Enclosure 3

(Referenced in Technical Letter F063-L09-015)

MITRE

Center for Advanced
Aviation System Development

Initial* Weather Analysis for the Texcoco Area

*Data Period:
Wind as of 1 January 2009
Ceiling as of 1 May 2009
Visibility as of 1 May 2009

Preliminary Report

Prepared for

Dirección General de Aeronáutica Civil
Secretaría de Comunicaciones y Transportes

June 2009

1.0 Introduction

Meteorological conditions are an important consideration to determine the suitability of a site for an airport. Frequent periods of low ceilings or poor visibility can cause an airport to close an undesirable percentage of the time. Likewise, a correct analysis of wind data is necessary to avoid incorrect runway orientations that, for example, may lead to frequent periods of strong crosswind components that, in some cases, can adversely impact the operation of some aircraft. Therefore, it is critical to conduct a detailed analysis of accurate and reliable weather data to ensure that meteorological conditions are suitable. That is what is being done for Texcoco.

MITRE has also been examining the terminal airspace surrounding Mexico City to determine if there are any potential issues that could impact dual- and eventually triple-independent operations at Texcoco. This includes an analysis of potentially adverse interactions between operations at nearby airports that may lead to airspace conflicts. This, for example, may apply to interactions between Texcoco and Toluca airports, specifically when both airports are conducting approaches in a north flow. While these analyses are not complete (i.e., simultaneous north flows at Toluca and Texcoco may after all not interact), MITRE decided to initiate wind data comparisons from the same time period at both Texcoco and Toluca in case simultaneous north flow operations prove to be an issue.

The objective of this report is to provide a summary of weather conditions at Texcoco based on data from a recently installed on-site Automated Weather Observing System (AWOS). A comparison of corresponding weather data from Toluca, also obtained through an on-site AWOS, is included.

The information contained in this report is based on a very limited data period. The information is also *preliminary* in the sense that it has to go through an internal review. Therefore, the results of this report cannot be considered either final or representative. This work represents only the beginning of a comprehensive analysis that will continue throughout the duration of the project. The results will evolve as more data are obtained.

2.0 Background

The International Civil Aviation Organization (ICAO) recommends obtaining five years of wind data to determine the orientation of runways at an airport. Additionally, ICAO recommends the wind data be associated with other weather variables such as visibility and ceiling. In cases where a five-year data collection does not occur, some agencies allow a substitute weather evaluation. For example, United States (U.S.) Federal Aviation Administration (FAA) guidelines indicate that a minimum of one year of on-site wind observations may be used if augmented by weather observations from other sources (e.g., wind-bent trees, interviews with the local population, etc.) to ascertain if a discernible wind pattern can be established. Although such substitutions may sometimes be useful or practical, they may increase the uncertainty of the results of an analysis.

A data collection effort took place in the Texcoco area in recent years. While useful, it was partially supported by weather observers. Given the magnitude of the project in sight, however, MITRE recommended that a state-of-the-art (i.e., through an AWOS) effort be mounted to

collect on-site data in the Texcoco area. Therefore, on the basis of the combined recommendations from ICAO and the FAA mentioned above, it was decided that at least one year of reliable, non-erratic on-site AWOS data should be obtained in order to characterize the patterns of weather present at the site. As a result of this, Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) acquired and installed an AWOS in the Texcoco area. MITRE provided support, as needed. Figure 1 shows the location of the AWOS within the Texcoco site boundaries (shown in red). Figure 2 shows a picture of the Texcoco AWOS during its installation. The AWOS began acquiring data in late December 2008.

