds (FAA Definition) = 43.93% (wind < 5 knots)

(f) Find the design crosswind wind speed used in the wind rose analysis if the Airbus A300-600 is the critical aircraft (see Figure 1). State the ADG and AAC groups used in the analysis.

ADG IV, AAC - C. ***The design crosswind is 20 knots.***



Figure 1. Airbus A300-600F Freighter at ROA Airport (A.A. Trani).

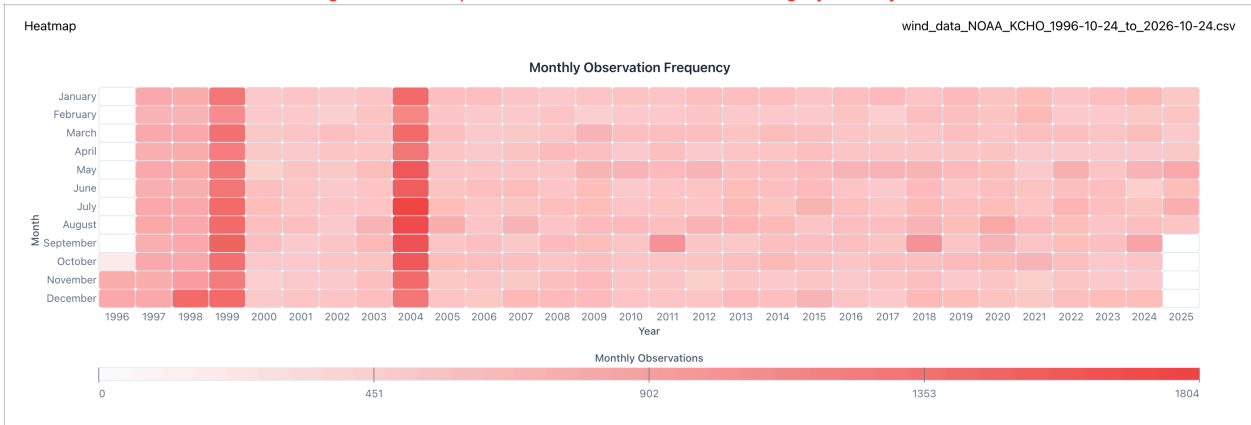
Problem # 2

Use the **Wind Rose Tool** demonstrated in class to do a wind rose analysis for Charlottesville, Virginia (KCHO).

a) Specifically, collect 30 years of wind data for KCHO using the Wind Rose Tool. Use the NOAA web server to do this analysis.

b) Verify the wind data heat map and tell me if there are any gaps in the 30-year data.

The heatmap of the wind data for 20 years is shown below. There are no apparent gaps in the data. For years 1999 and 2004 the number of wind observations is higher but acceptable since wind conditions change year to year.



