CEILING VISIBILITY WIND TABULATIONS

Hourly aviation weather reports are made at about 1200 locations in the 50 states. Some stations report each hour (24/day), while others report only during hours of daylight or during peak tourist seasons, or in some cases, only when aircraft are scheduled to operate. The content of the observation varies somewhat depending on the type of station. The elements of interest in developing a ceiling-visibility wind tabulation are ceiling, visibility, and wind direction and speed.

In general, at least five years of continuous (i.e., no long periods of missing records) observations are necessary to obtain an annual distribution that is representative of the site. Care must be exercised to include only those observations pertinent to airport use. That is, if an airport will operate only during daylight hours, only those hours should be included in developing the tabulations. The same applies to seasonal operations; use only those observations during the months when the airport will be in operation.

Although stations enter the weather reports on forms each hour, only selected observations (every third hour) are digitized onto magnetic tape when the records are processed at the National Climatic Center. This practice began in January 1965. Prior to that date all hourly observations for a selected network of stations were digitized. The reduction from 24 observations per day to 8 observations per day does not significantly affect the representativeness of the derived wind summary. Because observations from only about 500 of the 1200 airports are digitized, manual tabulation of the data is necessary for many stations. Costs for processing data manually can run five to ten times as much as when the observations are on magnetic tape which can be processed by computer.

Wind is one of the major factors in determining runway orientation. Ideally, runways should be aligned to minimize crosswinds, since they are often contributing factors in small aircraft accidents. In some cases it may be necessary to construct two runways to give the desired wind coverage. The crosswind component is the resultant vector which acts perpendicular to the runway. Wind coverage is that percent of time for which operations are considered safe due to acceptable crosswind components. The Federal Aviation Administration (FAA) has indicated that the desirable coverage is 95% of winds below some assigned threshold, usually 12 or 15 mph (10.5 or 13 knots).

The first step in determining the wind pattern is to prepare a table showing the frequency of wind speeds by wind direction as shown in Exhibit I. If 12 mph and 15 mph values are assigned as the critical crosswinds, then classes are: 0-12, 13-15, 16-18, 19-24, 25-31, 32-38 and 39 mph and greater. The wind direction and speed reported at each observation are simply tallied in the cells of this table. If 29,216 observations are examined, the sum of the frequencies in all the cells will

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equal that number. Percentages are computed by dividing each cell count by the total number of observations. For example, if a count of 513 falls in the cell for direction S and 13-15 mph, then the percent would be 1.8 (see Exhibit II). Percentages should be checked against the totals shown on Exhibit I because of rounding. The "+" values indicate occurrences, but the percentage is less than 0.05%. The computed percentages are then transferred to the wind rose graph as shown in Exhibit III.

The wind rose is a scaled graphical presentation of surface wind data in terms of speed and direction. The radial lines of the diagram are positioned so that areas between them are centered on the direction from which the wind is blowing. The concentric circles represent limits between speed groups sectors; that is, 12.5, 15.5, 18.5, 24.5, 31.5, etc., miles per hour. Radii for these groups are accurately scaled to the respective speeds. The segments enclosed by radial lines and concentric circles on the diagram represent wind speed-direction combinations. The data from the wind tabulation, Exhibit II, are transferred to the appropriate segments on the diagram as a percentage of the total observations examined.

Separate graphs are required to accommodate wind observations reported to 16 and to 36 points (tens of degrees). Wind observations taken prior to 1964 were reported to 16 points of compass (true), while subsequent reports were to 36 points (10 degree increments). Data reported in the latter system (36 points) can be converted to 16 points; however, wind observations recorded in 16 points cannot be converted to the 36-point scale. In earlier years, wind speeds were reported in miles per hour, but are now reported in knots. Conversion to either speed scale presents no problem; however, class intervals of wind speed should conform to the scaled concentric circles on the graph, Exhibit III. When all percentages, including +'s, have been transferred to the graph, a transparent overlay (template) representing the runway is positioned on the graph. This overlay should be about 8 to 10 inches long and with three parallel and equally spaced lines having been drawn. The middle line represents the runway centerline and the distance between the outside lines is, to scale, equal to the diameter of the 12-unit circle for 12 mph crosswind, or the 15-unit circle in the case of a 15 mph crosswind analysis.