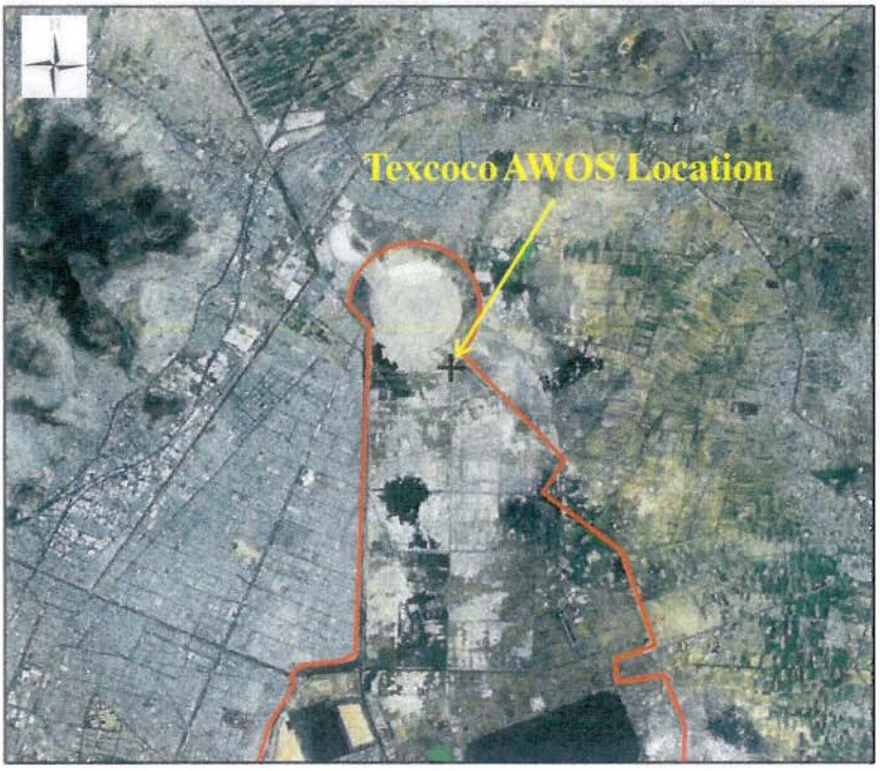


Figure 1. Location of the Texcoco AWOS

Figure 2. Texcoco AWOS Under Construction

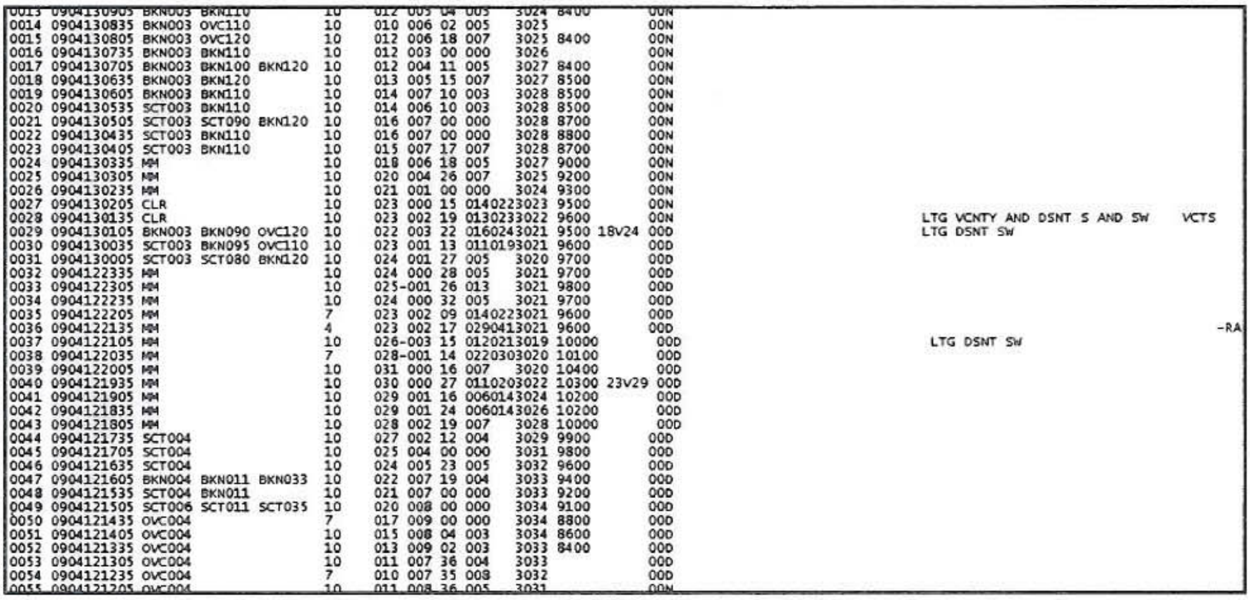
3.0 Data and Assumptions

This section describes the data used in this analysis.

3.1 Texcoco AWOS

As previously mentioned, the Texcoco AWOS became operational in late December 2008. The AWOS records a large number of weather variables every half-hour. Of these, the ones of most relevance to the MITRE project are ceiling, visibility, wind speed and direction, present weather conditions, and temperature. Out of the latter variables, MITRE has statistically analyzed ceiling, visibility, and wind speed and direction.