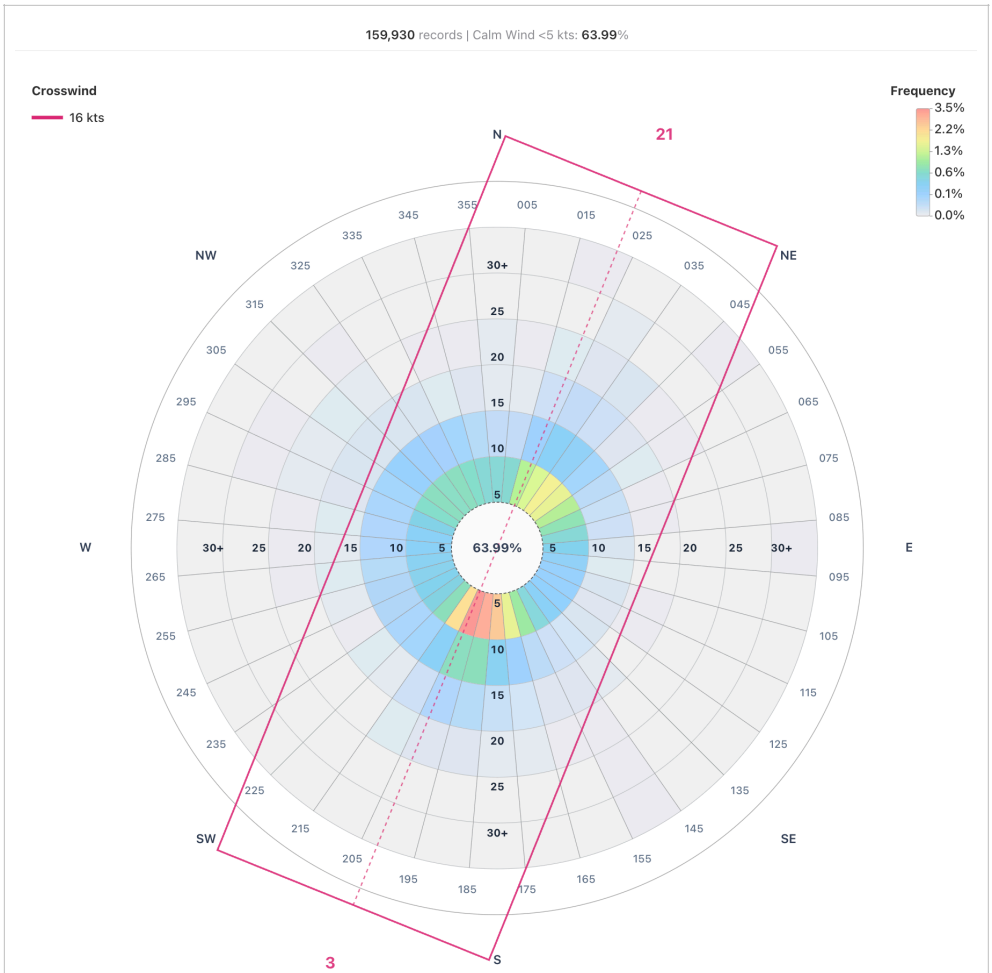
Heatmap for Charlottesville Airport (CHO) Wind Data.

c) Find the design crosswind component at KCHO. The largest regular use commercial aircraft using KCHO is the Boeing 717-200 (see Figure 2).

The design crosswind for ADG III and AAC C is 16 knots.

d) Do a wind rose analysis using the Wind Rose Tool. Show me the wind rose assuming both runway ends are used and consider the critical design crosswind found in part (c). Only the design crosswind rectangle is expected in this section of the analysis. Specify the runway orientations used (in degrees).

True runway headings at CHO are 22 and 202 degrees (source: Arnav). Do not active the multiple crosswind toggle to study the wind rose for 16 knots (see below).



Bi-directional Wind Rose for Runway 3/21 at CHO Airport.

e) Find if the runway meets the 95% FAA wind coverage criteria using both runway ends. Use all weather and time-weighted wind calculations.

Under all-weather conditions, the wind coverage is 99.97% using both runway ends (i.e., 60 knots tailwind). The wind coverage table is provided below.

Time-Weighted Wind Coverage

Condition	RWY 3 16/60	Current Airport Cumulative Airport	Avg Hrs/Year
All Weather	99.97%	99.97%	7,800
VMC	99.97%	99.97%	6,830
IMC	99.96%	99.96%	941
Cat I	99.95%	99.95%	797
Cat II	99.95%	99.95%	49
Cat III	100.00%	100.00%	96
Precipitation	99.94%	99.94%	439
Freezing Precipitation	99.96%	99.96%	81

