Project Report

ATC-296

A Statistical Analysis of Approach Winds at Capacity-Restricted Airports

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16. Abstract

A study was conducted on six major U.S. airports with closely-spaced parallel (CSP) runways that become capacity-restricted during times of lowered cloud ceilings and visibilities. These airports were SFO, BOS, EWR, PHL, SEA, and STL. Efforts are underway to develop a feasible system for simultaneous CSP approaches, which would increase the capacity at these airports during restrictive weather conditions. When considering any new procedure, the wind conditions on approach are needed to understand the impact of wake turbulence transport.

Wind observations from aircraft that are equipped with Meteorological Data Collection and Reporting System (MDCRS) capabilities were used to conduct a statistical analysis on wind characteristics at each airport. Data from January 1997 through December 1999 were used in each analysis. Data analysis techniques and the statistical results are presented in this report. This information is expected to support procedure and benefits assessment models.

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ABSTRACT

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1. INTRODUCTION

Many major airports in the U.S. rely on simultaneous approaches to closely-spaced parallel (CSP) runways to maintain a high airport acceptance rate. During Visual Meteorological Conditions (VMC), aircraft are able to utilize both runways by making side-by-side landings and are able to meet the demands of heavy volume. However, when conditions deteriorate to marginal-VMC or Instrument Meteorological Conditions (IMC), side-by-side approaches are not possible due to the inherent safety concerns associated with lowered ceilings and visibilities. This situation is severely limiting to an airport's capacity and can create large delays and increased costs. Various ideas have been suggested that would facilitate the simultaneous use of CSP runways during low ceiling and visibility (LCV) conditions at capacity-restricted airports.

This report addresses the inadvertent or intentional scenario of a pair of approaching aircraft being staggered by some longitudinal distance. This situation alleviates the collision hazard presented by LCV conditions, but also introduces the possibility of a wake vortex encounter, particularly if the following aircraft is downwind of the leading aircraft. This situation is illustrated in Figure 1.

Since ambient wind speed and direction are the most important factors when considering the possibility of a lateral wake vortex encounter, wind behavior around airports with CSP runways needs to be well-understood before simultaneous approaches during restrictive weather could ever be used in an operational setting.

The speed of an existing crosswind is essential in calculating the time it would take the wake of a leading aircraft to enter the flight path of a trailing aircraft located downwind. A small difference in crosswinds can create a substantial difference in the maximum separation allowed between a staggered pair of aircraft to avoid the possibility of a wake vortex encounter. The stronger the crosswind, the closer together the aircraft must be so that the trailing aircraft may remain ahead of a laterally drifting vortex. If the aircraft are not on visual approaches, there may be a minimum separation required between aircraft for collision avoidance. Although some airports may theoretically be able to configure all CSP approaches to position the trailing aircraft upwind of the leading aircraft, it is assumed for this study that this is not possible, that the crosswinds are such that the upwind flight path is not clearly defined, or that pilot behavior makes this determination ahead of time unreliable.

Headwinds over the length of an entire approach are also an important factor when considering the separation between a pair of landing aircraft. Since headwinds are involved in the calculation of ground speed for each aircraft, they are imperative in determining the maximum allowable amount of space between the aircraft in order to avoid a wake vortex encounter.

This paper presents a statistical analysis of wind behavior for several major airports with CSP runways using aircraft wind observations. Specifically, speed and direction characteristics of headwinds and crosswinds are examined, as well as correlations between the two wind components with respect to each other and with respect to altitude. The resulting data should prove useful in Monte Carlo simulations of new CSP approach procedures.

For this study, there were six major airports of particular interest. They were San Francisco (SFO), Newark (EWR), Philadelphia (PHL), Seattle (SEA), Boston (BOS), and St. Louis (STL). These airports are useful to study because they all have CSP runways that severely restrict capacity during LCV conditions. All of these airports could benefit greatly from an operational simultaneous-approach procedure. Unfortunately, there were not enough data available for STL to produce meaningful statistics, so the results were excluded from this report.

Table 1 summarizes several important factors when considering the possible benefit of a simultaneous approach procedure for the airports of interest. The number of annual operations and average rate of delay were obtained from the Federal Aviation Administration Office of System Capacity. The %LCV refers to the percentage of time that the airport experiences cloud ceilings lower than 4500 feet and visibilities less than 7 miles as reported by hourly surface observations produced by the National Weather Service.

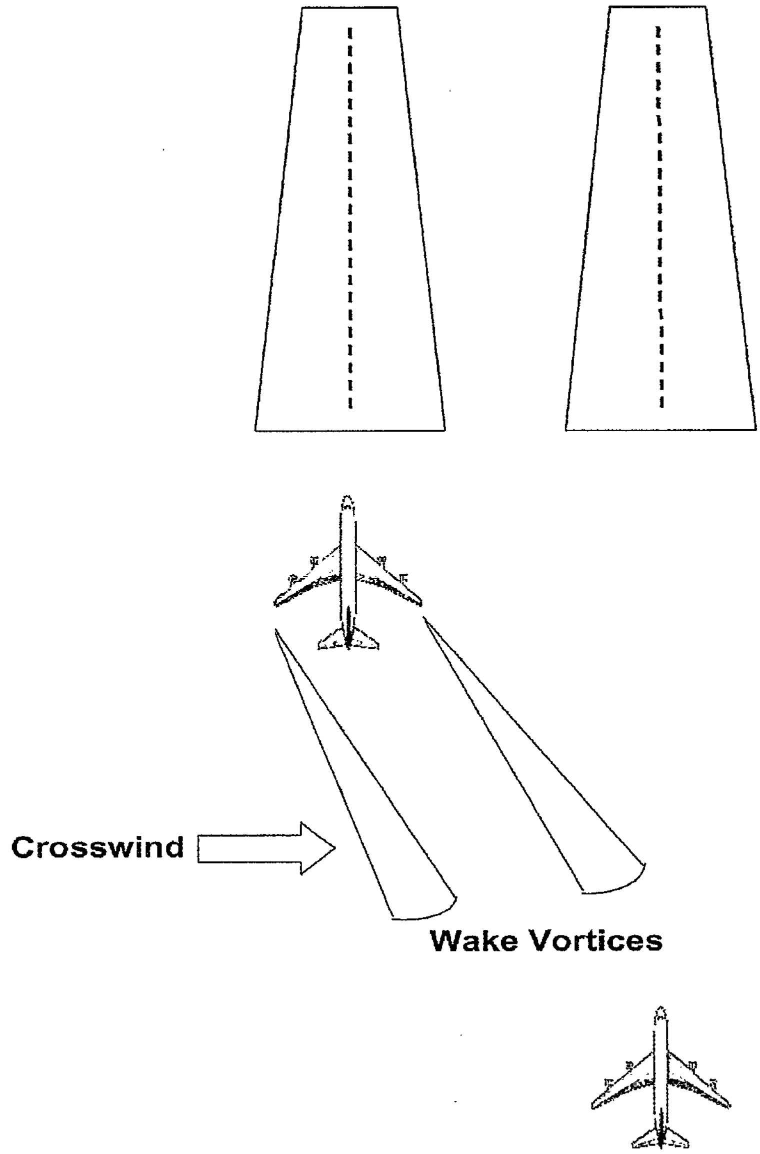

Figure 1. Wake turbulence encounters are possible in parallel approaches if the aircraft are staggered.

Table 1.
Airport Runway and Delay Statistics *

Airport	Parallel Runways	Separation (ft.)	1999 Annual Ops.	1999 Delay/1000 Ops.	% LCV
SFO	28R/28L	751	441,606	48.0	26.51%
BOS	4L/4R	1495	502,822	29.8	24.95%
EWR	22L/22R	948	463,000	78.9	22.47%
PHL	27L/27R	1401	480,279	30.2	26.30%
SEA	16L/16R	797	433,832	18.4	34.20%

* U.S. Department of Transportation, Federal Aviation Administration, "1999 Aviation Capacity Enhancement (ACE) Plan."

2. MDCRS DATA PROCESSING AND ANALYSIS TECHNIQUES

2.1. MDCRS Background Information

Wind observations from the Meteorological Data Collection and Reporting System (MDCRS) are a valuable resource for producing statistical results for wind behavior over a given airport for lower altitudes. In fact, MDCRS is the only source of routine wind information above the surface at many airports. These data are what were used for the airports included in this study.

Nearly 50,000 MDCRS observations are provided by commercial aircraft every day over the U.S. (Moninger, 2000). These observations are relayed to the ground via the Aircraft Communications, Addressing, and Reporting System (ACARS), which is operated by Aeronautical Radio, Inc. (ARINC). These data are also processed, quality-controlled, and archived at the Forecast System Laboratory (FSL) (Schwartz and Benjamin, 1995).

The airlines that currently participate in providing reports to the MDCRS database are American, Delta, Federal Express, Northwest, United, and United Parcel Service. Since the number of observations is dependent on air traffic, there are a fewer number of reports at night, but the cargo airlines give a substantial amount of nighttime observations with about 16,000 coming in between 0500 and 1400 GMT. In all, nearly 500 aircraft are currently equipped to provide MDCRS observations (Moninger, 2000).

The variables recorded in each MDCRS observation are latitude, longitude, altitude, time, temperature, wind direction, and wind speed. The wind observations are determined by the difference between the motion vector of the aircraft with respect to the earth, provided by the onboard inertial navigation system (INS), and the motion vector of the aircraft with respect to the air. This vector is calculated from the total airspeed measurement and heading measurement (Schwartz and Benjamin, 1995). Observations are made roughly every five to six minutes at cruising altitudes and often more frequently at lower altitudes, especially during take-off (Moninger, 2000).

MDCRS wind observations are considered to be fairly accurate when compared to other data sources. In a MDCRS versus rawinsonde collocation study by Schwartz and Benjamin (1995), an RMS vector difference of 3.8 m/s was reported. Much of this can be accounted for by a small sampling period relative to the mean wind and by wind variability. In an ACARS-only collocation study by Benjamin, Schwartz, and Cole (1999), an RMS vector error of 1.8 m/s was reported.

2.2. MDCRS Variables

From the national database of MDCRS observations provided by FSL, a three-year span of reports were used for this study from January 1997 through December 1999. The following variables were used:

- Latitude/longitude (hundredths of degree)
- Time (nearest minute)
- Pressure (tenth of millibar, converted from kPa)
- Altitude (tenths of meter)
- Wind direction (nearest degree true-north)
- Wind speed (hundredth of meter/second, converted to knots)

Observations that were flagged as erroneous by the quality-control procedures run by FSL were not used in this study.

2.3. MDCRS Altitude Correction

The altitudes reported by MDCRS observations assume a standard atmosphere between the ground and the aircraft pressure level. This can introduce significant errors in altitude readings since the atmosphere rarely matches all standard conditions. In an effort to compensate for this error, hourly surface observations recorded by the National Weather Service (NWS) at each of the airports in this study were used to replace the standard assumed values with measured values. The recorded surface pressure and ambient temperature were used in conjunction with the MDCRS pressure at flight level to recalculate a more accurate altitude. The altitude was corrected with a variation of the hydrostatic equation as:

$$\text{Altitude} = \left(\frac{T_{surface} * std\_lapse}{P_{surface}^{(std\_lapse * R/g)}} \right) * \left(P_{surface}^{(std\_lapse * R/g)} - P_{mdcrs}^{(std\_lapse * R/g)} \right)$$

where

$T_{surface}$ = surface temperature (Kelvin)

$P_{surface}$ = surface pressure (millibars)

P_{mdcrs} = MDCRS pressure (millibars)

std_lapse = 6.5 degrees Kelvin/kilometer (standard lapse rate of US Standard Atmosphere)

R = 287.05 Joules/kilogram*Kelvin (ideal gas constant)

$g = 9.8 m/s^2$ (gravitational force of Earth)

Hourly wind observations were not always available to correct the MDCRS altitudes. In these cases, the altitudes were simply left as reported. This could potentially introduce some error into the results where wind observations with uncorrected altitudes are being compared with observations that were corrected. However, since only relatively low altitudes were of interest in this study, the differences between corrected and uncorrected altitudes are not very large. One millibar of pressure difference would lead to an average altitude error of around 5.5 feet. Observed surface pressures rarely exceed 40 millibars above or below the standard atmospheric pressure, meaning that the altitude adjustment on the report is normally within 200 feet.

2.4. Headwind and Crosswind Calculation

The next step towards making the MDCRS wind data more useful was to break the wind vectors into positive and negative headwind and crosswind components. A positive headwind is simply the conventional headwind. A tailwind originates from the negative direction. A positive crosswind refers to a wind originating from the right of the aircraft and a negative crosswind is from the left. All components were calculated with respect to the true-north heading of the most frequently used configuration for the parallel runways of interest at each airport. However, since runway configurations can shift frequently due to changing wind directions, the headwind and crosswind statistics generated for each airport are only valid for the specified configuration. It is understood that the presence of moderate or strong tailwinds would indicate that a different runway configuration would be used, but the statistics generated are helpful in determining how often the specific configuration of interest is employed.

2.5. Altitude and Position Restrictions

MDCRS observations taken at or below 5000 feet above ground level were used in this study. The data were grouped into bins of 1000 feet to ensure that there would be enough observations in each layer to generate meaningful statistics. Also, in an effort to ensure a sufficient amount of data, wind observations taken within 1 degree latitude and 1 degree longitude from each airport of interest were included in the data set. This did lead to the inclusion of some observations from aircraft which were operating at other nearby airports, but it was determined that this had very little impact on the results.

Even using these liberal methods of data acceptance, Table 2 shows that some of the airports of interest yielded a relatively small amount of data considering the three-year sample that was used. The smaller amounts of data are most likely due to a lack of flights into and out of the airport by airlines participating in the MDCRS observation effort. STL was of interest in this study, but there were insufficient data to analyze.

Table 2.
MDCRS Observation Totals

Airport	Total Observations
BOS	12442
EWR	54517
PHL	35946
SFO	39586
SEA	11174
STL	3331

2.6. Exceedance Probability

The first parameter calculated for each wind component was the probability that either the headwind or crosswind would exceed a particular value at any given time, hereafter referred to as exceedance probability. These values were calculated by dividing the number of observations that exceed the given value by the total number of observations. Exceedance probabilities were calculated for headwind and crosswind speeds for one-knot intervals in a range spanning from –20 to +20 knots. It must be noted that the probabilities calculated for the negative values of the range represent an observation exceeding that value's magnitude in the negative direction (i.e., a stronger tailwind or negative crosswind).

Probabilities were also calculated from wind observations taken strictly during LCV times. As previously noted, LCV is defined to be cloud ceilings lower than 4500 feet and/or visibilities less than 7 miles. The presence of these conditions was determined by using the NWS hourly surface observations. The exceedance probability values are very useful in determining general characteristics of wind behavior at each of the airports.

2.7. Headwind and Crosswind Comparisons

To assess the dependence between headwind and crosswind values, probabilities were determined for all possible headwind and crosswind pairings over a range from –20 knots to +20 knots for each wind component. Plots were made which displayed the probability of each possible pairing over the entire data set. Conditional probabilities for each headwind and crosswind pair were also computed and the results were plotted. To further quantify the results of all these plots, correlation coefficients were calculated between the headwind and crosswind values for each airport.

2.8. Headwinds and Crosswinds with Altitude

Hourly means of both headwind and crosswind values from each 1000-foot layer were computed to compare the correlation of winds with altitude. The hourly means were used in order to minimize the influence of wind variability.

In this study, adjacent altitude layers were compared to determine headwind or crosswind relationships with respect to altitude. Conditional probabilities for each headwind and crosswind pair between the altitude layers were computed and plots were made of the results. Correlation coefficients were also calculated from these data.