MITRE receives AWOS data from SENEAM on a weekly basis. Upon receipt of data, MITRE weather analysts assess its completeness and, where appropriate, provide feedback to SENEAM on sensor malfunctions or other potential problems with the AWOS. For example, MITRE observed that starting in early 2009 the ceilometer sensor began to experience problems. This was reported to SENEAM and the sensor was replaced (see Figure 3).



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0055 0904121205 OVC004               10    011 008 36 005      3031               00N
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Figure 3. Portion of Texcoco AWOS Data
(the third column shows ceilometer malfunctions denoted by "MM")

Ceiling data is an important factor in the determination of overall weather conditions. Therefore, given that no less than 14 percent of all ceiling data was compromised before the 29 April replacement of the sensor, MITRE decided to incorporate ceiling data into its analyses starting on 1 May 2009. Figure 4 shows progressive worsening of the ceilometer data for the January-April time period. Notice the sharp improvement in May 2009.

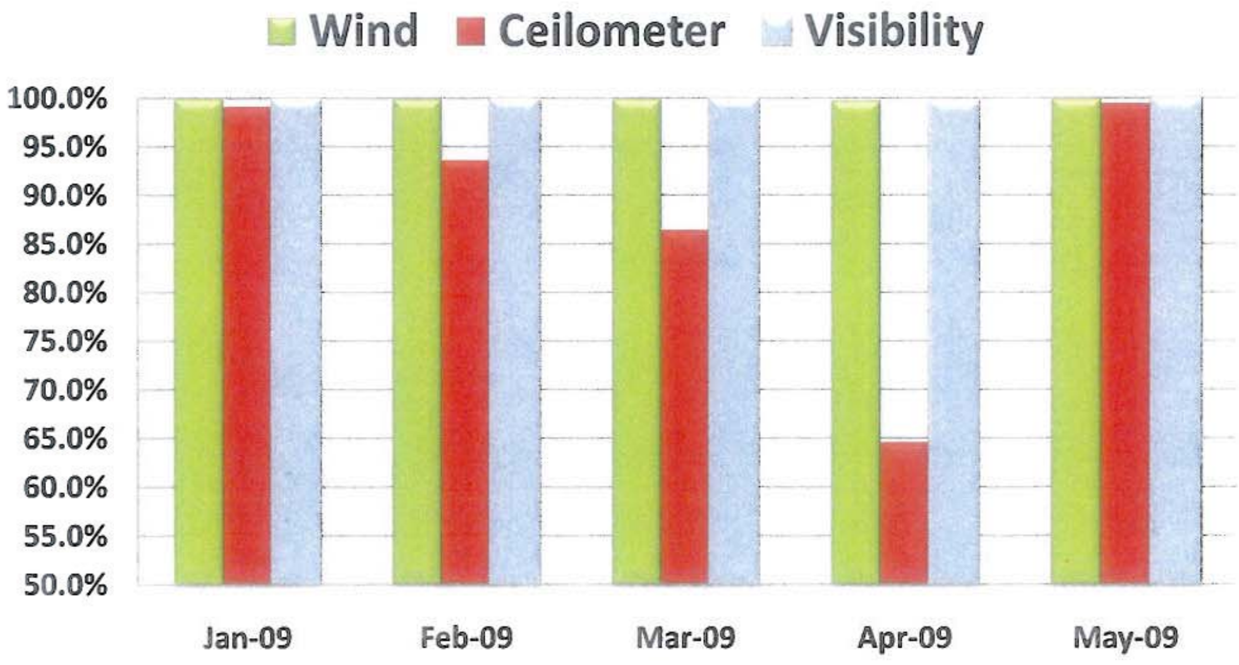

Figure 4. Texcoco AWOS Data Completeness

In aviation, ceiling and visibility are often analyzed together in order to characterize weather conditions, such as Instrument Landing System (ILS) approach minima. Therefore, to ensure that the most accurate, reliable, and complete weather information are being analyzed, MITRE decided to utilize the following data for this analysis:

- Ceiling and visibility – 1 May 2009 through 31 May 2009
- Wind (direction and speed) – 1 January 2009 through 31 May 2009

To avoid a delay in the project it is critical that no new "restarts" of weather data collection occur. One concern worth mentioning is the all-important grading and drainage work around the Texcoco AWOS that has been pending since its December 2008 installation. With the onset of heavy rains in June, the visibility sensor accuracy may easily be compromised through the evaporation of standing water in close proximity to the AWOS. In summary, if the grading and drainage work is not completed soon, it is possible that more data will become unusable, which could ultimately delay the project.