Using the center of the wind rose graph as a pivot, the template is rotated until the sum of the percentages appearing between the outside lines becomes maximum. The percentage shown in each segment of the wind rose is assumed to be equally distributed over the area of the segment. When one of the outside lines on the template cuts through a segment, the fractional part of the percentage appearing in that segment within the outside lines is used in the summation of the percentages contributing to the wind coverage. Fractional areas are determined visually and tabulated to the nearest tenth of a percent.

The total percentage of all the areas covered by the template is the estimated percentage of time that winds with a 90-degree crosswind component of the critical speed or less will occur. It is usually easier to total the percentages that lie outside the template and subtract this total from 100. Several orientations to either side of the original trial heading should be made to assure that the best possible coverage and orientation have been determined. The runway orientation resulting from the wind rose analysis should be adjusted from true to magnetic azimuths in accordance with the above and as shown in FAA publications.

The distribution of winds under all weather conditions is but one of many types that can be prepared. Knowledge of wind patterns during specified weather conditions may be critical to certain operations such as during periods of low ceiling and visibility (IFR) conditions.

Tabulations of wind direction and speed for IFR conditions are prepared in the same manner as for the all weather, except that only those observations falling within the specified ceiling-visibility limits are used. For example, if IFR is defined as ceilings less than 1000 ft. and/or visibility less than 3 miles, but ceilings equal to or greater than 400 feet and visibility 1 mile or more, then input data to the wind tabulation are limited to just those observations. NOTE: The requester (FAA, engineer, etc.) must specify the thresholds of ceiling and visibility for each tabulation, in addition to wind speed class limits, units, periods of record, etc.; NCC does not specify these thresholds.

A VFR wind tabulation would generally include observations when ceilings were equal to or greater than 1000 feet and visibility was equal to or greater than 3 miles, while ILS conditions might be specified as ceilings less than 400 feet and/or visibility less than 1 mile. The 1978 cost for preparing wind tabulations for the VFR, IFR and ILS conditions is $200 for a five-year period of record on magnetic tape. The output would be in percentages, as in Exhibit II, for each of the three categories. The cost breakdown is $168 for the computer run and $32 for the three graphs. NCC does not analyze the graphs to determine runway alignment.

If an all weather graph is also required, the user should request that the output of the three tabulations (VFR, IFR and ILS) be in frequencies rather than percentages. Since an All Weather wind distribution includes all conditions, it is simply the sum of the frequencies in each cell; i.e., VFR + IFR + ILS = All Weather. NOTE: This is true only as long as the categories are defined to include all possible combinations of ceiling and visibility.

No firm cost figures can be given if the input data are not on magnetic tape. This is due to the variability in the number of observations required for processing and other factors. Requesters should contact NCC for information about data availability and processing costs by either writing National Climatic Center, Federal Building, Asheville, NC 28801, or by calling (704) 258-2850, extension 683; the FTS telephone number is 672-0683. Data surveys and cost estimates will be provided at no obligation.

NCC will begin work upon receipt of agreed-upon specifications and a commitment for payment, e.g., Purchase Order or other obligating document. For single work requests, the cost of which is estimated to be less than $5,000, the estimated cost is a fixed price and the requester will be billed that amount upon completion of the job. For single work requests, the cost of which is estimated to be $5,000 or more, the requester will be charged the actual cost of the job upon completion of the job. Cost estimates for fixed price jobs will be valid for ninety days, unless otherwise stated, from the date of the estimate. The time required to process a wind rose varies from three to six weeks, depending upon the workload at the Center and the format in which the observational data are held.

EXHIBIT I

WIND DIRECTION VERSUS WIND SPEED

STATION NAME/NUMBER Hypothetical/12345 DATA Frequency PERIOD OF RECORD 1965-1974

SPEED GROUPS IN MPH

Mo	Code	Speed / Dir	0 – 3	4 – 7	8 – 12	13 – 15	16 – 18	19 – 24	25 – 31	32 – 38	39 & Gr.	Total	Percent	Avg Speed
AN		N	769	1491	1186	302	149	85	41	15		4038	13.8	7.8
		NNE	477	1137	670	137	50	29				2500	8.6	7.3
		NE	348	808	347	35						1538	5.3	6.3
		ENE	277	435	69	3	1					785	2.7	5.0
		E	424	373	43	4	2	3				849	2.9	4.4
		ESE	330	235	43	10	4	7	2			631	2.2	4.7
		SE	268	222	114	70	56	27	2	1		760	2.6	7.5
		SSE	357	467	560	547	513	255	47	3		2749	9.4	11.8
		S	642	1070	1067	513	374	156	15	1		3838	13.1	9.3
		SSW	286	390	228	56	25	7	1			993	3.4	6.6
		SW	335	309	126	33	10	2				815	2.8	5.5
		WSW	396	366	120	12	1					895	3.1	5.0
		W	507	765	325	35	3					1635	5.6	5.7
		WNW	456	919	462	30	7					1874	6.4	6.0
		NW	397	609	252	29	11	7	1			1306	4.5	5.9
		NNW	416	670	235	70	75	37	21	15		1539	5.3	7.0
		Calm	2471									2471	8.5	
Total			9156	10266	5847	1886	1281	615	130	35		29216	100.0	6.8
Percent			31.3	35.1	20.0	6.5	4.4	2.1	0.4	0.1				