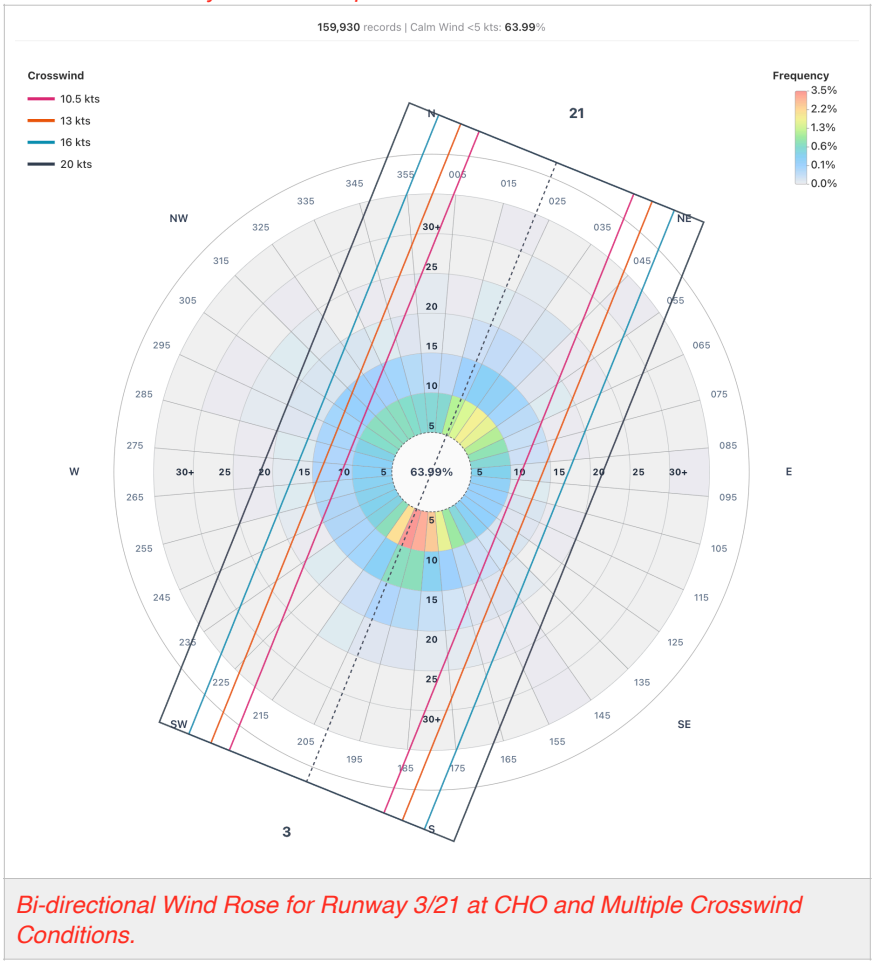
Wind Coverage for Various Weather Conditions.

f) Compare the wind coverage at KCHO under all-weather, VMC, and IMC conditions using both runway ends. Comment on any differences observed.

Under IMC conditions, runway 3/21 provides a coverage of 99.96%. Under VMC conditions the wind coverage is 99.97%. Practically the same.

g) Perform a wind rose analysis using multiple crosswind conditions and both runway ends in use. Compare the wind coverage between 10.5 and 13 knots.

The wind rose analysis with multiple crosswind conditions is shown below.



Bi-directional Wind Rose for Runway 3/21 at CHO and Multiple Crosswind Conditions.

Use the table below generated with the Wind Rose Tool activating the multiple crosswind toggle. The wind coverage with 10.5 knots is 99.04% for all-weather conditions. The wind coverage with 13 knots is 99.76% for all-weather conditions. The solution is consistent because higher tolerance to crosswinds (i.e., higher design crosswind threshold) results in higher wind coverage for the same wind set.