3.2 Toluca AWOS

SENEAM regularly provides MITRE with data from the AWOS located at Toluca. To date, data from 1 December 2008 through 31 May 2009 have been provided. Although the data are similar to the Texcoco AWOS data, it comes in a different format and the recording occurs every hour (see Figure 5). MITRE has observed minor problems with the Toluca AWOS data during the above-mentioned period, but none have a significant impact on the overall completeness of the data set. In general, the Toluca AWOS data are appropriate to conduct weather analyses and to perform comparisons with data from the Texcoco AWOS.

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                                        MARZO  2009

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Figure 5. Portion of Toluca AWOS Data

3.3 Weather Criteria

Four weather categories are defined in this report based on ceiling and visibility conditions. Table 1 details the weather categories, as well as the corresponding types of procedures typically required to land during each of the four weather categories.

Table 1. Weather Categories Used in this Analysis

Weather "Category"	Ceiling Height Above Airport (HAA)	Visibility (Statute Miles)	Notes
Visual Meteorological Conditions (VMC)	≥ 5000 ft	≥ 5 mi	Conditions during which visual approach procedures would be conducted
Marginal Meteorological Conditions (MMC)	< 5000 ft and ≥ 1000 ft	< 5 mi and ≥ 3 mi	Conditions during which instrument procedures may be conducted during the first portion of the approach and visual procedures during the final portion
High-Instrument Meteorological Conditions (H-IMC)	< 1000 ft and ≥ 200 ft	< 3 mi and ≥ ½ mi	Conditions that may require the use of a Category (CAT) I ILS approach procedure
Low-Instrument Meteorological Conditions (L-IMC)	< 200 ft	< ½ mi	Conditions that may require the use of a CAT II or CAT III ILS approach procedure. Specialized aircraft and ground equipment, as well as pilot training are required.

Note: Some of the weather conditions mentioned above were defined by MITRE for planning purposes only. A weather condition in this table is determined by the lower of the two weather measurements (i.e., ceiling or visibility). Also note that Instrument Meteorological Conditions (IMC) are represented in the table as all conditions except the ones referred to as VMC and MMC. Under IMC conditions aircraft operate under Instrument Flight Rules (IFR) instead of under Visual Flight Rules (VFR).

4.0 Texcoco AWOS Data Analysis

This section shows the results of the initial weather analyses of Texcoco.

The overall weather conditions that occurred in the Texcoco area in the month of May 2009 are shown in Figure 6. The data suggests that VMC and MMC together accounted for approximately 99.7 percent of the time; MMC occurred only 9 percent of the time. The analysis shows that low ceiling or visibility conditions that would require CAT I approaches (i.e., H-IMC) occurred only about 0.3 percent of the time. L-IMC weather was not observed for the period. Again, the results are based on only one month of data and, therefore cannot be treated as representative of overall weather conditions in the Texcoco area.

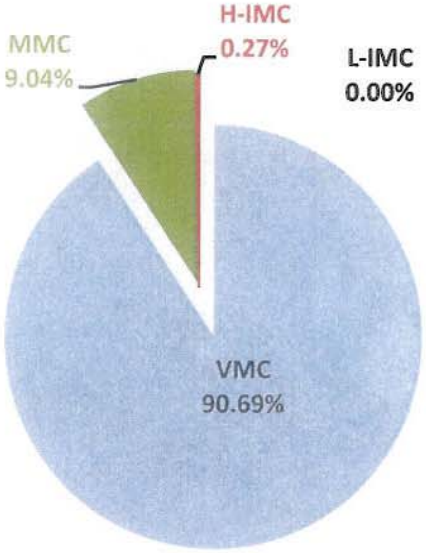

Figure 6. Texcoco AWOS Data: Weather Conditions (1 May 2009 through 31 May 2009)

Since weather conditions are not evenly distributed throughout the day, and sometimes high variances in weather are observed, it is important to analyze the weather fluctuations as a function of time of the day (here, in units of half-hour). As shown in Figure 7, the weather in Texcoco varies throughout the day: it was worse during the morning hours than during the afternoon and evening. For example, from 6:00 to 10:00 in the morning, MMC conditions were observed about 18 percent of the time, compared to only 5 percent for the period from 18:00 to 22:00. H-IMC conditions, on the other hand, were not quite common, and it is difficult to establish a pattern. As previously mentioned, L-IMC conditions were not observed during this period at all.