MO : AN = Annual; 1 = January; 2 = February; ......; 12 = December.
CODE : Blank = All Weather; 10 = VFR; 20 = IFR; 30 = ILS

EXHIBIT II

WIND DIRECTION VERSUS WIND SPEED

STATION NAME/NUMBER Hypothetical/12345 DATA Percentage Frequency PERIOD OF RECORD 1965-1974

SPEED GROUPS IN MPH

Mo	Code	Speed / Dir	0 – 3	4 – 7	8 – 12	13 – 15	16 – 18	19 – 24	25 – 31	32 – 38	39 & Gr.	Total	Percent	Avg Speed
AN		N	2.6	5.1	4.1	1.0	0.5	0.3	0.1	0.1		4038	13.8	7.8
		NNE	1.6	3.9	2.3	0.5	0.2	0.1				2500	8.6	7.3
		NE	1.2	2.8	1.2	0.1						1538	5.3	6.3
		ENE	0.9	1.5	0.2	+	+					785	2.7	5.0
		E	1.5	1.3	0.1	+	+	+				849	2.9	4.4
		ESE	1.1	0.8	0.1	+	+	+	+			631	2.2	4.7
		SE	0.9	0.8	0.4	0.2	0.2	0.1	+	+		760	2.6	7.5
		SSE	1.2	1.6	1.9	1.9	1.8	0.9	0.2	+		2749	9.4	11.8
		S	2.2	3.7	3.7	1.8	1.3	0.5	0.1	+		3838	13.1	9.3
		SSW	1.0	1.3	0.8	0.2	0.1	+	+			993	3.4	6.6
		SW	1.1	1.1	0.4	0.1	+	+				815	2.8	5.5
		WSW	1.4	1.3	0.4	+	+					895	3.1	5.0
		W	1.7	2.6	1.1	0.1	+					1635	5.6	5.7
		WNW	1.6	3.1	1.6	0.1	+					1874	6.4	6.0
		NW	1.4	2.1	0.9	0.1	+	+	+			1306	4.5	5.9
		NNW	1.4	2.3	0.8	0.2	0.3	0.1	0.1	0.1		1539	5.3	7.0
		Calm	8.5									2471	8.5	
Total			9156	10266	5847	1886	1281	615	130	35		29216	100.0	6.8
Percent			31.3	35.1	20.0	6.5	4.4	2.1	0.4	0.1				