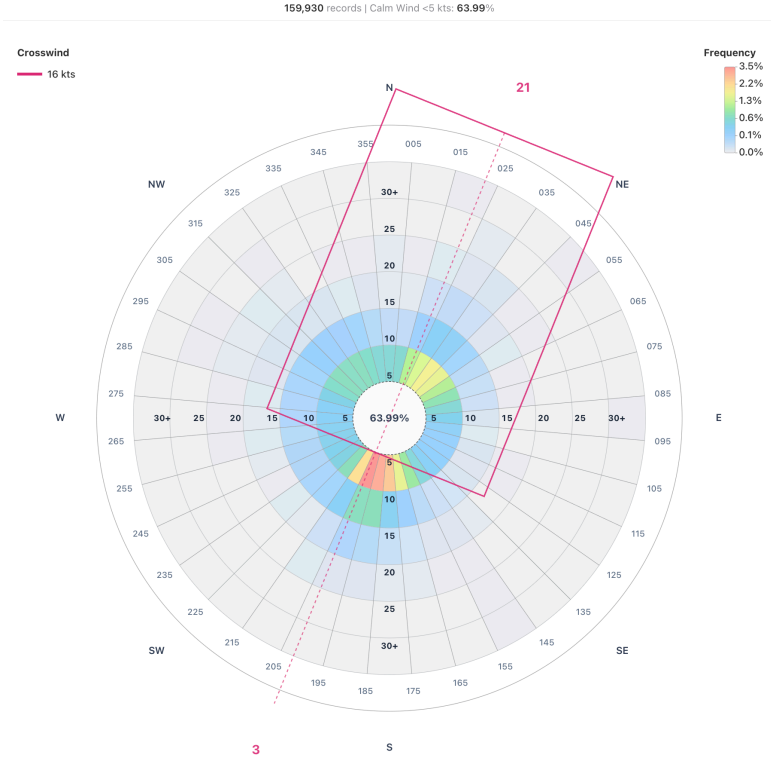
Time-Weighted Wind Coverage

	RWY 3				Current Airport	
Condition	10.5/60	13/60	16/60	20/60	Cumulative Airport	Avg Hrs/Year
All Weather	99.04%	99.76%	99.97%	99.99%	99.99%	7,800
VMC	98.95%	99.74%	99.97%	100.00%	100.00%	6,830
IMC	99.77%	99.90%	99.96%	99.98%	99.98%	941
Cat I	99.74%	99.89%	99.95%	99.98%	99.98%	797
Cat II	99.84%	99.95%	99.95%	99.95%	99.95%	49
Cat III	99.97%	100.00%	100.00%	100.00%	100.00%	96
Precipitation	99.45%	99.86%	99.94%	99.98%	99.98%	439
Freezing Precipitation	99.73%	99.92%	99.96%	99.96%	99.96%	81

Wind Coverage for Various Weather Conditions and Four Crosswind Conditions.

h) Find the percent of time, runway end 03 is favored due to wind conditions alone. Assume a 5-knot tailwind allowance.

For this analysis select runway 3 true heading (22 degrees), crosswind 16 knots, and tailwind 5 knots. The diagram below shows the graphic solution. The all-weather coverage is reported to be 83.01%.



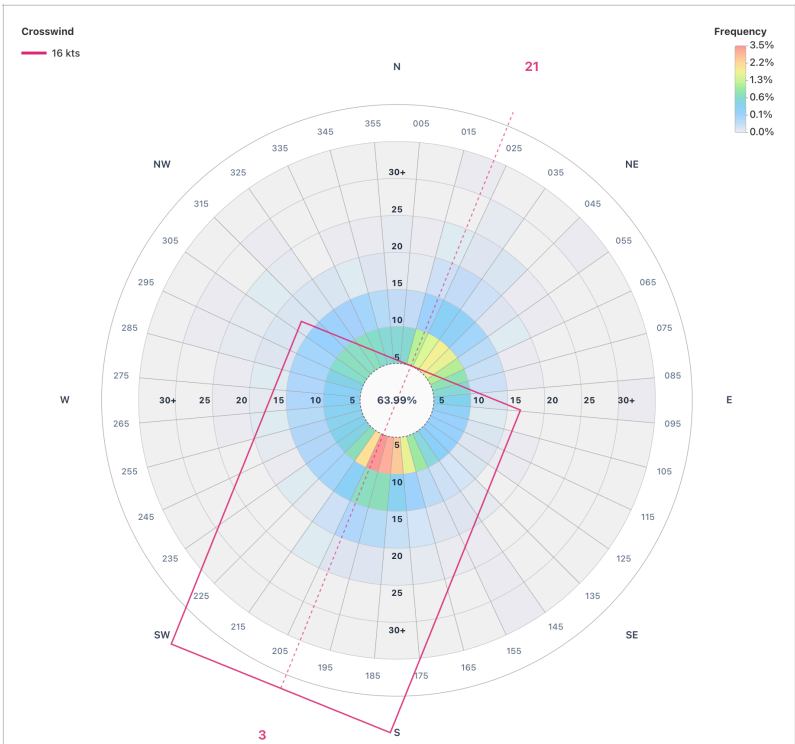
Time-Weighted Wind Coverage

	RWY 3	Current Airport
Condition	16/5	Cumulative Airport
All Weather	83.01%	83.01%