MITRE's analysis of the wind conditions in the Texcoco area are based on AWOS wind data from 1 January 2009 through 31 May 2009 (5 months). Results show that for the period under consideration, winds occurred predominantly from the north and north-northwest. This is illustrated in a wind rose in Figure 8.

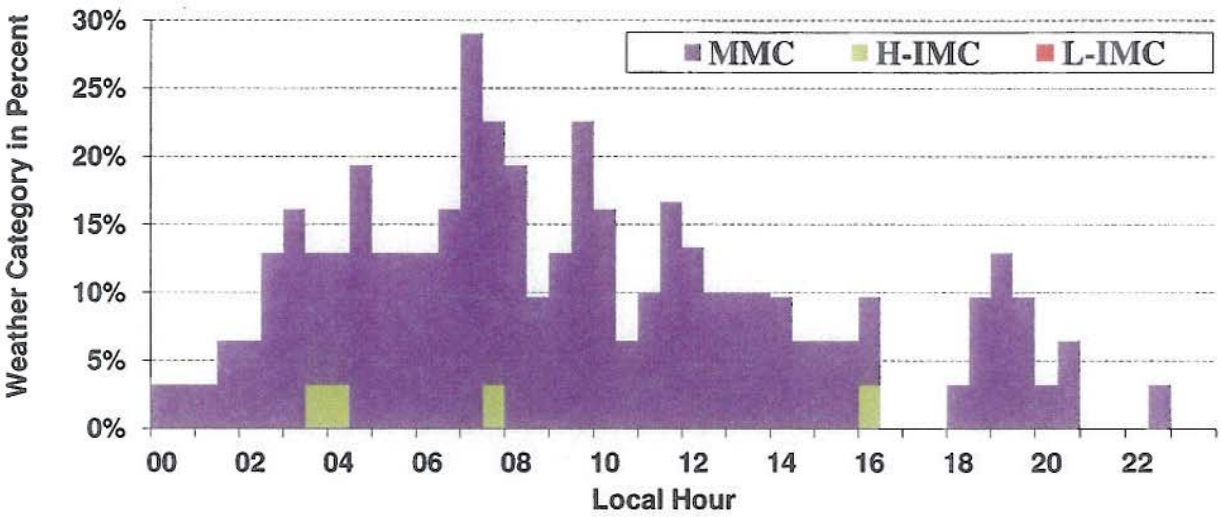

Figure 7. Texcoco AWOS Data: Overall Weather Conditions by Hour (1 May 2009 through 31 May 2009)

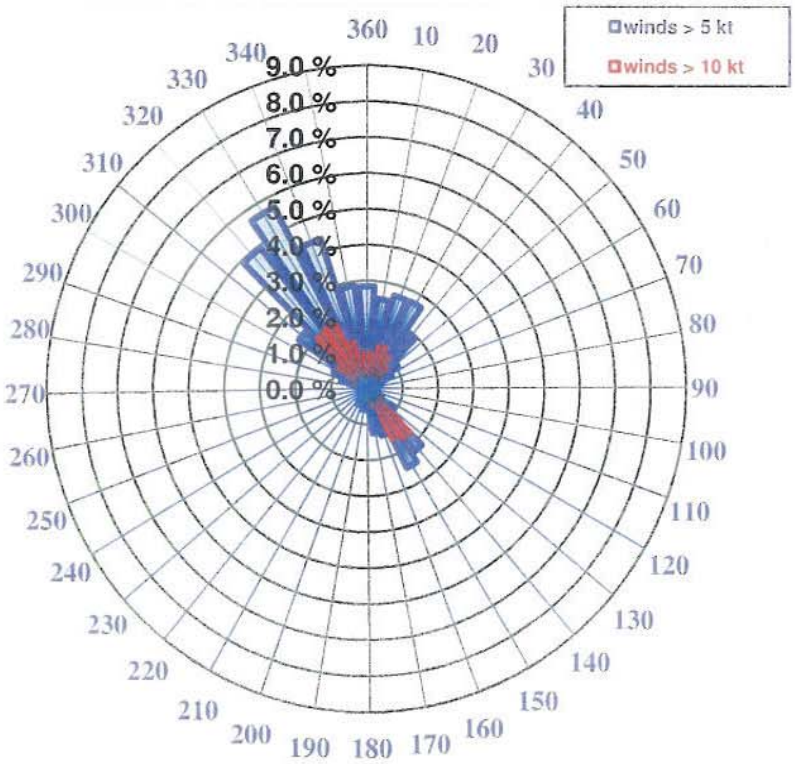

Figure 8. Texcoco AWOS Data: Wind Rose (1 January 2009 through 31 May 2009)