3. WIND ANALYSIS RESULTS

3.1 Exceedance Probability Results

3.1.1 SFO

Figure 2 shows headwind exceedance probabilities for the entire SFO data set. It can be easily seen that there is a high probability of experiencing a strong positive headwind when landing on runways 28R or 28L. Note that tailwind probabilities were computed even though this may mean that a different approach runway would be used. There also tends to be little directional or speed shear with altitude since the results for each 1000-foot layer shown are very similar. Figure 3 shows the results for LCV times. Note that there are very few differences, with the exception being a little more shear possible with altitude as the probabilities between layers are a bit more widely-spaced.

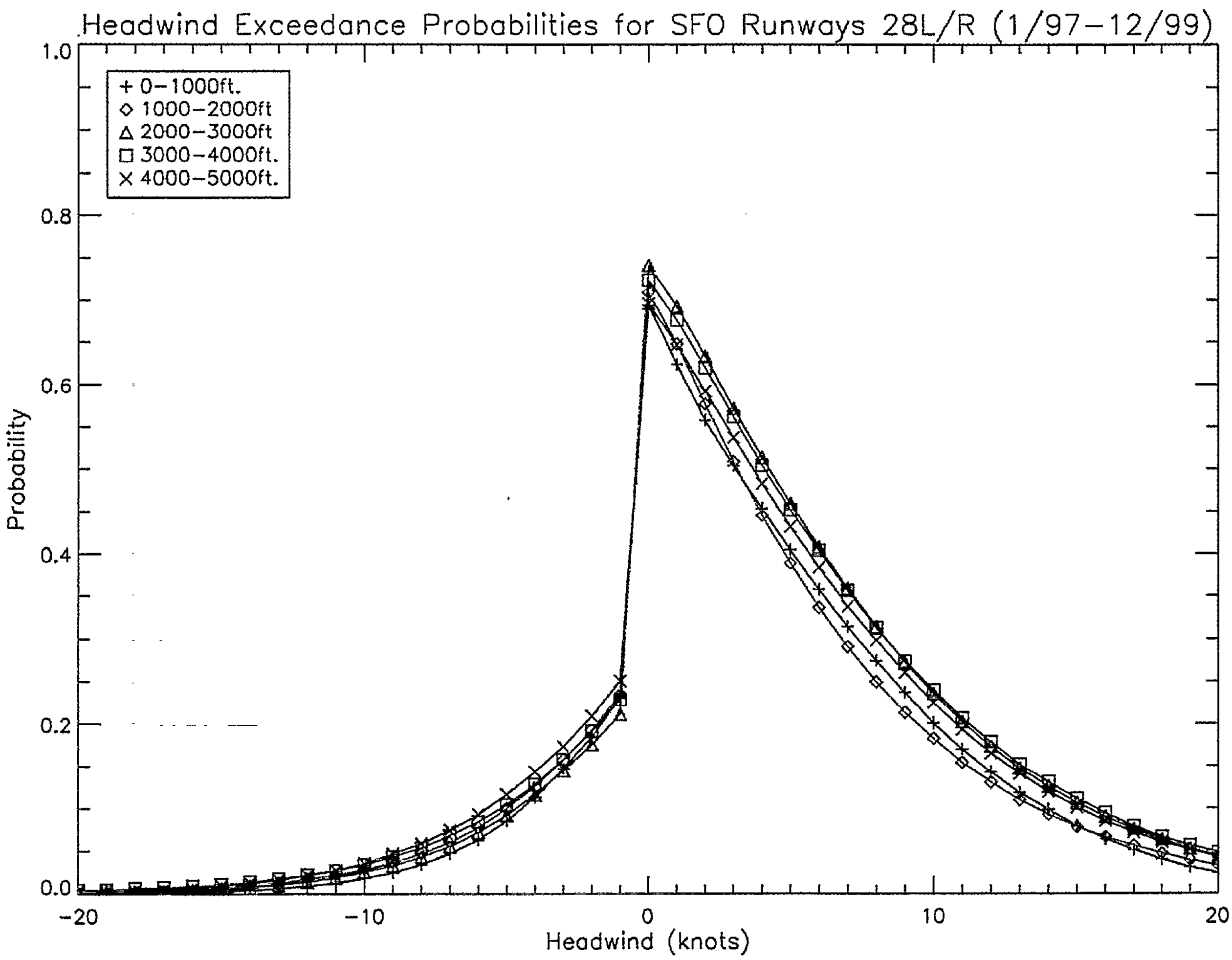

Figure 2. Headwind exceedance probabilities for SFO comparing 1000-foot layers between 0-5000 feet.

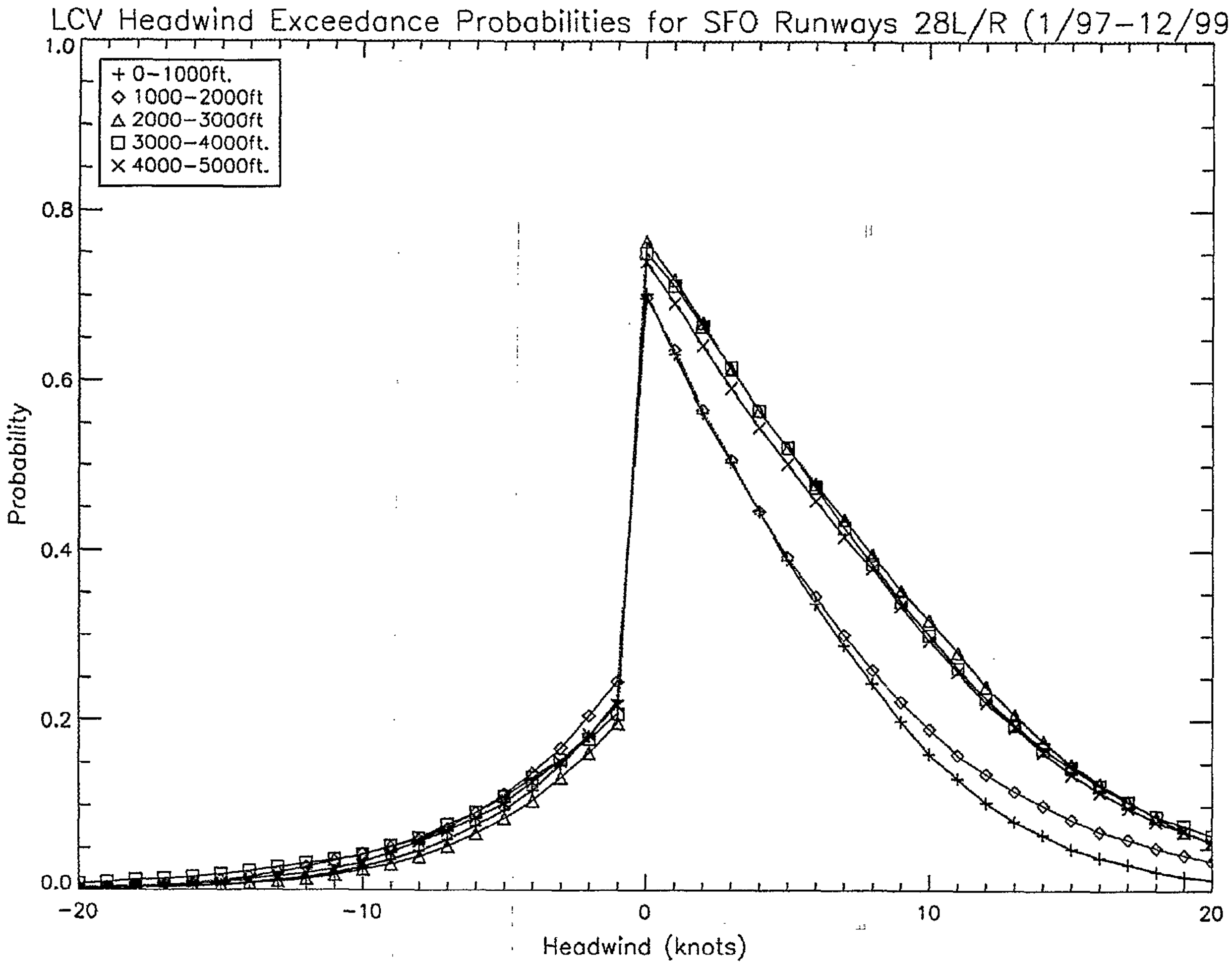

Figure 3. Headwind exceedance probabilities for SFO during LCV conditions.

Figure 4 shows a nearly equal distribution of positive and negative crosswind probabilities during all weather conditions. Crosswinds also look to be light in either direction given the steep decline in exceedance probabilities with increasing wind magnitude. During LCV times in Figure 5, there tends to be a higher probability of negative crosswinds than during all conditions.

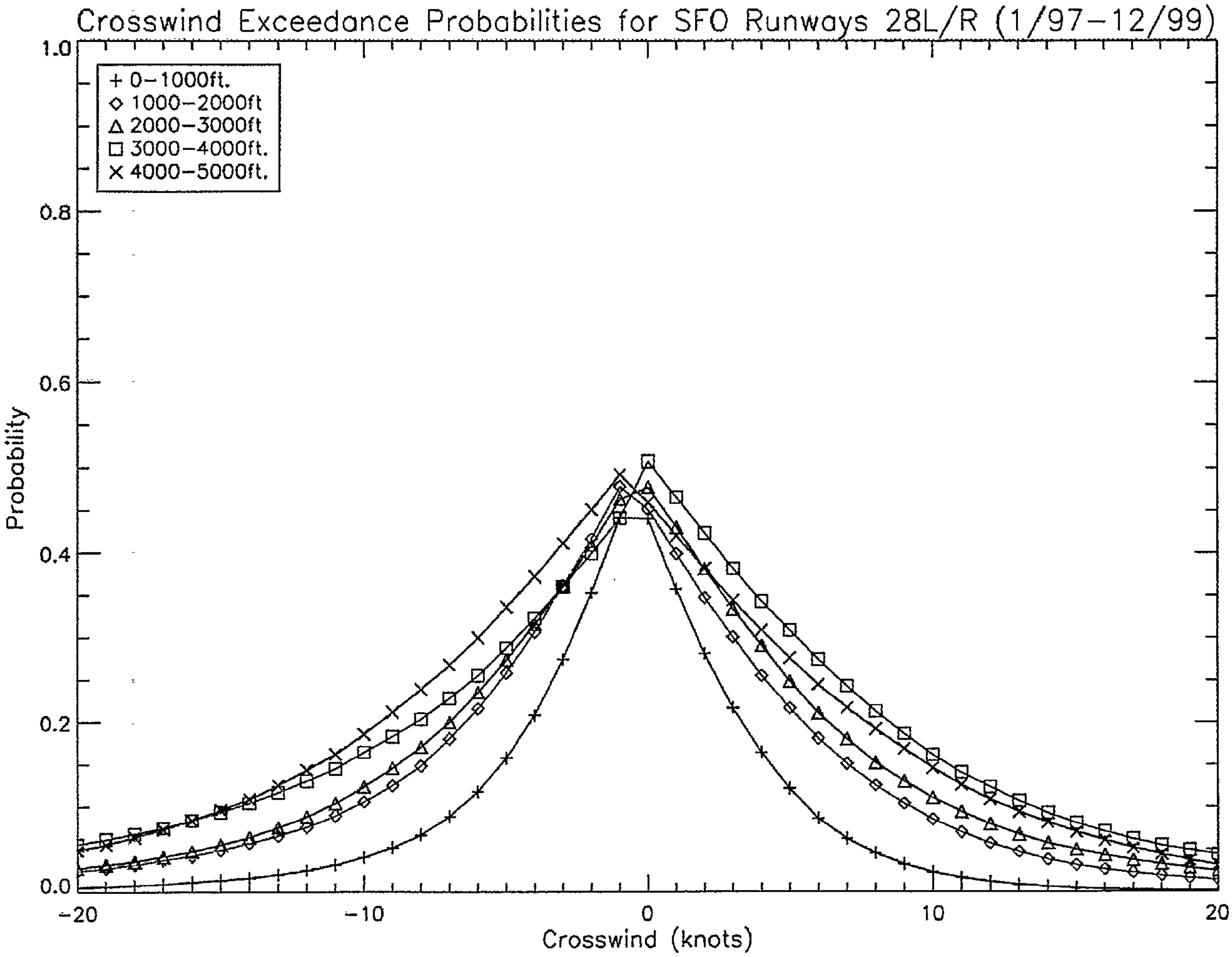

Figure 4. Crosswind exceedance probabilities for SFO comparing 1000-foot layers between 0-5000 feet.

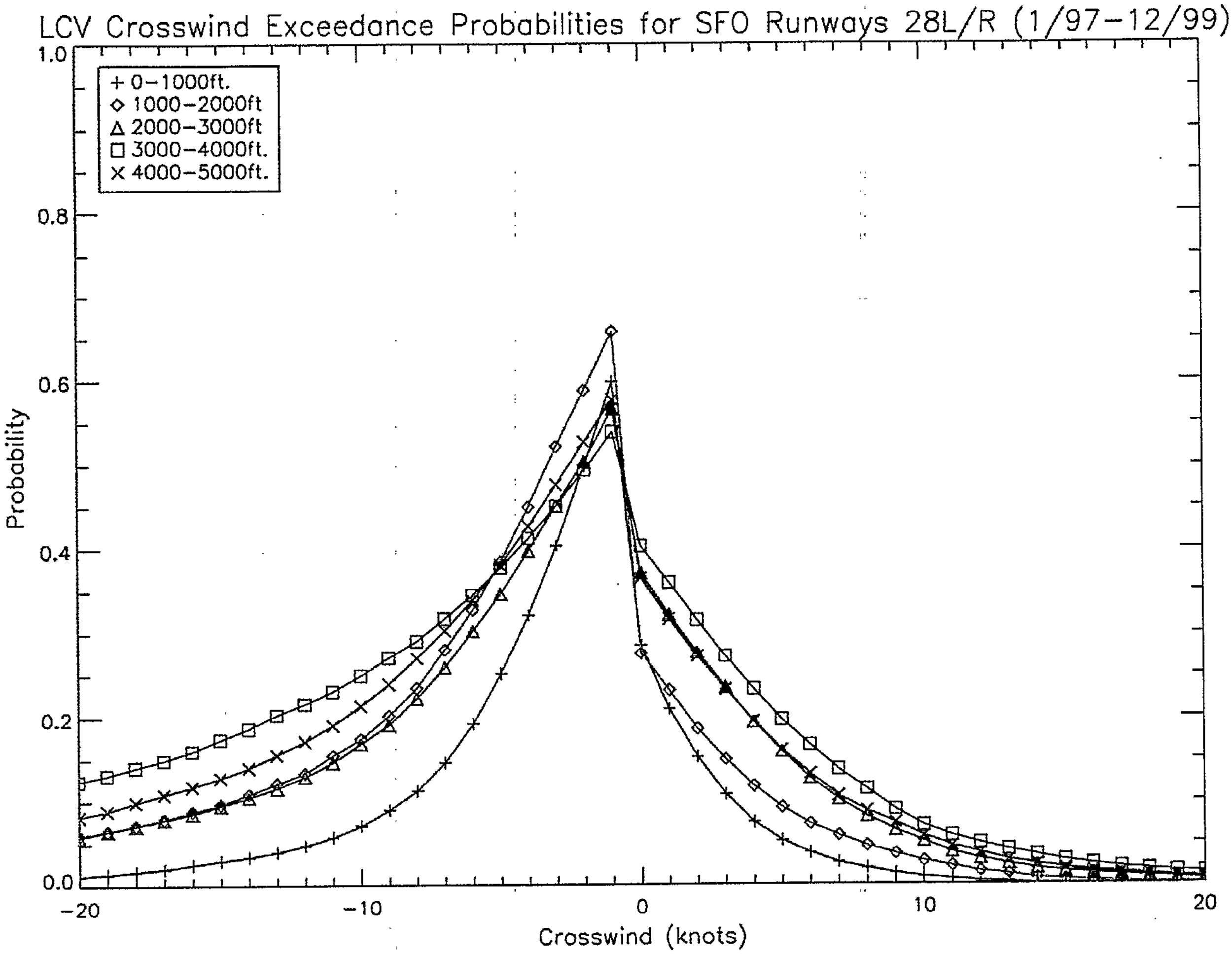

Figure 5. Crosswind exceedance probabilities for SFO during LCV conditions.