Wind Coverage Using Runway 3 for Arrivals and Departures at CHO. 5-knot Tailwind Allowance and 16-knot Design Crosswind.

i) Find the percent of time, runway end 21 is favored due to wind conditions alone. Assume a 5-knot tailwind allowance.

For this analysis select runway 21 true heading (202 degrees), crosswind 16 knots, and tailwind 5 knots. The diagram below shows the graphical solution. The all-weather coverage is reported to be 92.20%.



Time-Weighted Wind Coverage

Condition	RWY 21 16/5	Current Airport Cumulative Airport
All Weather	92.20%	92.20%
VMC	93.04%	93.04%
IMC	86.25%	86.25%

Wind Coverage Using Runway 21 for Arrivals and Departures at CHO. 5-knot Tailwind Allowance and 16-knot Design Crosswind.

In conclusion, the Charlottesville airport has a 99.97% coverage under all-weather conditions. One runway satisfies the 95% wind coverage required by the FAA under all-weather conditions.

Considering wind alone, runway 21 can be used 92.20% of the time with a 5-knot tailwind allowance. Runway 3 can be used 83.01% of the time with the same 5-knot tailwind allowance.



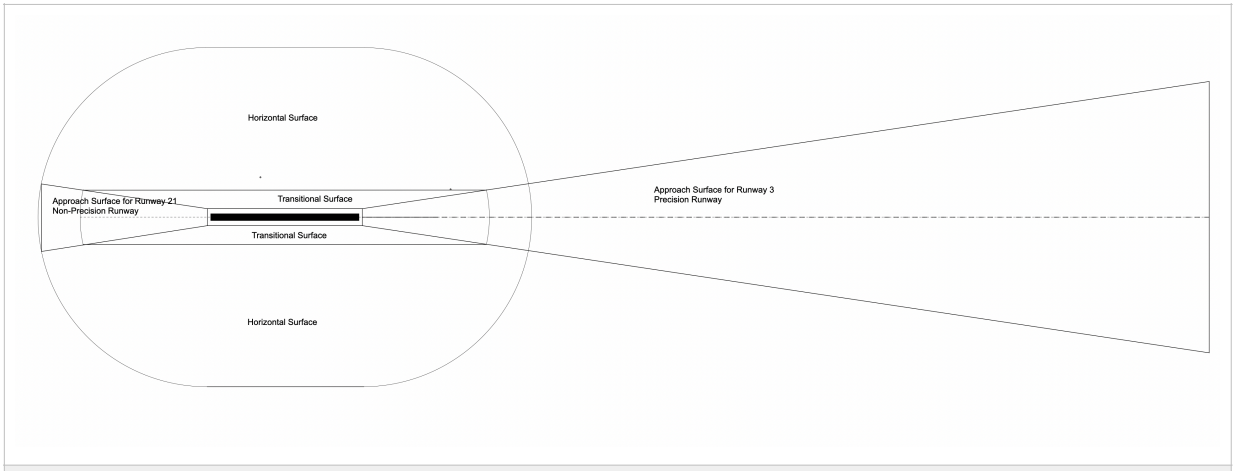
Figure 2. Boeing 717-200 (A.A. Trani).

Problem #3

Consider the Charlottesville, Virginia (KCHO) to answer the following.

a) Draw to scale (top view only) the following Part 77 imaginary surfaces for KCHO. Please no sketches accepted.

1. Runway 3/21 primary surface.
2. Approach surfaces for runways 3 and 21
3. Transitional surface between primary and horizontal surface
4. Horizontal surface for both runways.