As with visibility, wind speed and direction also tend to fluctuate during the day, so it is important to analyze wind patterns as a function of time of the day. As shown in Figure 9, Texcoco winds tend to be milder, rarely exceeding 10 knots (kt), during the night to the mid hours of the morning (i.e., 2:00 to 11:00), and much stronger during the afternoon to the night hours (i.e., 14:00 to 23:00).

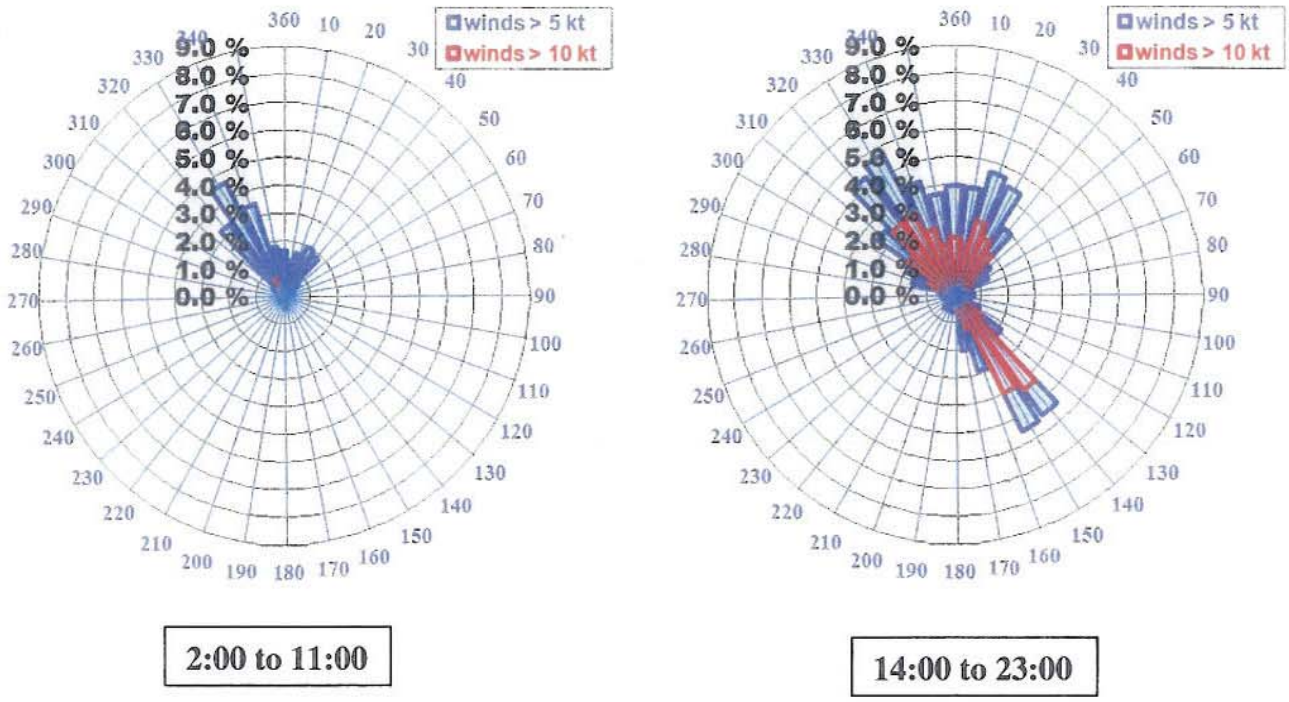

Figure 9. Texcoco AWOS Data: Wind Roses by Time of the Day (1 January 2009 through 31 May 2009)

Winds less than 5 kt were common in Texcoco, occurring about 50 percent of the time. Winds were 10 kt or less approximately 81 percent of the time. Strong winds (20 kt and higher), however, were rare (4 percent). The maximum steady state wind speed recorded was 30 kt and the maximum gust was 41 kt. Figure 10 illustrates the overall wind distribution by speed during all weather conditions.