3.1.2 BOS

The nearly equal distribution of positive and negative headwind exceedance probabilities in Figure 6 shows that there is no clearly predominant wind direction for Boston's parallel runways when sampling the entire data set. This figure also shows that there is very little shear between layers once above 1000 feet. However, the behavior during LCV times shown in Figure 7 shows a stronger tendency for positive headwinds in the lower layers, and a tendency for negative headwinds in the upper layers with more range in speed between all of them. This may be due to the general tendency for winds to originate out of the east and northeast (positive headwinds) near the surface during LCV conditions.

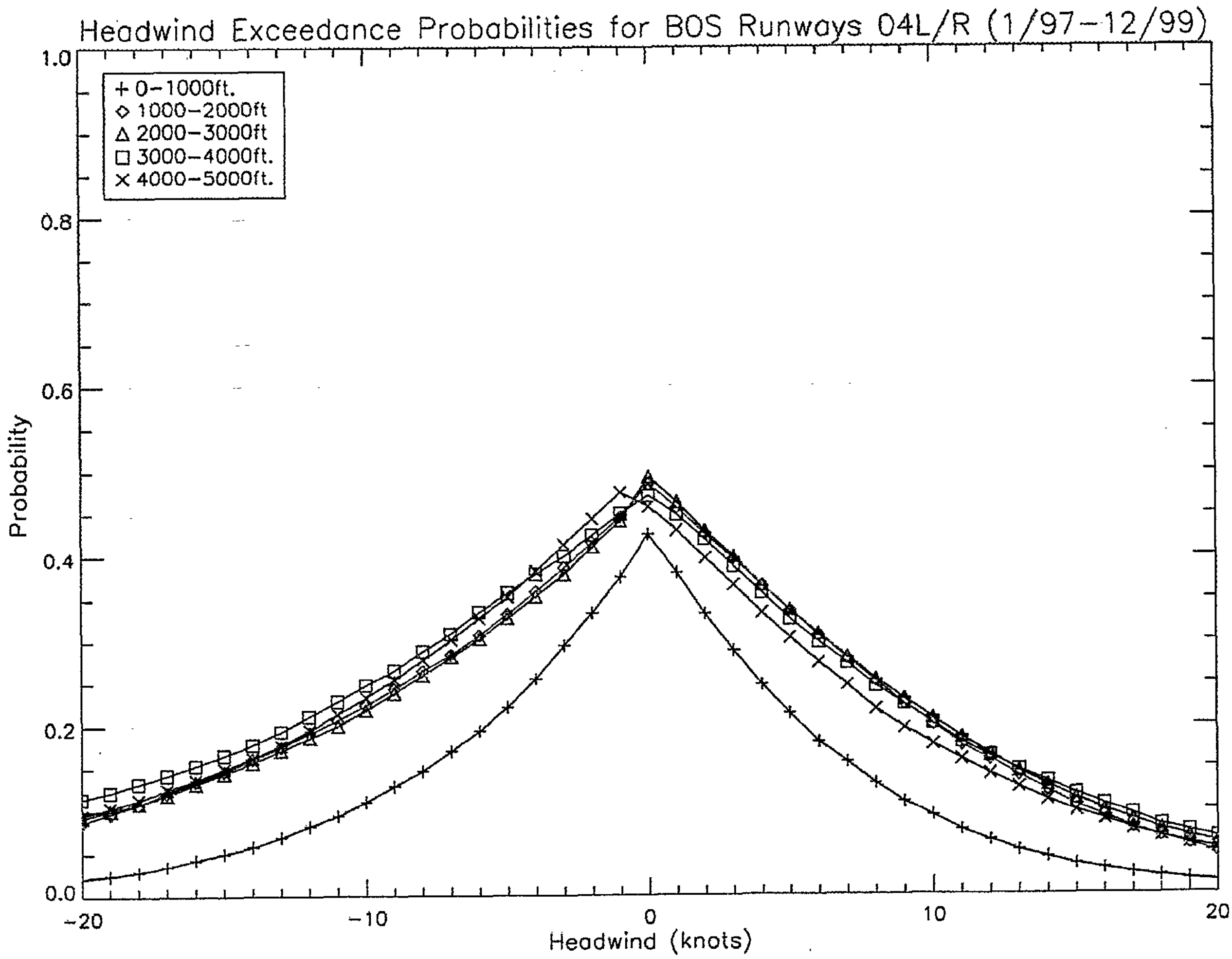

Figure 6. Headwind exceedance probabilities for BOS comparing 1000-foot layers between 0-5000 feet.

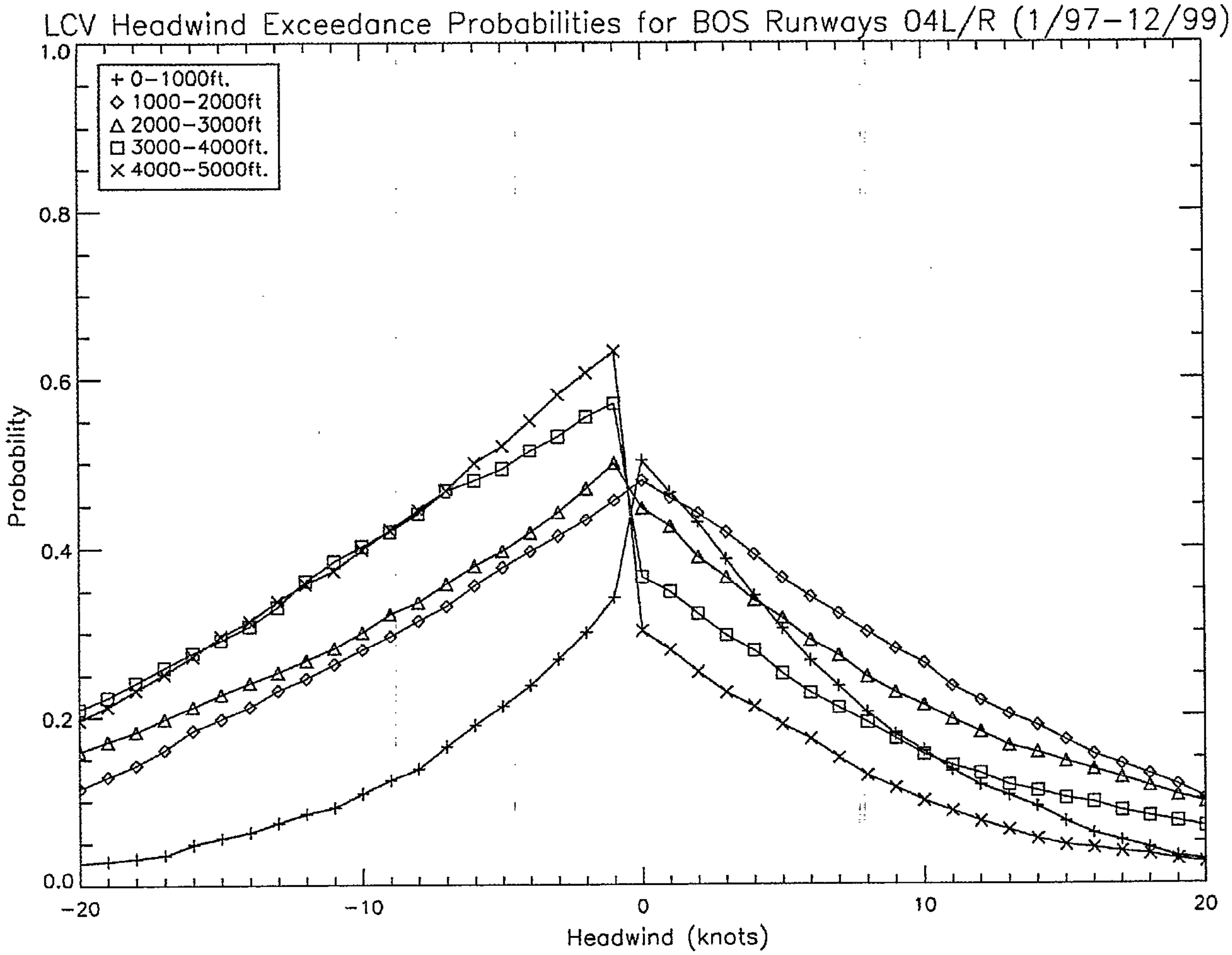

Figure 7. Headwind exceedance probabilities for BOS during LCV conditions.

Figure 8, which displays crosswind exceedance probabilities over the entire data set, shows a tendency for negative crosswinds near the surface with much higher probabilities in the upper layers. During LCV times, shown in Figure 9, crosswinds are distributed more evenly than during all conditions, but the tendency for negative crosswinds remains in the upper layers. However, it is not as pronounced.

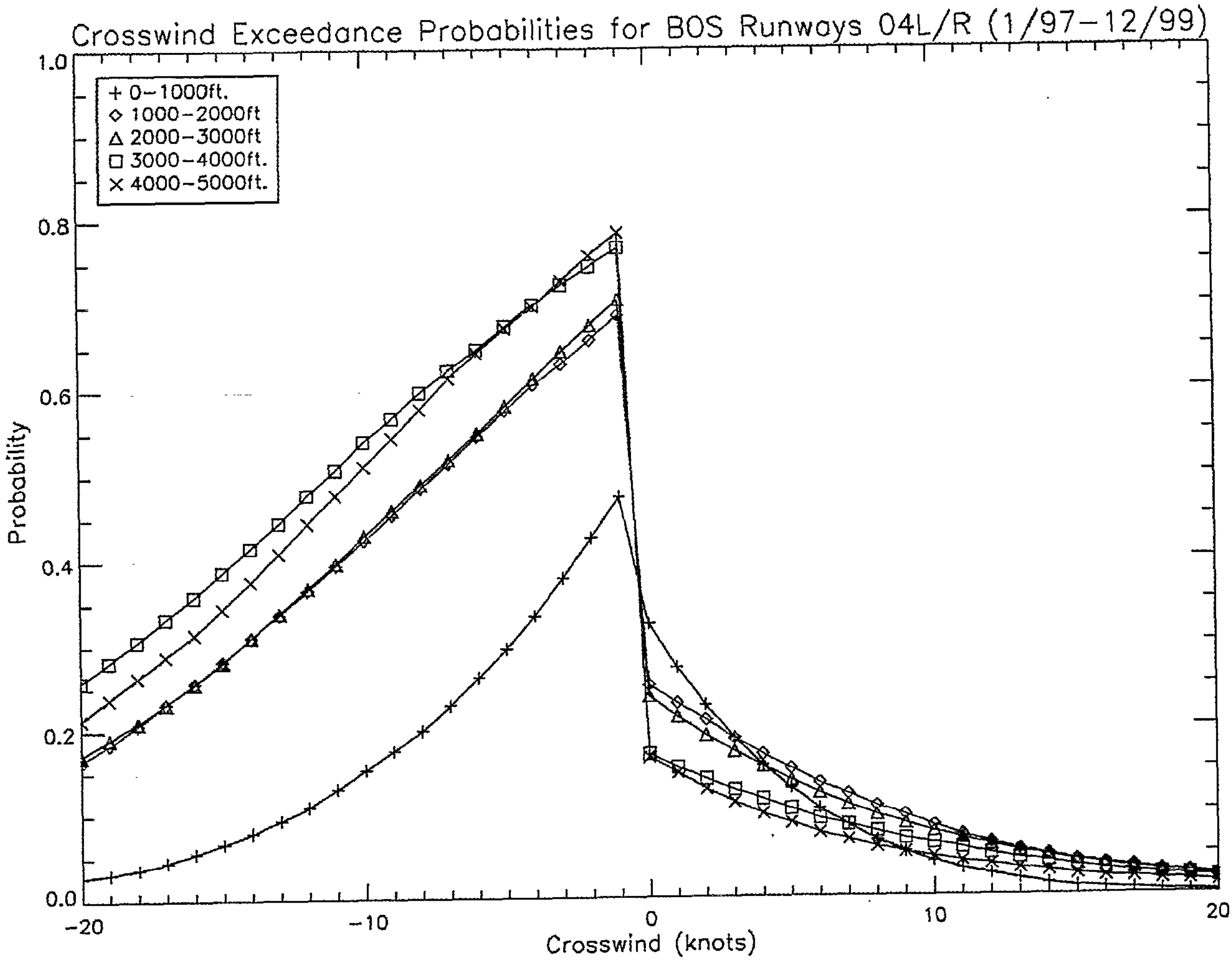

Figure 8. Crosswind exceedance probabilities for BOS comparing 1000-foot layers between 0-5000 feet.

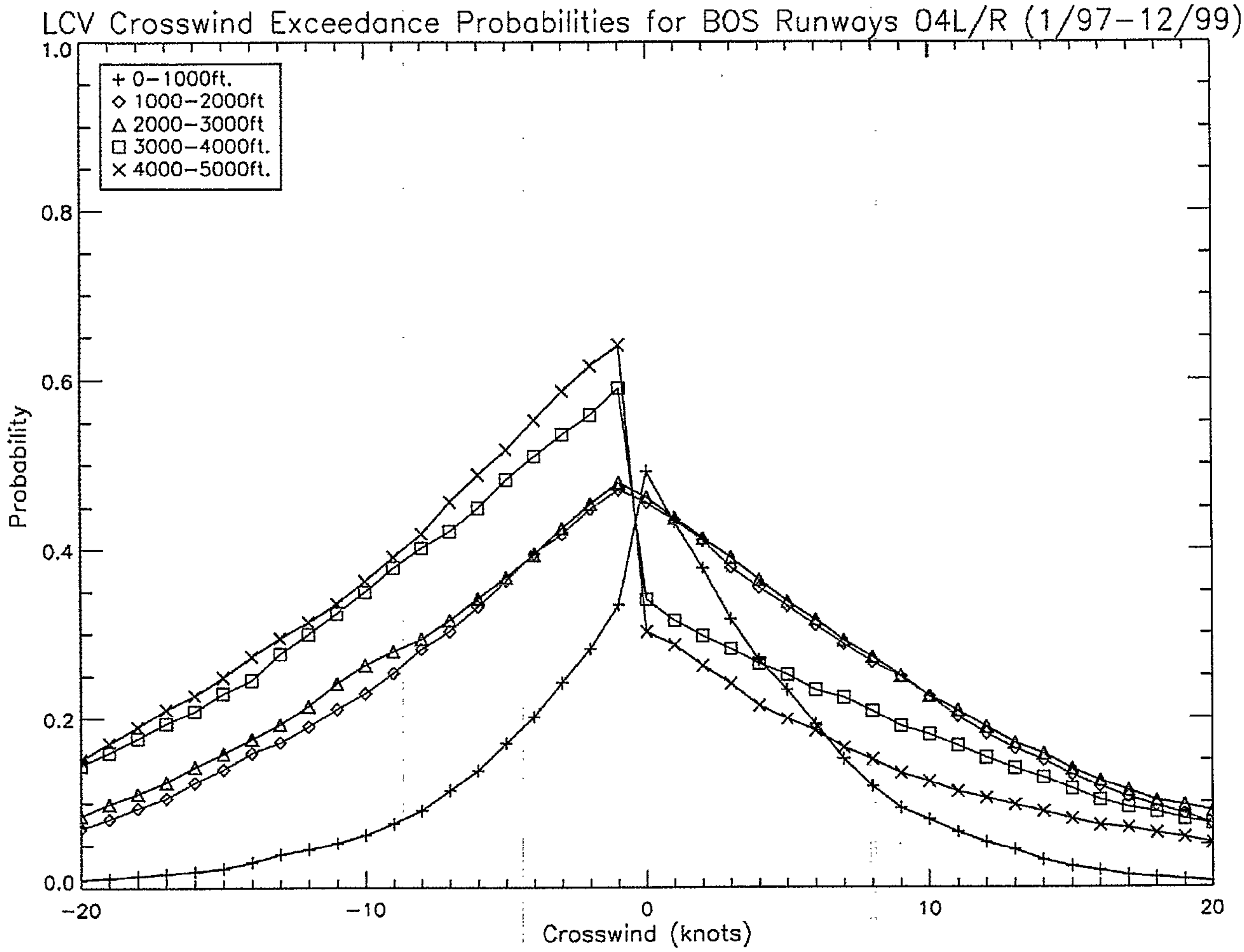

Figure 9. Crosswind exceedance probabilities for BOS during LCV conditions.