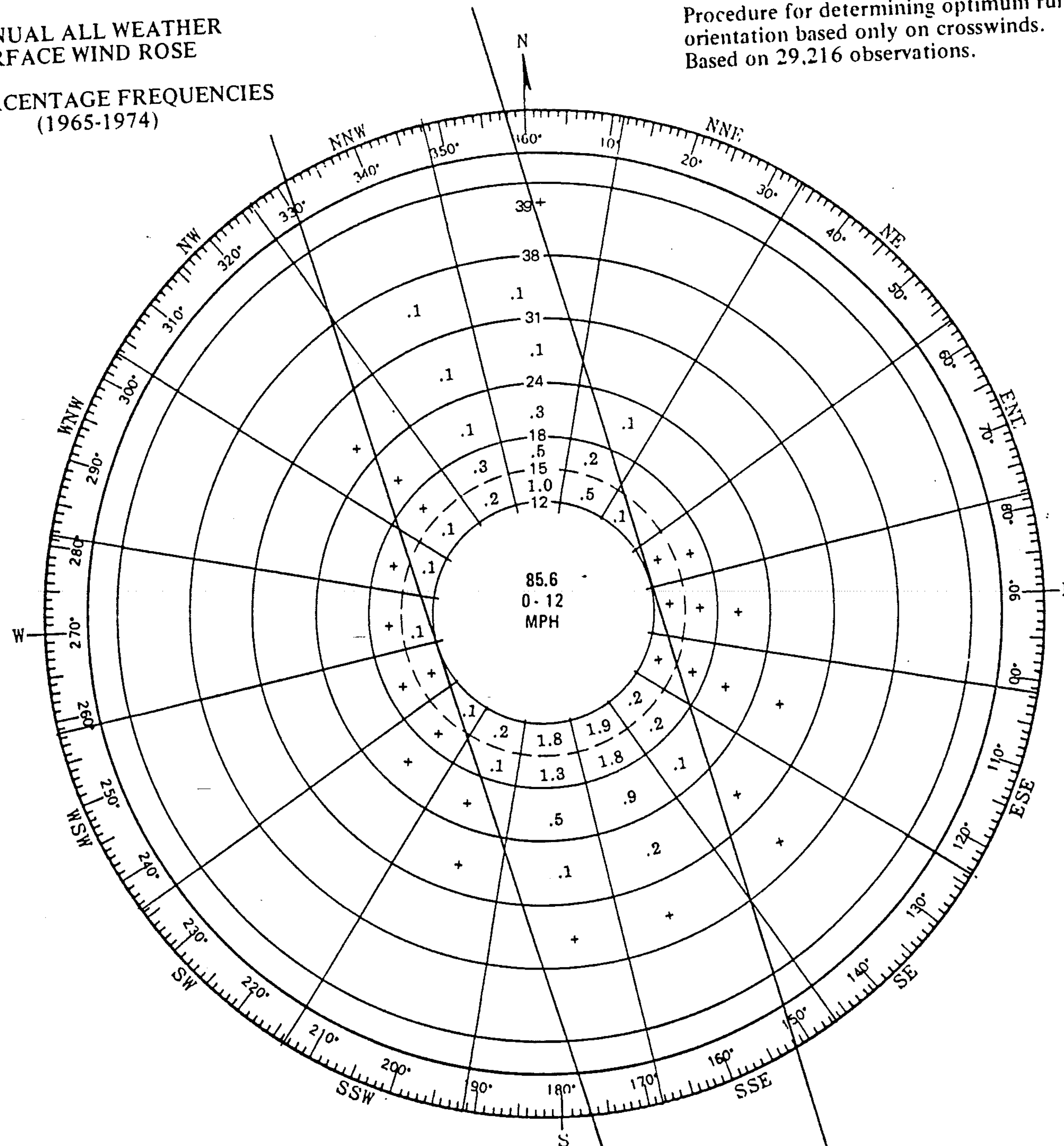
MO : AN = Annual; 1 = January; 2 = February; ......; 12 = December.
CODE : Blank = All Weather; 10 = VFR; 20 = IFR; 30 = ILS
+ = less than 0.05 percent
Percentages are derived by dividing the frequencies in Exhibit I by the total observation count.
Note the percentage of winds less than 13 mph is computed from (9156 + 10266 + 5847)/29216 = 86.5.

HYPOTHETICAL/12345

ANNUAL ALL WEATHER
SURFACE WIND ROSE

PERCENTAGE FREQUENCIES
(1965-1974)

Procedure for determining optimum runway orientation based only on crosswinds.
Based on 29,216 observations.



+ = less than .05%

THE WIND ROSE IS A SCALED GRAPHICAL PRESENTATION OF SURFACE WIND DATA IN TERMS OF SPEED AND DIRECTION. THE RADIAL LINES OF THE DIAGRAM ARE POSITIONED SO THAT AREAS BETWEEN THEM ARE CENTERED ON THE DIRECTION FROM WHICH THE WINDS ARE REPORTED. THE CONCENTRIC CIRCLES REPRESENT LIMITS BETWEEN SPEED GROUPS SECTORS, I.E. 12, 15, 18, 24, 31, 38, AND 39+ MILES PER HOUR. RADII FOR THESE GROUPS ARE ACCURATELY SCALED TO THE RESPECTIVE SPEEDS. THE SEGMENTS ENCLOSED BY RADIAL LINES AND CONCENTRIC CIRCLES ON THE DIAGRAM REPRESENT WIND SPEED-DIRECTION COMBINATIONS. THE DATA FROM A WIND SUMMARY ARE TRANSFERRED TO THE APPROPRIATE AREA ON THE DIAGRAM AS A PERCENTAGE OF THE TOTAL OBSERVATIONS EXAMINED.