Partial View of Part 77 Imaginary Surfaces for CHO Airport. Runway 3 is a Precision Runway and its Approach Surface Extends to 50,000 feet. Runway 21 is a Non-precision runway (approach surface ends at 10,000 feet)

b) State the runway type (i.e., precision, non-precision, visual) used for each runway end in your drawing. Use Google Earth and Arnav to support your answer.

According to Arnav.com:
Runway 3 is a precision runway with a 1,400 foot medium intensity approach lighting system (MALSR).
Runway 21 is a non-precision runway.

c) A communications company would like to install a cell phone antenna (116 feet) at a location 6,300 feet from runway end 3 and offset 180 feet from the extended centerline. Is the antenna an obstruction to navigation? Explain the surfaces involved in your analysis.

The antenna is inside the approach imaginary surface for runway 3. The approach surface starts 200 feet from the runway end (i.,e., end of primary surface). At a location 6,100 feet from the start of the approach surface, the approach surface height at the location of the antenna is 122 feet (slope of the approach surface for a precision runway is 50:1 for the first 10,000 feet). ***The cell phone will not be an obstruction to navigation.***

d) A developer would like to build an eight-story hotel (88-feet maximum height) to be located 1,230 feet perpendicular to the runway centerline. Would the hotel be an obstruction to navigation? Explain.

The hotel is in the transition surface. The transition surface starts 500 feet from the runway centerline and rises at 7:1 slope. The proposed hotel location is 830 feet from the start of the transition surface (1230-500 feet). The height of the transition surface at that location is 104.3 feet. ***The hotel can be constructed at the desired location.***

Problem # 4

Use the **Wind Rose Tool** demonstrated in class to do a wind rose analysis for Lewisburg, West Virginia (KLWB).

a) Specifically, collect 30 years of wind data using the Wind Rose Tool. Use the NOAA web server to do this analysis.

b) Find the design crosswind value at KLWB. The largest regular use aircraft at the airport is the Global Express 6000 (see Figure 3).

The design crosswind is 16 knots because the Global Express is ADG-III and AAC C.

c) Do a wind rose analysis using the Wind Rose Tool. Show me the wind rose assuming both runway ends are used and consider the critical design crosswind found in part (b). Tell me the coverage using both runway ends. Specify the runway orientations used (in degrees).

Runway 4/22 at Lewisburg is oriented 35 degrees true (runway 4) and 215 degrees true (runway 22).