3.1.3 EWR

The exceedance probabilities seen in Figure 10 for the entire EWR data set display a nearly even distribution between positive and negative headwinds in all layers over runways 22L and 22R. Those shown in Figure 11 for LCV times show a strong tendency for positive headwinds, especially in the higher layers. However, in the surface layer, probabilities are nearly evenly distributed with a large gap between this layer and all the other layers.

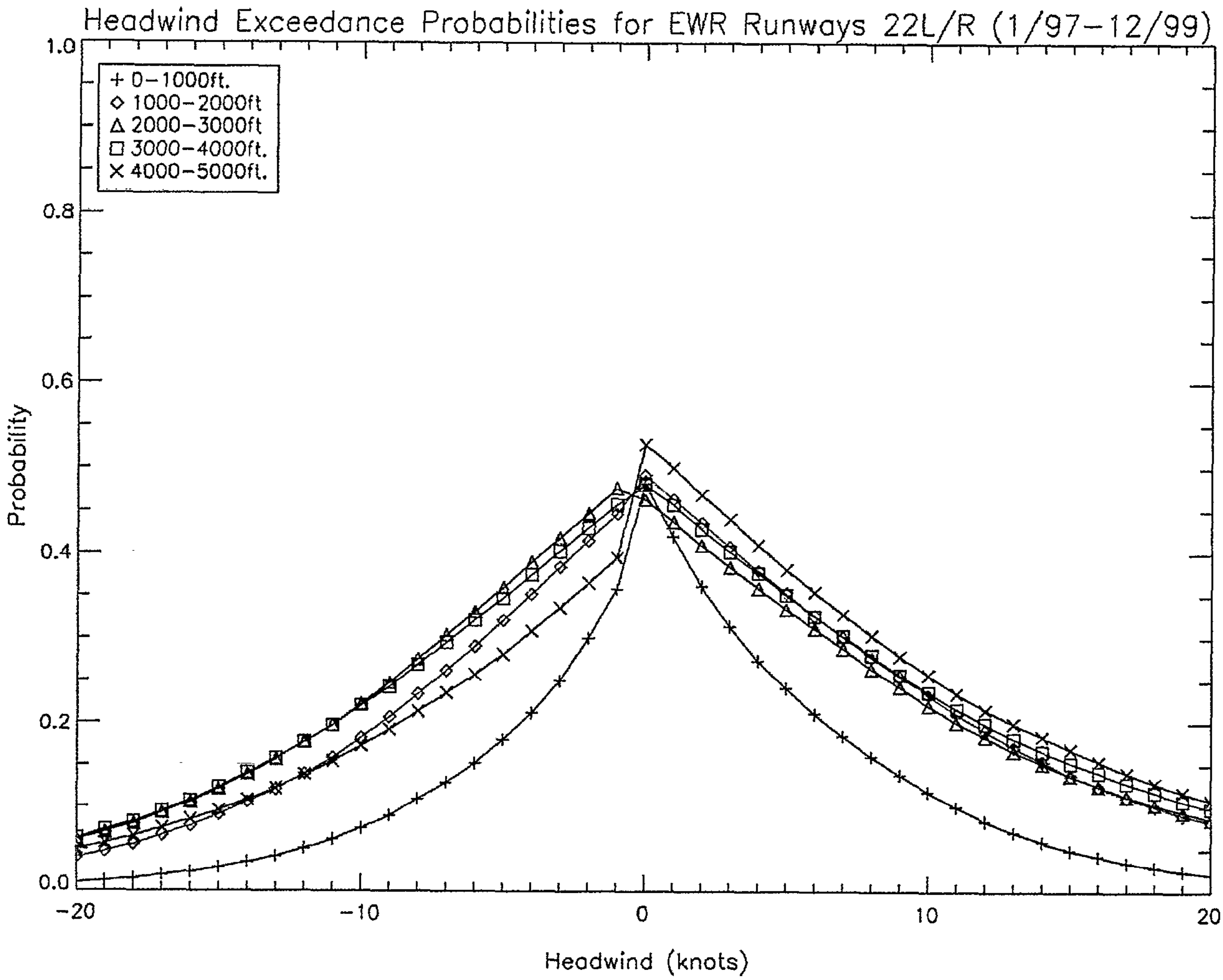

Figure 10. Headwind exceedance probabilities for EWR comparing 1000-foot layers between 0-5000 feet.

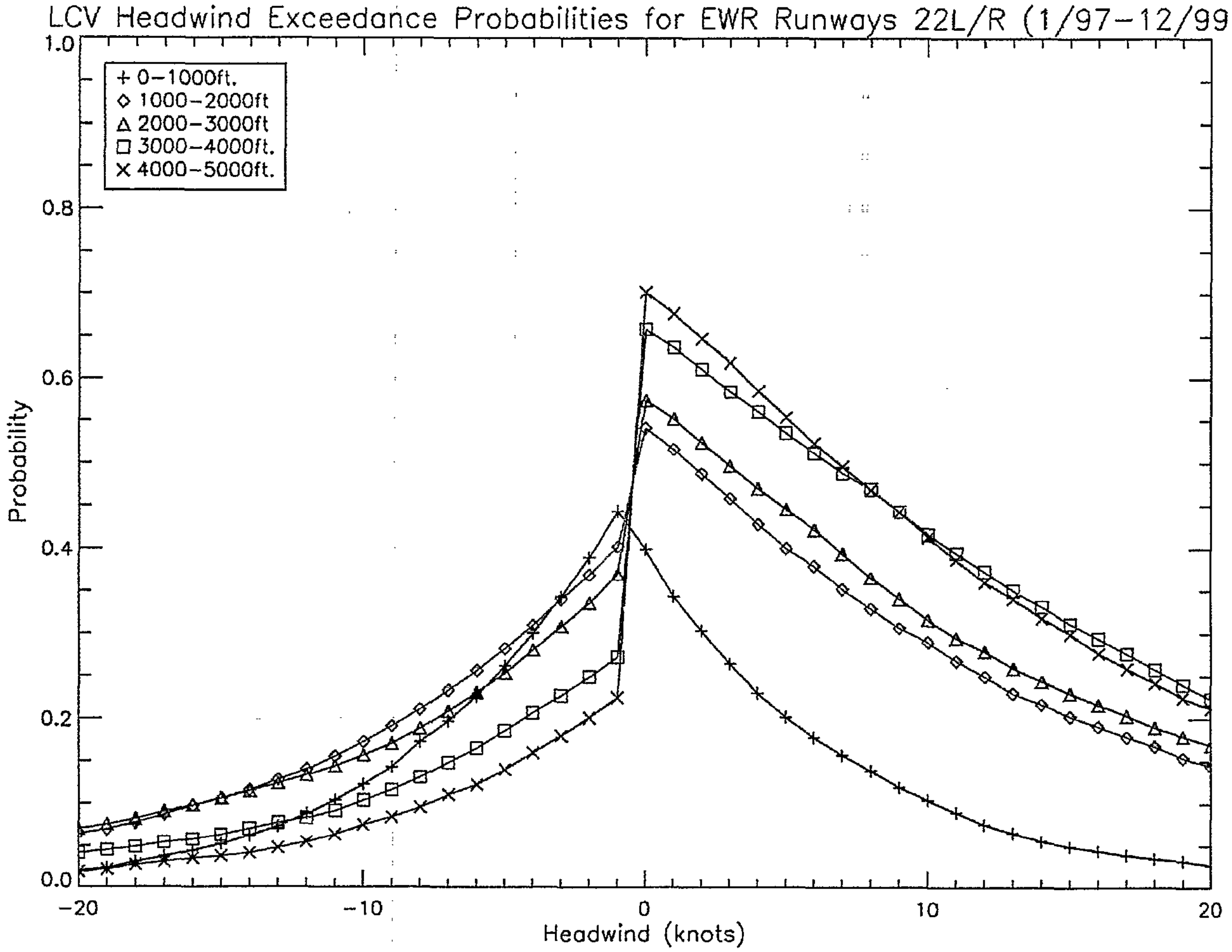

Figure 11. Headwind exceedance probabilities for EWR during LCV conditions.

Figure 12 shows a strong tendency for positive crosswinds over all weather conditions. During LCV times, Figure 13 shows that the probabilities are more evenly distributed. This figure also shows that there seems to be a slight change in wind direction with altitude. The lower layers show a higher probability of negative crosswind, but probabilities gradually favor the positive direction in the upper layers.

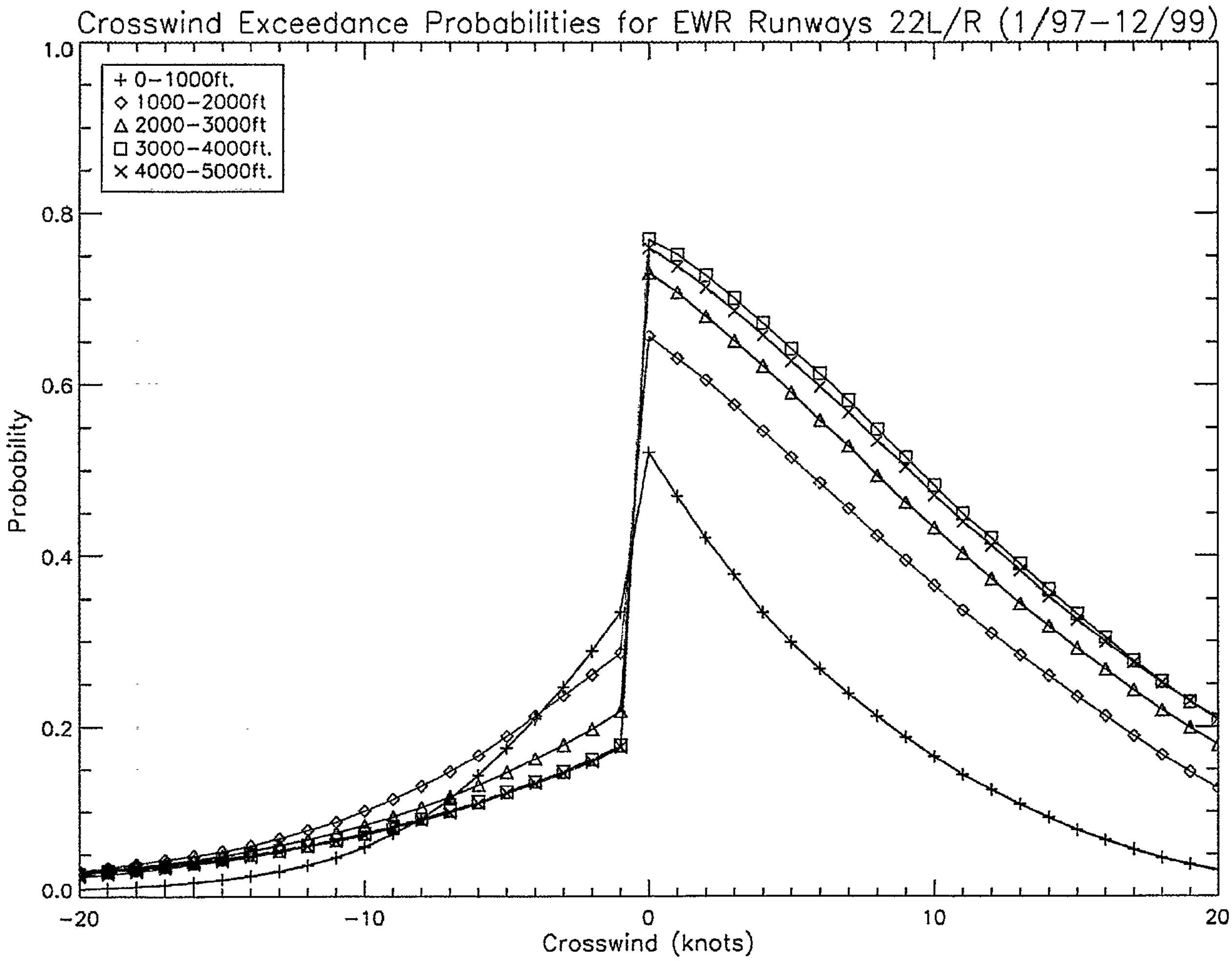

Figure 12. Crosswind exceedance probabilities for EWR comparing 1000-foot layers between 0-5000 feet.

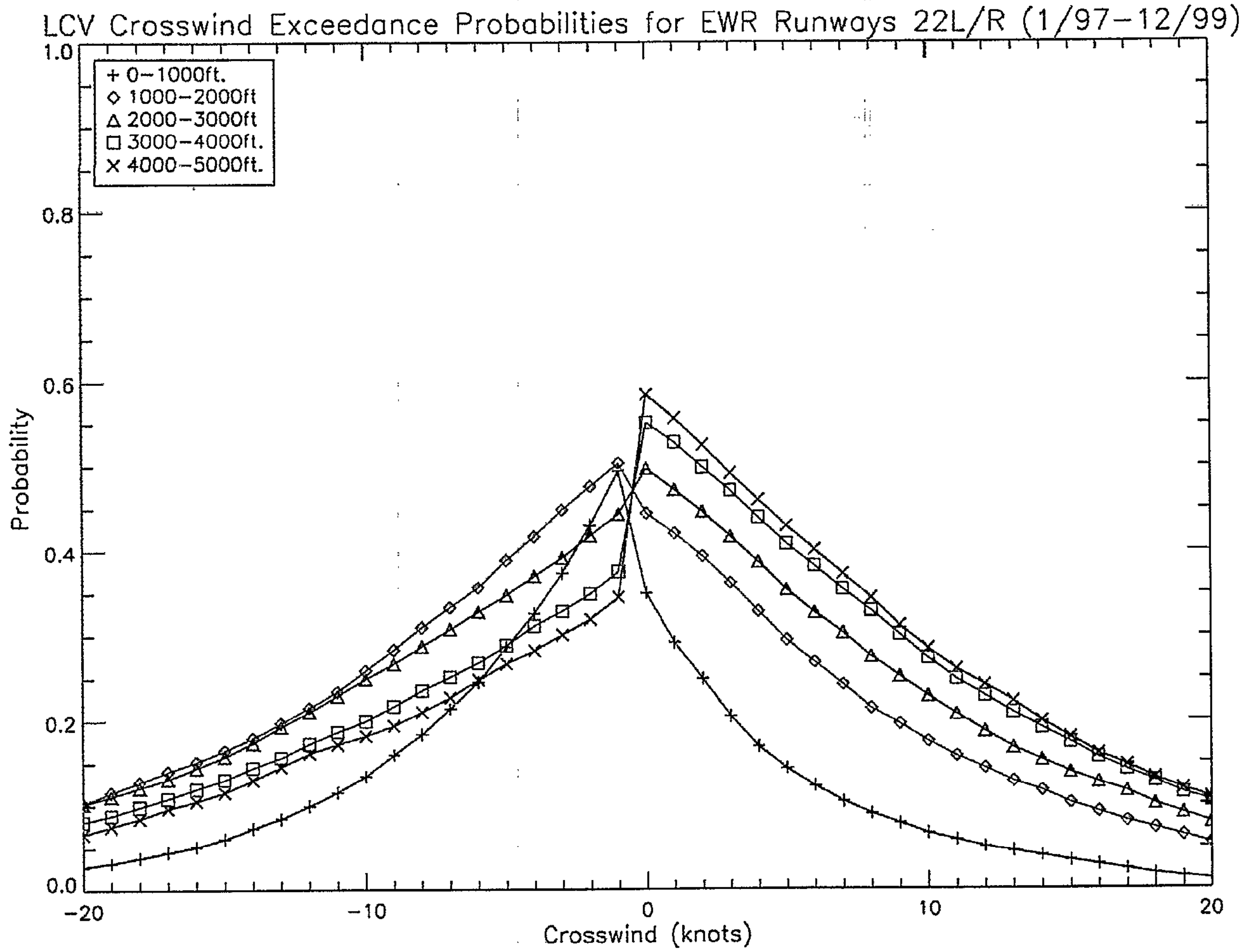

Figure 13. Crosswind exceedance probabilities for SFO during LCV conditions.

3.1.4 PHL

Figure 14 shows a strong tendency for positive headwinds over runways 27L and 27R in Philadelphia when sampling the entire data set. Much the same behavior can be seen during LCV times in Figure 15, with a slightly greater probability of tailwinds than during all weather conditions.

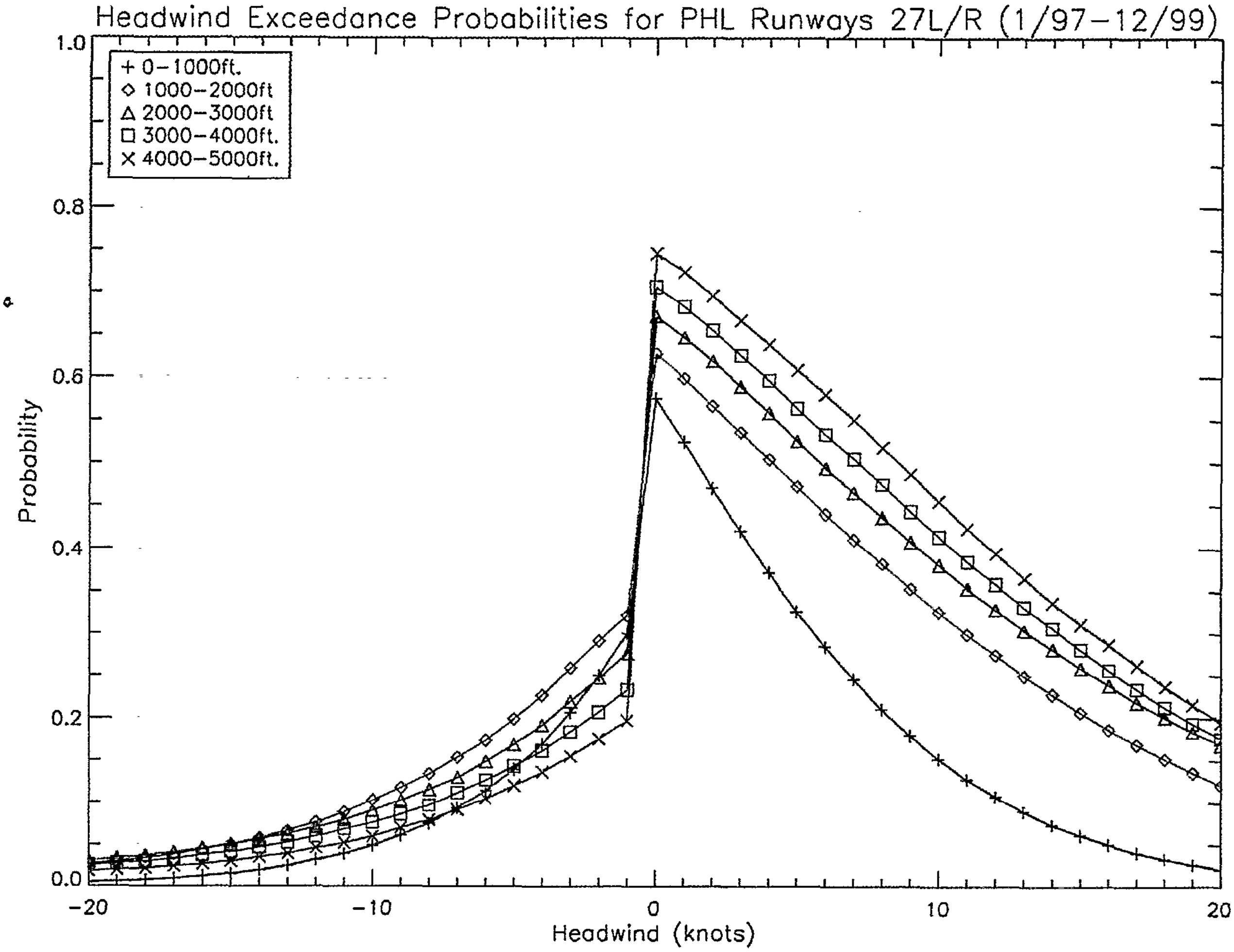

Figure 14. Headwind exceedance probabilities for PHL comparing 1000-foot layers between 0-5000 feet.

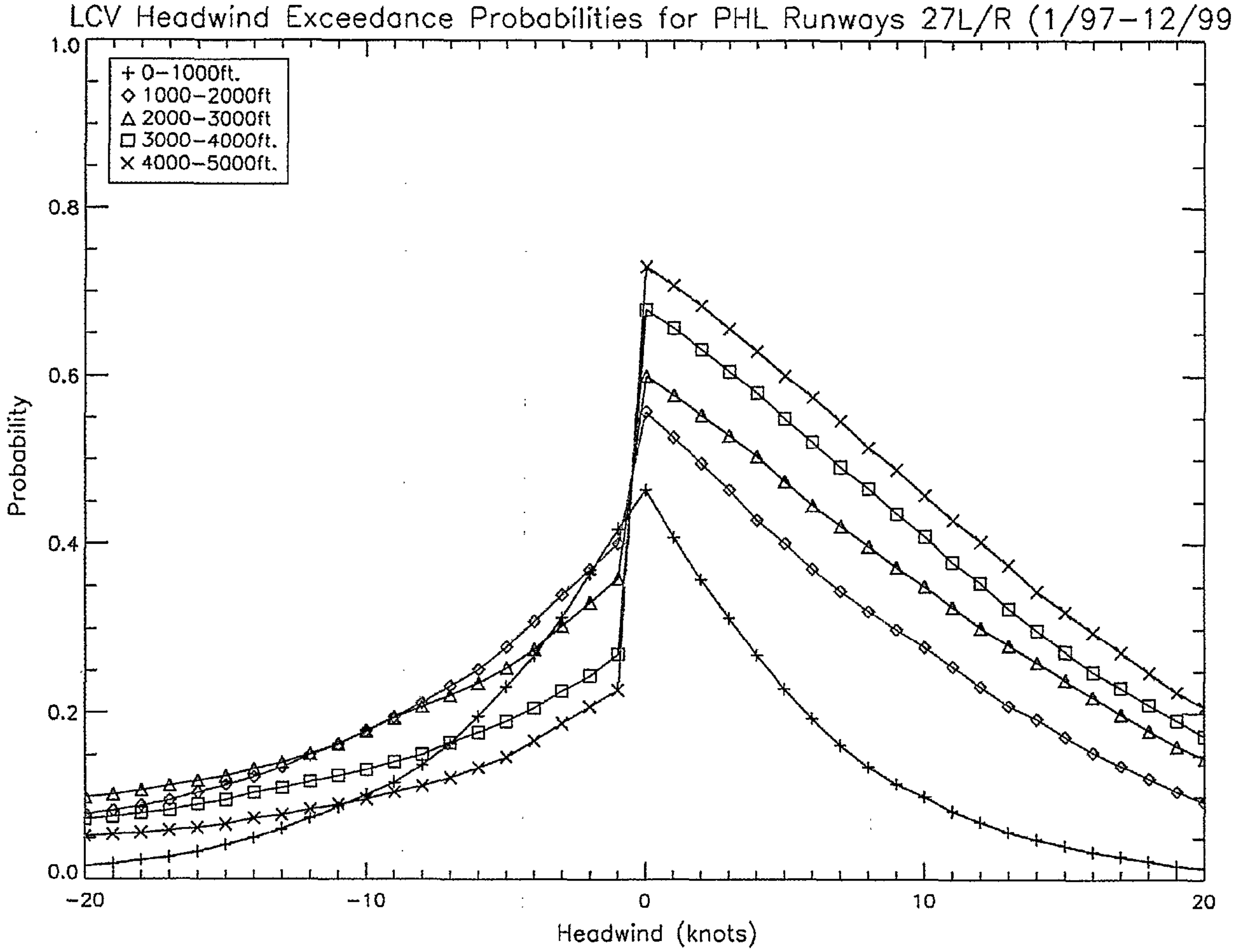

Figure 15. Headwind exceedance probabilities for PHL during LCV conditions.

Figure 16 shows that a strong tendency exists for positive crosswinds, especially in the layers above the surface. The large gap between the surface layer probability values and the upper layers shows that surface winds on average may be substantially lower than the adjacent layers above. The LCV data seen in Figure 17 show a more even distribution of crosswinds than during all conditions with the tendency shifted to the negative direction in the upper layers.

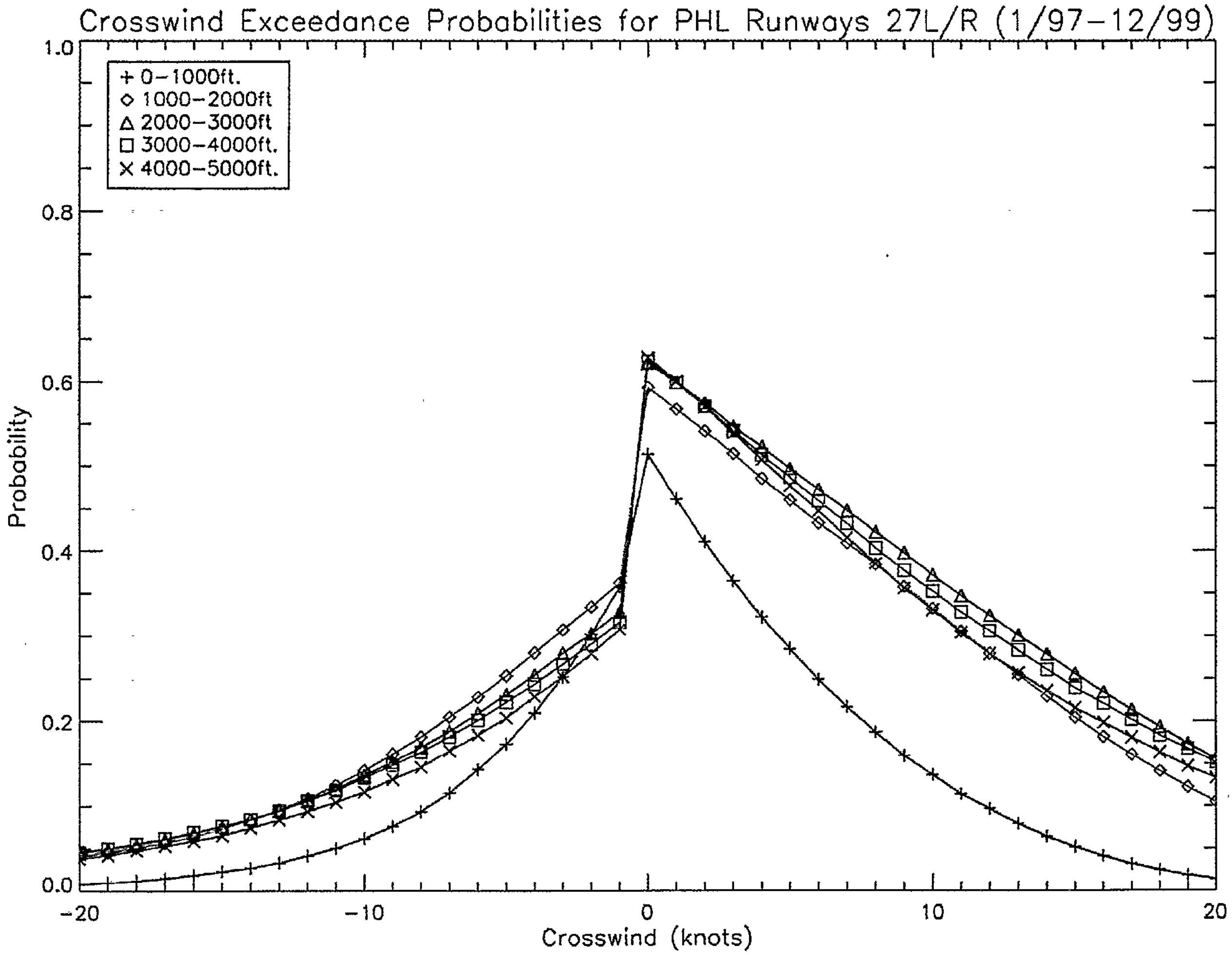

Figure 16. Crosswind exceedance probabilities for PHL comparing 1000-foot layers between 0-5000 feet.

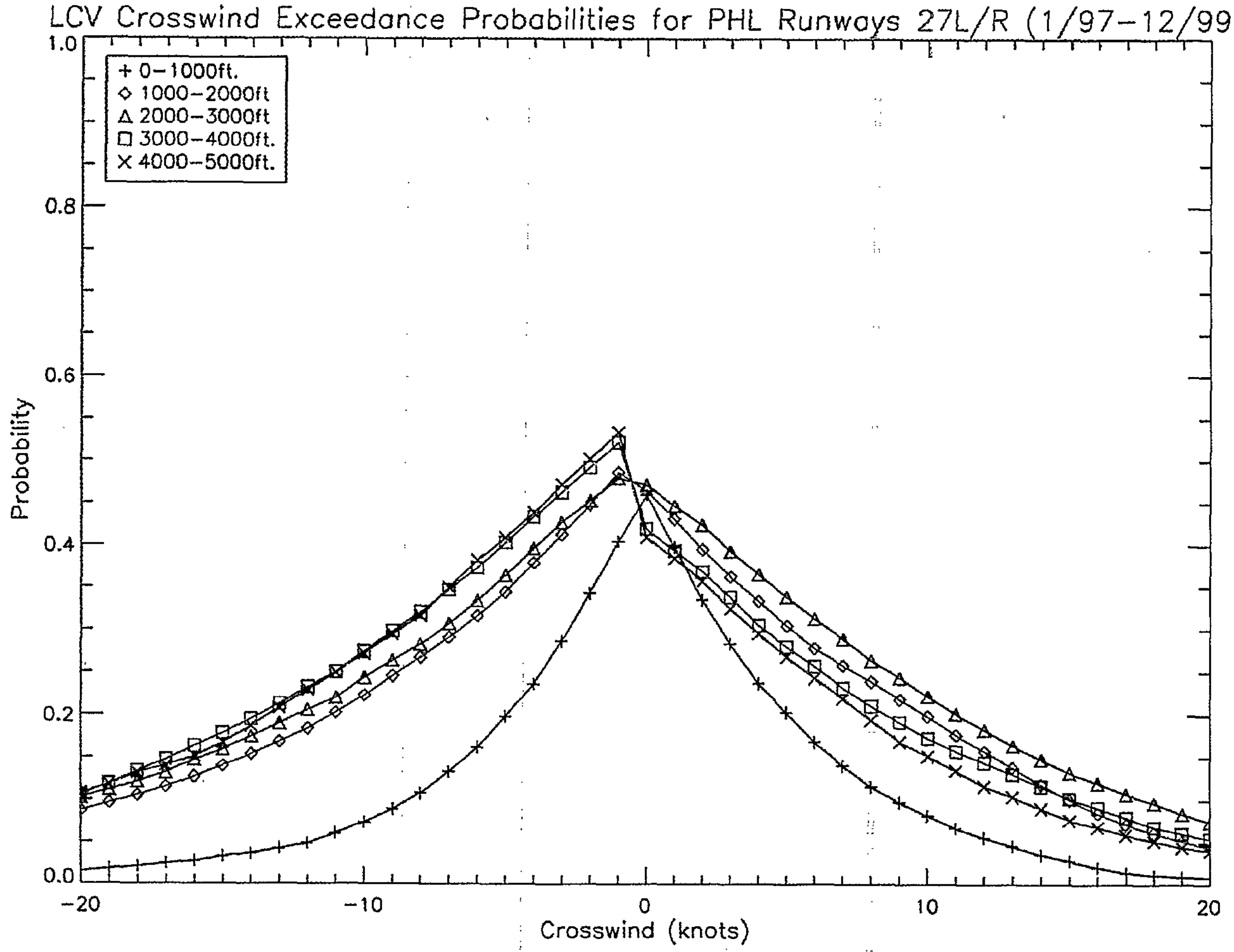

Figure 17. Crosswind exceedance probabilities for PHL during LCV conditions.