All-weather coverage on both runways is 99.91%

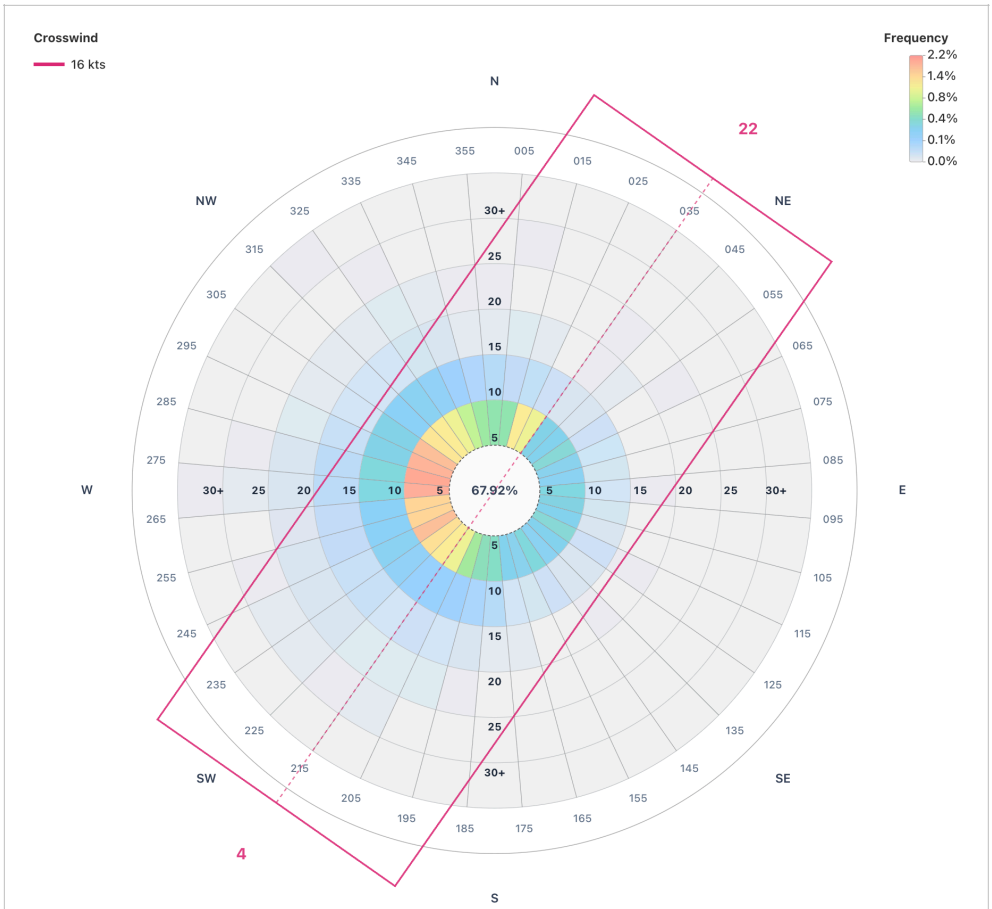
Runway 4 coverage results
All-weather coverage for runway 4 is 89.94% assuming a 5-knot tailwind
All-weather coverage for runway 4 is 64.52% assuming a zero knot tailwind

Runway 22 coverage results
All-weather coverage for runway 22 is 95.39% assuming a 5-knot tailwind
All-weather coverage for runway 22 is 75.79% assuming a zero knot tailwind

Considering wind conditions alone, Runway 22 is more likely to be used during all-weather operations.

Under IMC conditions (low visibility), the runway 4 coverage is 96.89% (using 5-knot tailwind).
Under IMC conditions (low visibility), the runway 22 coverage is 94.09% (using 5-knot tailwind).

Under IMC weather conditions, runway 4 is more likely to be used. This explains why runway 4 is a precision runway and has a 1,400 foot medium intensity approach lighting system (MALSR).



Time-Weighted Wind Coverage

Condition	RWY 22 16/60	Current Airport Cumulative Airport	Avg Hrs/Year
All Weather	99.91%	99.91%	7,907
VMC	99.91%	99.91%	6,900
IMC	99.94%	99.94%	910
Cat I	99.92%	99.92%	584
Cat II	100.00%	100.00%	14
Cat III	100.00%	100.00%	312
Precipitation	99.89%	99.89%	177
Freezing Precipitation	99.73%	99.73%	252

Bi-directional Wind Rose for Runway 4/22 at LWB Airport.

d) At Lewisburg, which runway end is likely to be use the most in all-weather considering wind conditions alone? Explain.

Considering wind conditions alone, Runway 22 is more likely to be used during all-weather operations. The previous results are repeated here.

Runway 4 coverage results
All-weather coverage for runway 4 is 89.94% assuming a 5-knot tailwind

Runway 22 coverage results
All-weather coverage for runway 22 is 95.39% assuming a 5-knot tailwind

e) At Lewisburg, which runway end is likely to be use the most in IMC-weather conditions? Explain.

Under IMC conditions (low visibility), the runway 4 coverage is 96.89% (using 5-knot tailwind).
Under IMC conditions (low visibility), the runway 22 coverage is 94.09% (using 5-knot tailwind).

Under IMC weather conditions, runway 4 is more likely to be used. This explains why runway 4 is a precision runway and has a 1,400 foot medium intensity approach lighting system (MALSR).

f) Is the runway end found in part (e) consistent with the highest precision runway at LWB? Explain.

Yes, runway 4 at Lewisburg is a precision runway.



Figure 3. Global Express 6000 (A.A. Trani).