3.1.5 SEA

Figure 18 shows a higher probability of positive headwinds over Runways 16L and 16R in Seattle during all weather conditions. For strictly LCV times, as seen in Figure 19, the pattern is much the same with a slightly stronger tendency for positive headwinds during these times.

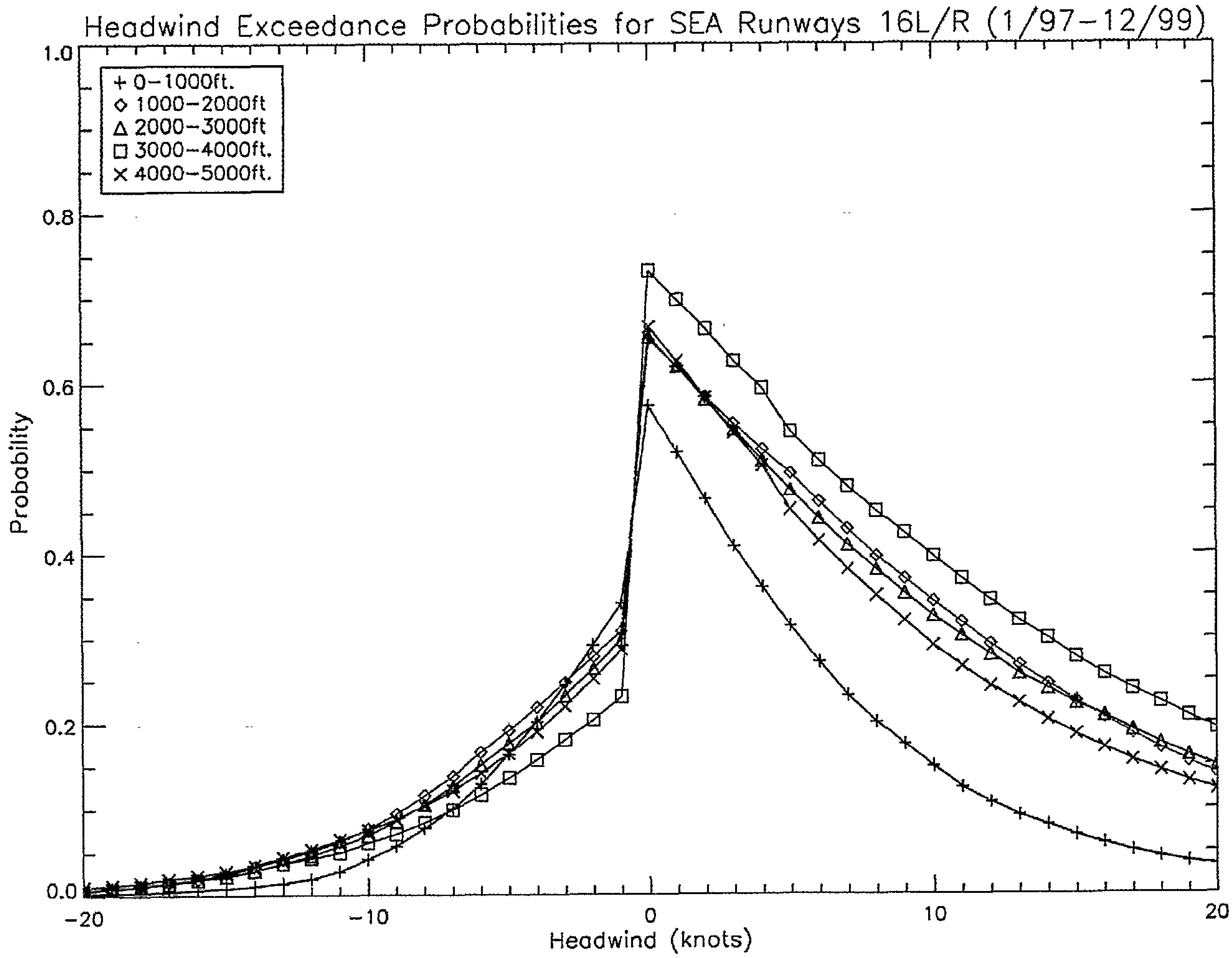

Figure 18. Headwind exceedance probabilities for SEA comparing 1000-foot layers between 0-5000 feet.

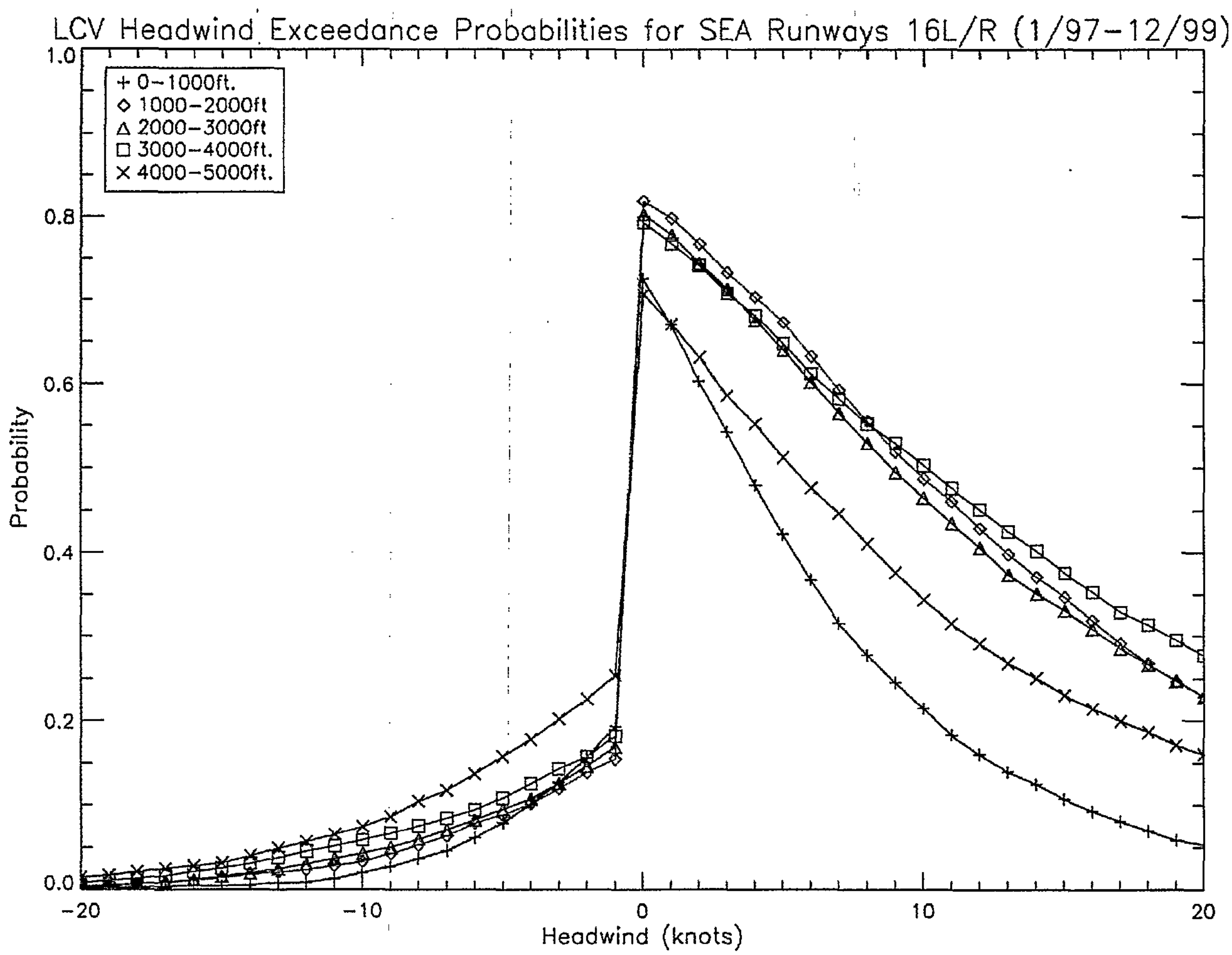

Figure 19. Headwind exceedance probabilities for SEA during LCV conditions.

Given the sharp decline in probability values with increasing magnitude in either direction seen in Figure 20, this is an indication that crosswind values are rarely high at this airport, especially in the surface layer. The observations during LCV times seen in Figure 21 show a similar pattern, but with stronger tendencies for positive crosswinds in the upper layers.

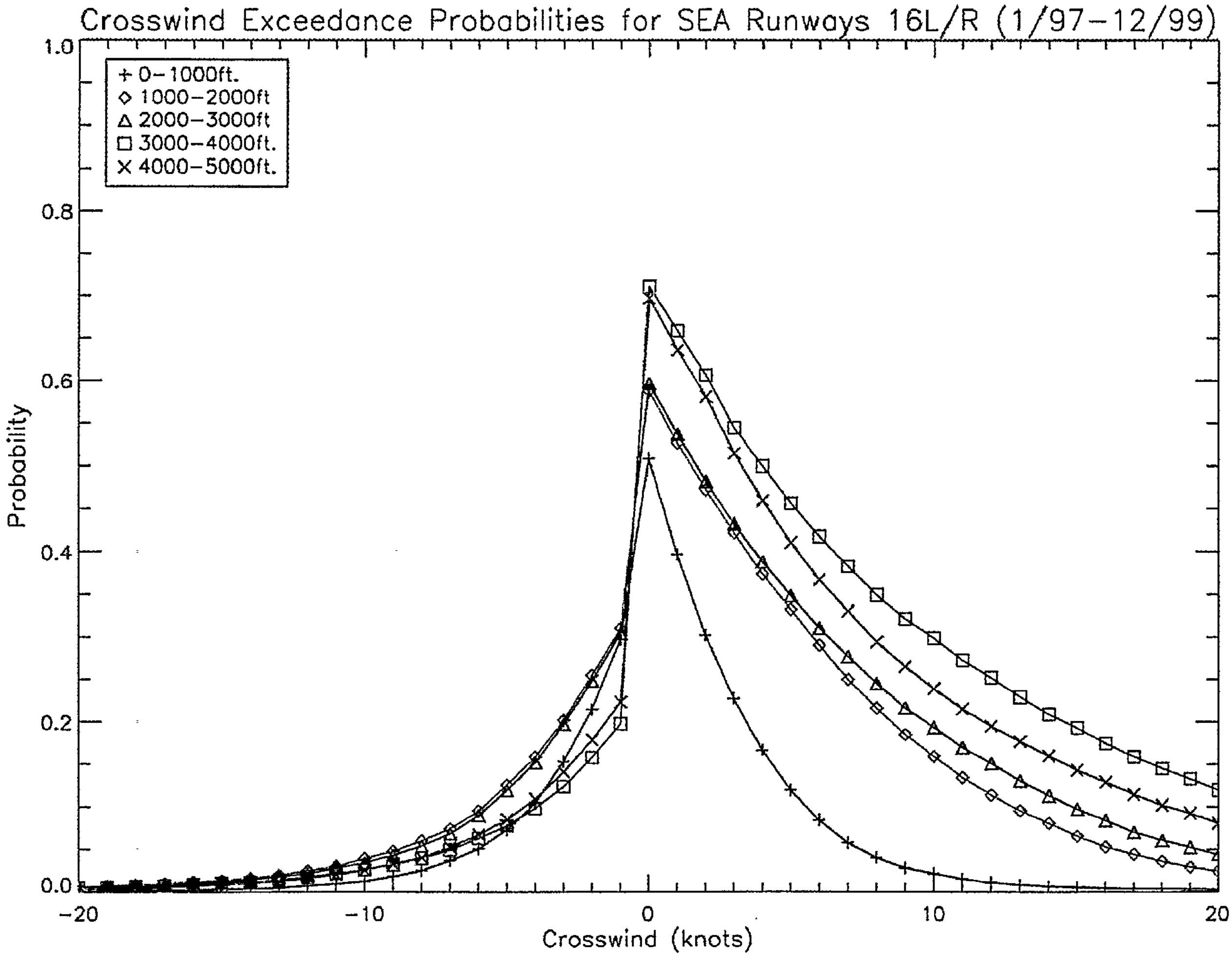

Figure 20. Crosswind exceedance probabilities for SEA comparing 1000-foot layers between 0-5000 feet.

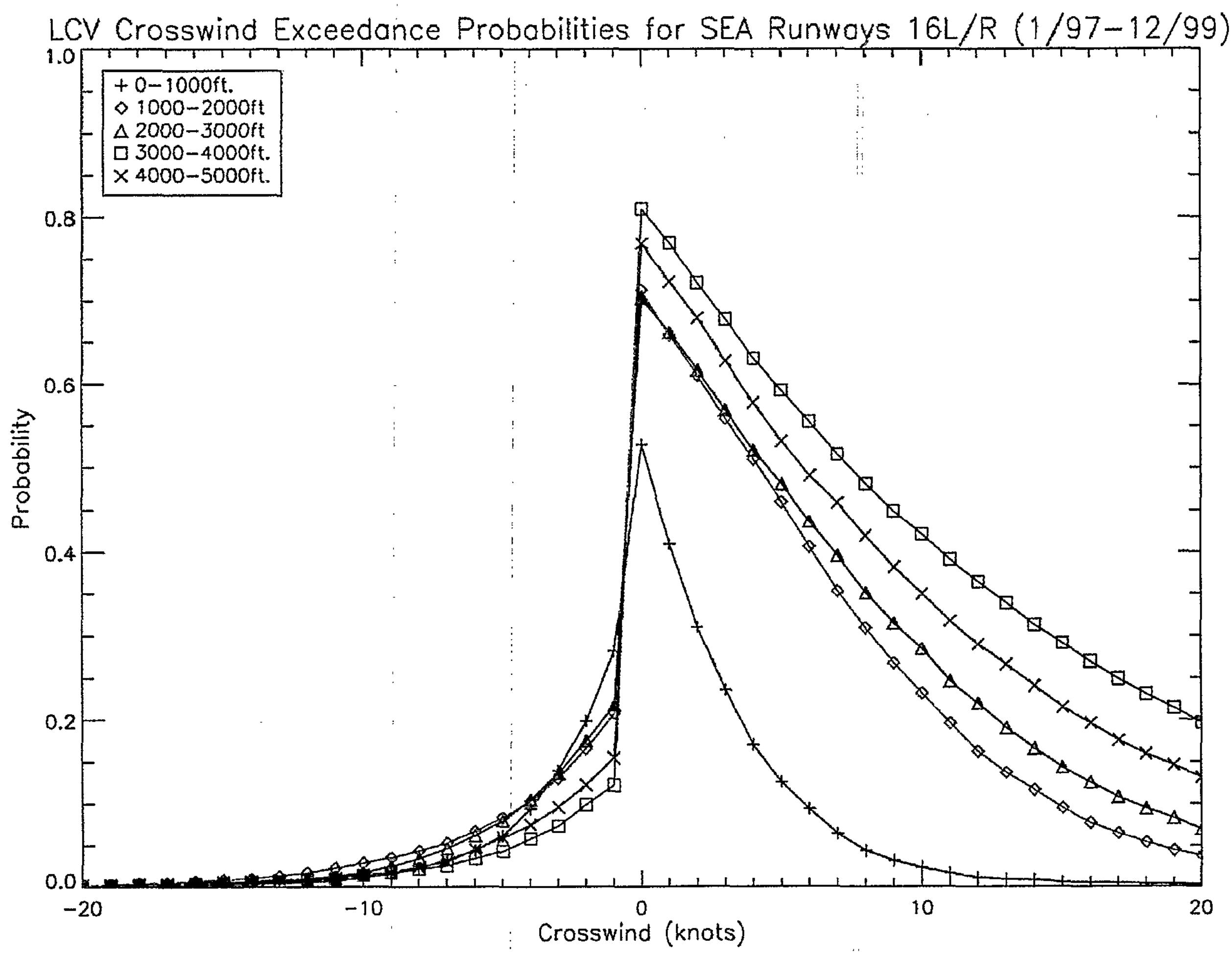

Figure 21. Crosswind exceedance probabilities for SEA during LCV conditions.

3.2 Correlation Results

3.2.1 Headwind and Crosswind Comparison

In an effort to determine the relationship between headwind and crosswind components from given wind observations, contour plots were created that show the conditional probability values of each possible headwind/crosswind pair in a range from +20 to –20 knots. These plots were done for each 1000-foot layer up to 5000 feet. Examples from SFO can be seen in Figures 22 and 23. To further quantify the relationship between headwinds and crosswinds, correlation coefficients were also calculated for each altitude layer. The results for each airport are summarized in Table 3.

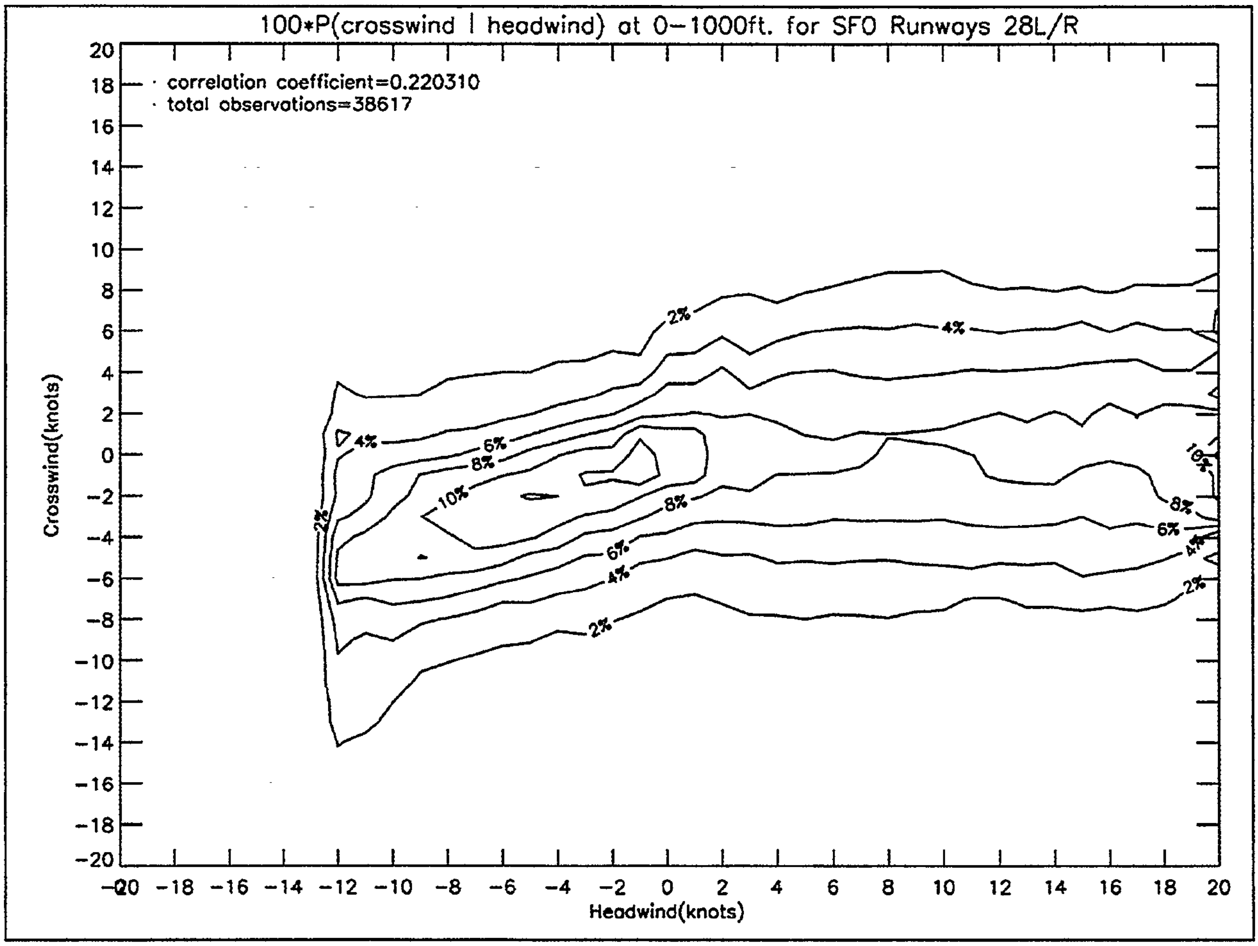

Figure 22. An example plot of conditional crosswind probabilities for SFO from 0-1000 feet.

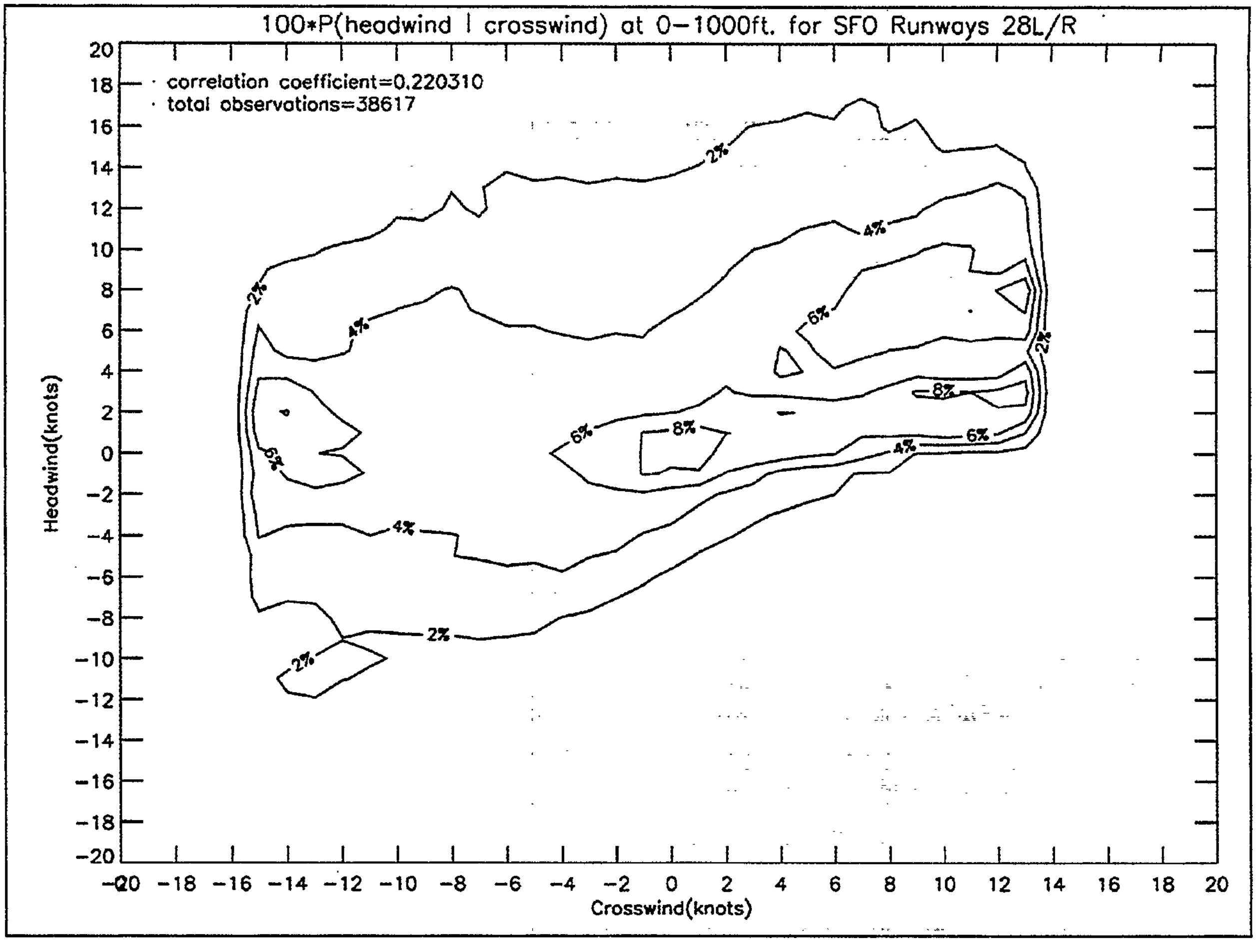

Figure 23. An example plot of conditional headwind probabilities for SFO from 0-1000 feet.

Table 3.
Correlation Coefficients between Headwind and Crosswind Values

Airport	Correlation Coefficient 0-1000 feet	Correlation Coefficient 1000-2000 feet	Correlation Coefficient 2000-3000 feet	Correlation Coefficient 3000-4000 feet	Correlation Coefficient 4000-5000 feet
SFO	0.22	0.12	0.06	0.14	0.12
BOS	-0.10	-0.07	-0.04	-0.05	-0.01
EWR	-0.08	-0.06	-0.08	-0.03	0.02
PHL	-0.10	-0.03	0.01	-0.01	-0.01
SEA	0.09	0.43	0.45	0.38	0.34

The results show that there seems to be very little correlation between simultaneous headwind and crosswind components. The only exception is in Seattle, where a significantly larger positive correlation is seen in all layers above 1000 feet than at any of the other airports. The other exception is San Francisco where the correlation coefficient value of 0.22 in the surface layer is more than twice as large as any other surface layer value for any of the other airports. However, these larger values are still not representative of a strong correlation.

The absence of a strong correlation between headwinds and crosswinds at each of the airports is very important when considering the use of a simulation model. Headwind and crosswind values used in any simulation may be considered independent of on another since there is very little relationship between them.

3.2.2 Headwinds and Crosswinds with Altitude

When determining a level of correlation between headwinds or crosswinds from adjacent altitude layers, the results are much different than when comparing headwinds and crosswinds. Figure 24 shows an example of the plots made which compare hourly- mean crosswind values for adjacent altitude layers. A similar plot is shown in Figure 25 for headwind. Table 4 summarizes the correlation coefficient values calculated from these crosswind data and Table 5 presents the results for headwinds. The coefficient column headings in each table contain numbers representing the particular altitude layers that were compared. The layer numbers are as follows:

- 0 = 0-1000 feet
- 1 = 1000-2000 feet
- 2 = 2000-3000 feet
- 3 = 3000-4000 feet
- 4 = 4000-5000 feet

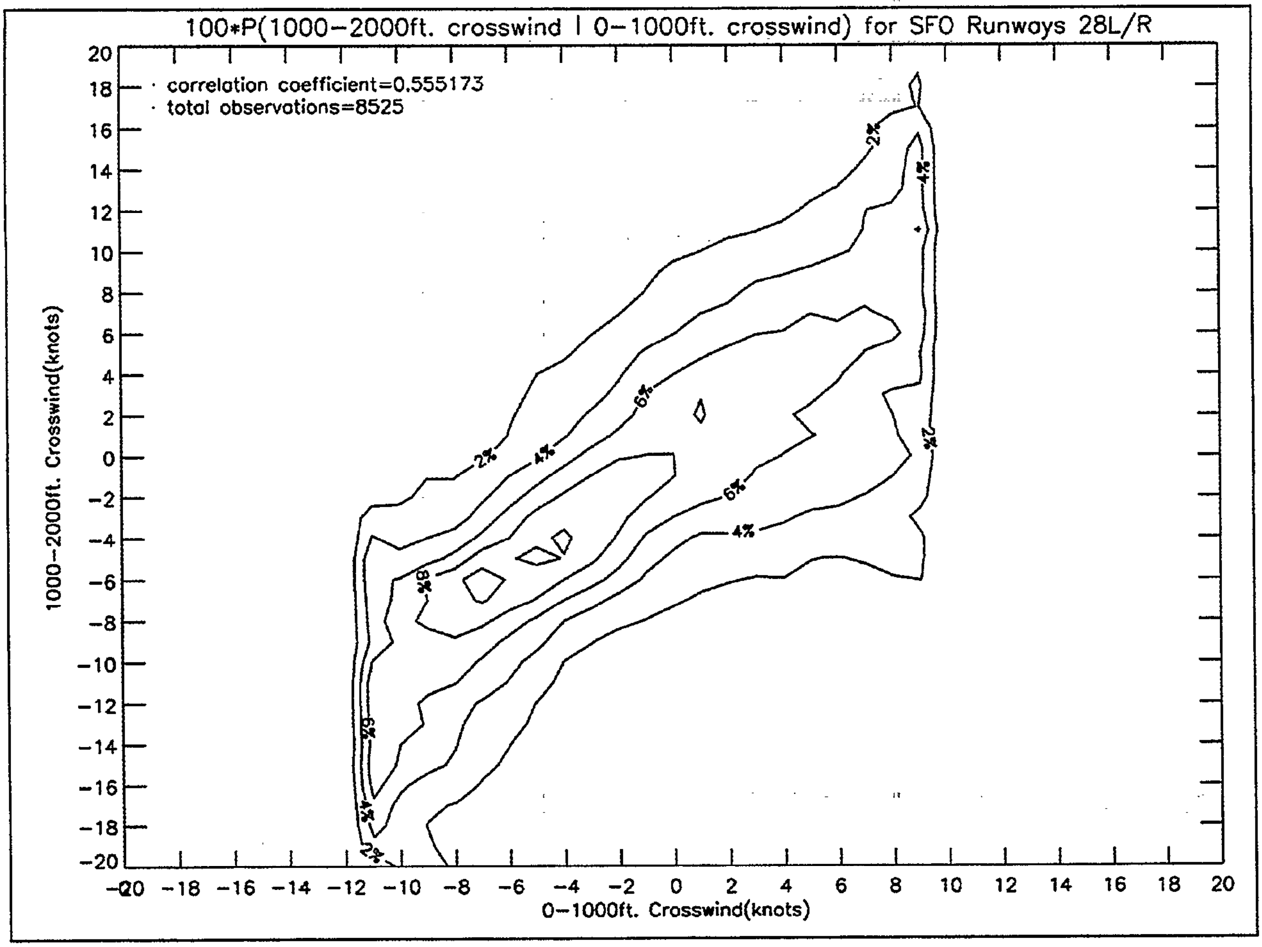

Figure 24. An example plot of conditional probabilities for crosswinds with respect to altitude at SFO.

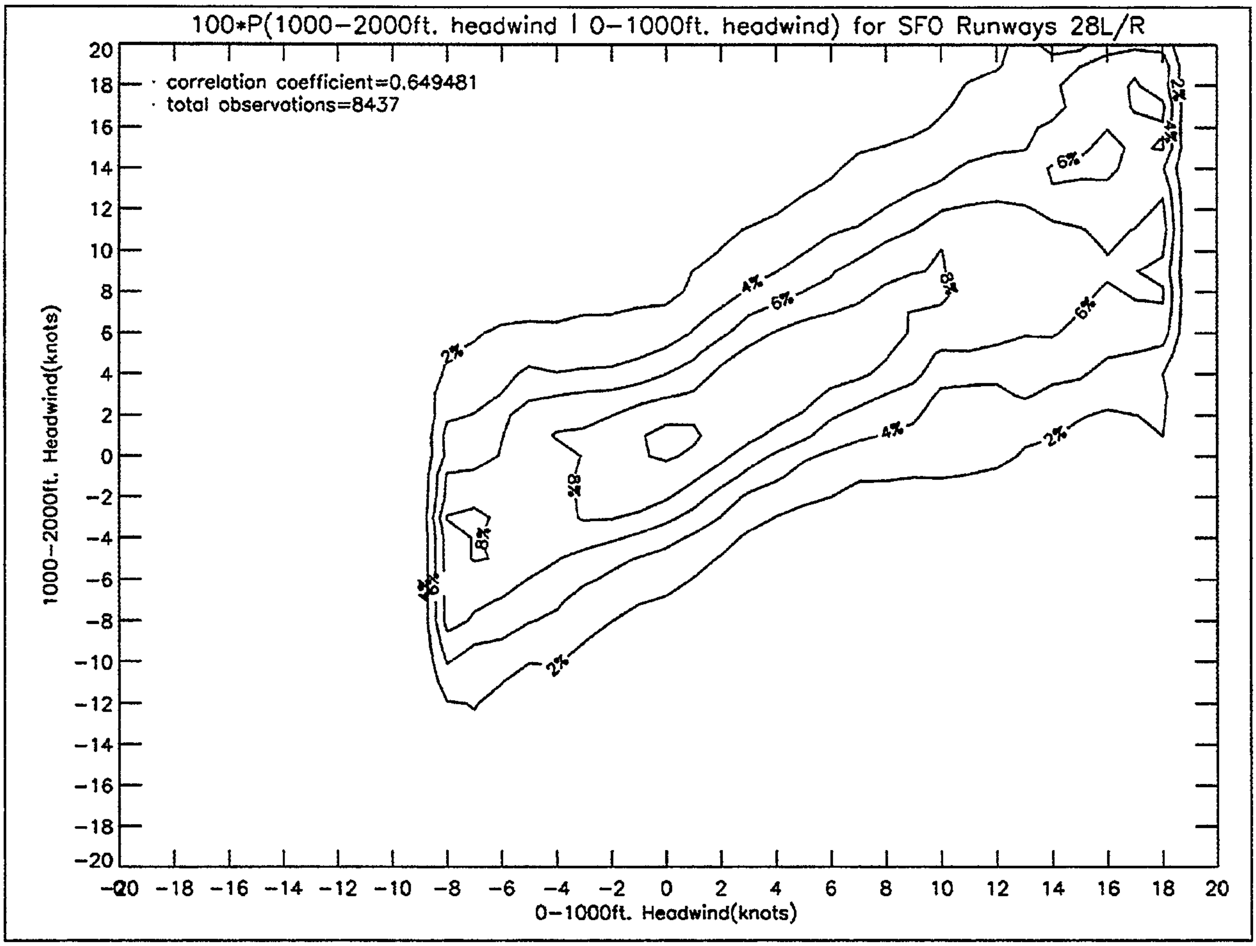

Figure 25.An example plot of conditional headwind probabilities with respect to altitude at SFO.

Table 4.
Correlation Coefficients for Crosswinds with Altitude

Airport	Correlation Coefficient (0-1)	Correlation Coefficient (1-2)	Correlation Coefficient (2-3)	Correlation Coefficient (3-4)
SFO	0.56	0.76	0.75	0.85
BOS	0.68	0.79	0.78	0.75
EWR	0.78	0.84	0.81	0.81
PHL	0.77	0.85	0.83	0.83
SEA	0.52	0.80	0.74	0.76
STL	0.76	0.86	0.84	0.85

Table 5.
Correlation Coefficients for Headwinds with Altitude

Airport	Correlation Coefficient (0-1)	Correlation Coefficient (1-2)	Correlation Coefficient (2-3)	Correlation Coefficient (3-4)
SFO	0.65	0.69	0.77	0.80
BOS	0.72	0.83	0.76	0.80
EWR	0.75	0.83	0.83	0.83
PHL	0.80	0.85	0.81	0.81
SEA	0.80	0.86	0.77	0.81
STL	0.77	0.80	0.83	0.82

As expected, the results of each table show that there is a strong correlation between both crosswinds with altitude and headwinds with altitude at all the airports of interest. There is a noticeably weaker correlation near the surface, especially at SFO and SEA in the crosswind data. This may indicate an outside influence on winds in the lower levels such as the local topography and its associated frictional force.

When considering the use of a simulation model to create wind profiles along an approach path, the strong relationship between the wind components with altitude must be accounted for. In choosing a simulated headwind or crosswind value for a particular altitude, the values for subsequent altitudes must follow the relationship established by the correlation results. The values are not independent of one another.

3.3 Critical-Crosswind Results

When considering the use of simultaneous CSP approaches, a minimum crosswind value can be calculated which would transport the wake of a leading aircraft into the flight path of a trailing aircraft. The variables needed to make this calculation are the distance between the parallel runways, the spacing between the pair of landing aircraft, the approach speeds of each aircraft, and the wingspans of each aircraft. An average critical-crosswind value was calculated for each airport assuming a 1 nautical-mile spacing between aircraft, average approach speeds of 130 knots, and wing spans of 33 meters, which matches that of a Boeing 727. The results of these calculations are summarized in Table 3. The exceedance probability values in Table 3 refer to the probability that the critical-crosswind will be exceeded anywhere from the surface up to 5000 feet at any given time. The LCV exceedance probabilities were calculated from wind observations taken exclusively during LCV conditions. These numbers are valuable in approximating how often a simultaneous CSP approach system could be used safely at each airport.

Table 6.
Exceedance Probability Values for Critical Crosswind

Airport	Critical Crosswind (knots)	Exceedance Probability	LCV Exceedance Probability
SFO	13.70	0.13	0.13
BOS	29.62	0.06	0.05
EWR	17.94	0.21	0.18
PHL	27.61	0.05	0.06
SEA	14.71	0.12	0.17

The results of Table 6 are approximations for the purpose of showing the use of the crosswind statistics. Based on these approximations, a CSP approach procedure would be safe to implement the vast majority of the time at every airport studied. However, exact benefit would require a more rigorous model of the procedure. In some cases, it is clear from Table 6 that the runway configurations that were analyzed would not even be used during times of such high crosswinds.

3.4 LCV Duration

An analysis was conducted on nine years of surface observations at each of the airports studied to determine the statistics on the length of time that a revised parallel runway procedure could be used. This is important since Air Traffic Control may only be able to effectively manage procedural changes at relatively coarse intervals on the order of several hours.

For the purpose of this analysis we assumed that a Simultaneous Operation of Independent Approaches (SOIA) procedure was being applied at the airports, such that the aircraft are kept greater than 3400 ft apart until visual acquisition below the cloud deck. At that time one of the aircraft performs a sidestep maneuver to the runway. We assumed that the SOIA procedure could be used if the cloud ceiling is above 1500 ft, the visibility is at least 5 nm, and the runway crosswind is sufficiently calm. A sufficiently calm crosswind was assumed to be the critical crosswind values in Table 6 minus 7 kts (which is a guess at the sum of normal wind variability and any wind-forecast error).

Figure 26 shows histograms of the duration of periods where a SOIA procedure may be able to be used at each facility. The histogram values are expressed as a fraction of the total time that the SOIA procedure may be able to be used. What is clear from the figure is that the events are short in duration. This suggests that a proactive process that predicts when a procedure can be used will be essential in assuring that enough aircraft are available to take advantage of the increase in capacity. Waiting until the conditions become conducive to the procedure may be too late to get aircraft to the runways for a sizable percentage (> 25%) of the time periods.

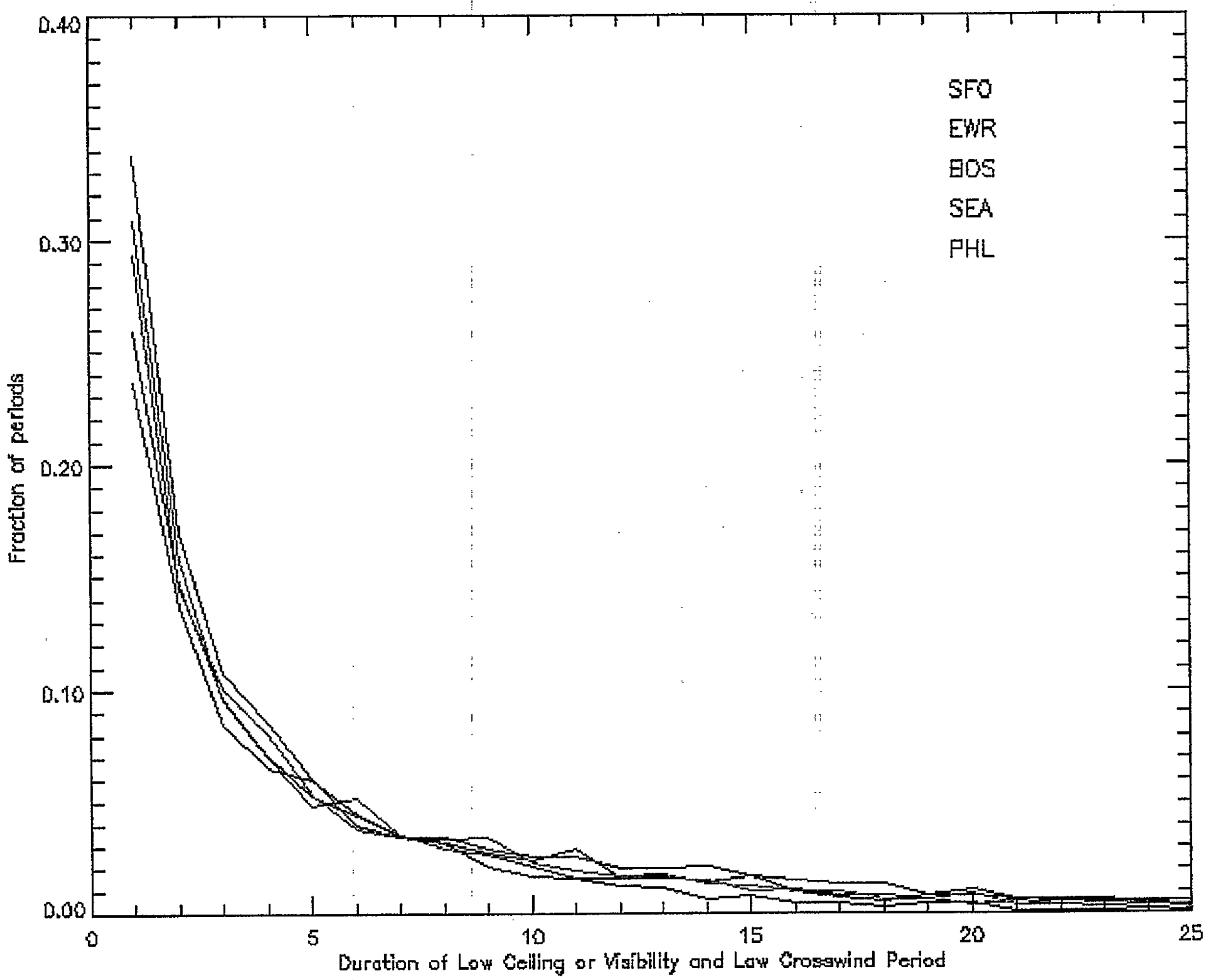

Figure 26. A histogram of the durations that a SOIA procedure could likely be used at each airport.

4. DISCUSSION

MDCRS are a very valuable data source for producing statistics of wind behavior over airports. They are temporally and spatially much more dense than any other data source available above the ground. The statistics generated by the analyses performed in this study should prove very helpful to the modeling effort in support of a modified approach procedure on parallel runways at capacity-restricted airports.

The five airports studied showed similar general qualities in wind behavior, but each had some traits specific to the airport that would be important to include in any modeling effort. As expected, all airports showed a strong correlation between both headwinds with altitude and crosswinds with altitude. However, there was very little correlation between headwind and crosswind components taken from the same wind observation.

The exceedance probability statistics generated for both headwinds and crosswinds at each airport are very useful in developing a general sense of wind behavior with respect to parallel runways of interest at these airports. General tendencies in strength and direction of each wind component with altitude can be determined by examining the plots provided.

Based on the results from this study, the following steps should be used in constructing wind profiles for procedural or benefits models:

- Choose a crosswind surface value for a particular facility by using the crosswind probability distribution provided.
- Use the conditional probability distribution results to choose crosswinds at higher altitudes.
- Repeat steps 1 and 2 for headwinds.

When comparing the statistics generated exclusively for LCV times, some differences in wind behavior can be seen for all airports. However, the differences are usually not very large. Future work may include gathering more MDCRS wind observations to increase the total amount of LCV observations. This will ensure that the results represent a longer-term climatological average.

Although MDCRS observations are a valuable resource due to the fact that they are measurements from the glide path, they are not an ideal data source due the short sampling period of the measurements and the relatively few number of samples per time period. An appropriate future study should evaluate the use of pencil-beam Doppler radars (EWR, BOS

TDWRs) for a more robust estimate of mean approach-wind statistics. Potential operational wind monitoring systems for wake vortex drift estimation should include ground-based wind measurements in addition to MDCRS for the most robust wind estimates.

In addition to a knowledge of the current wind and cloud ceiling on approach, an operational procedure with a wake vortex component will need to have a forecast of the weather. This is needed so that Air Traffic Control can match the airport's supply with the capacity, based on whether the enhanced capacity procedure can be used. This forecast will need to be available at a tactical level, with a 0-2 hour forecast. A longer-term strategic forecast will also be desired. Since Numerical Weather Models currently have a difficult time making accurate 0-2 hour forecasts, these wind nowcasts will need to use local and regional observations heavily. An extension to this study would analyze the frequency of LCV to non-LCV transitions.

GLOSSARY

ACARS	Aircraft Communications, Addressing, and Reporting System
ARINC	Aeronautical Radio, Inc.
BOS	Boston
CSP	Closely-Spaced Parallel
EWR	Newark
FSL	Forecast System Laboratory
IMC	Instrument Meteorological Conditions
INS	Inertial Navigation System
LCV	Low Ceiling and Visibility
MDCRS	Meteorological Data Collection and Reporting System
NWS	National Weather Service
PHL	Philadelphia
SEA	Seattle
SFO	San Francisco
STL	St. Louis
TDWR	Terminal Doppler Weather Radar
VMC	Visual Meteorological Conditions

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