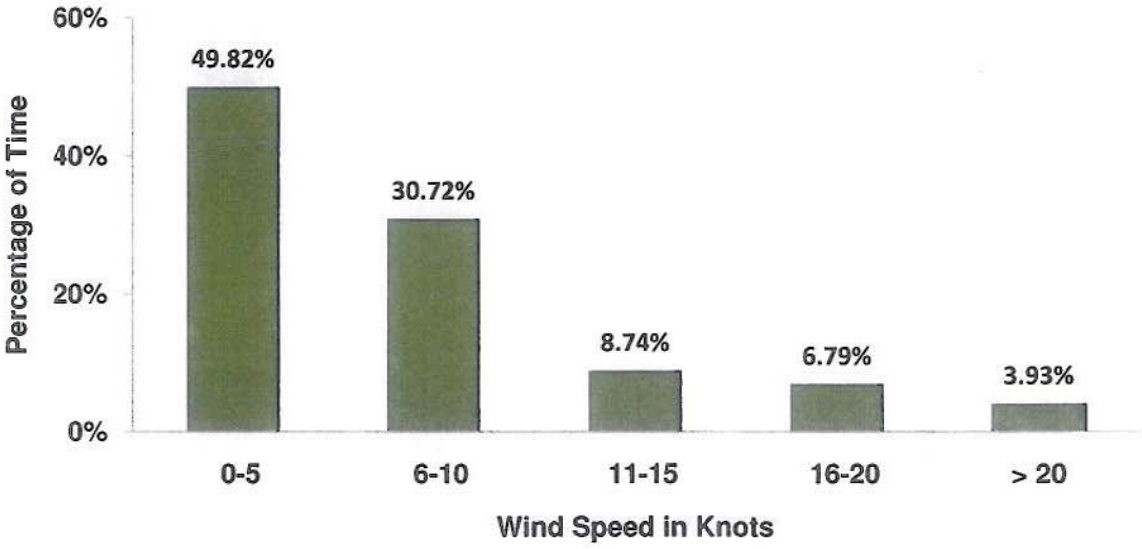

Figure 10. Texcoco AWOS Data: Wind Speeds (1 January 2009 through 31 May 2009)

Wind direction and speed are determinant in deciding runway orientations. ICAO states that for planning purposes in determining the usability factor of an airport by wind distribution it should be assumed that the landing or takeoff of aircraft is precluded when the crosswind component exceeds 20 kt in the case of aircraft whose reference field length[1] is 1500 m or more (i.e., relatively large aircraft), 13 kt in the case of aircraft whose reference field length is less than 1500 m, but equal to or more than 1200 m, and 10 kt in the case of aircraft whose reference field length is less than 1200 m (i.e., small aircraft). ICAO recommends that the number and orientation of runways at an airport should be such that the usability factor of the airport is not less than 95 percent for the aircraft that the airport is intends to serve.

MITRE conducted a usability analysis of Texcoco based on 1 January 2009 through 31 May 2009 wind data. The usability analysis is based on the wind data only and per individual bi-directional potential runway orientations (i.e., tailwinds are not considered). The analysis does not consider operational factors, such as terrain and airspace issues as these may potentially affect the feasibility of runway orientations.

As shown in Figure 11, the Texcoco area usability factor is about 99 percent when considering a 20-kt crosswind component limitation for any runway orientation. This means that the landing or takeoff of aircraft with reference field length requirements at or exceeding 1500 m might be precluded due to winds only about 1 percent of the time or less. This usability factor

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[1] Field length is defined as the minimum length required for takeoff at maximum certificated takeoff mass, at sea level and standard atmospheric conditions, still air and zero runway slope, as shown in the appropriate aeroplane flight manual prescribed by the certificating authority or equivalent data from the aeroplane manufacturer. Field length means balanced field length for aeroplanes, if applicable, or takeoff distance in other cases.

meets the minimum of 95 percent criteria recommended by ICAO. At a 10-kt crosswind component limitation, on the other hand, the usability factor is lower than the ICAO-recommended 95 percent for runway orientations ranging from about 10 to 150 degrees. For the 13-kt crosswind component limitation, the usability factor is estimated to be less that 95 percent for runway orientations ranging from about 35 to 125 degrees. Crosswinds for smaller aircraft may exceed limits at times, but it is expected that the majority of aircraft operating at the airport will be large commercial aircraft.

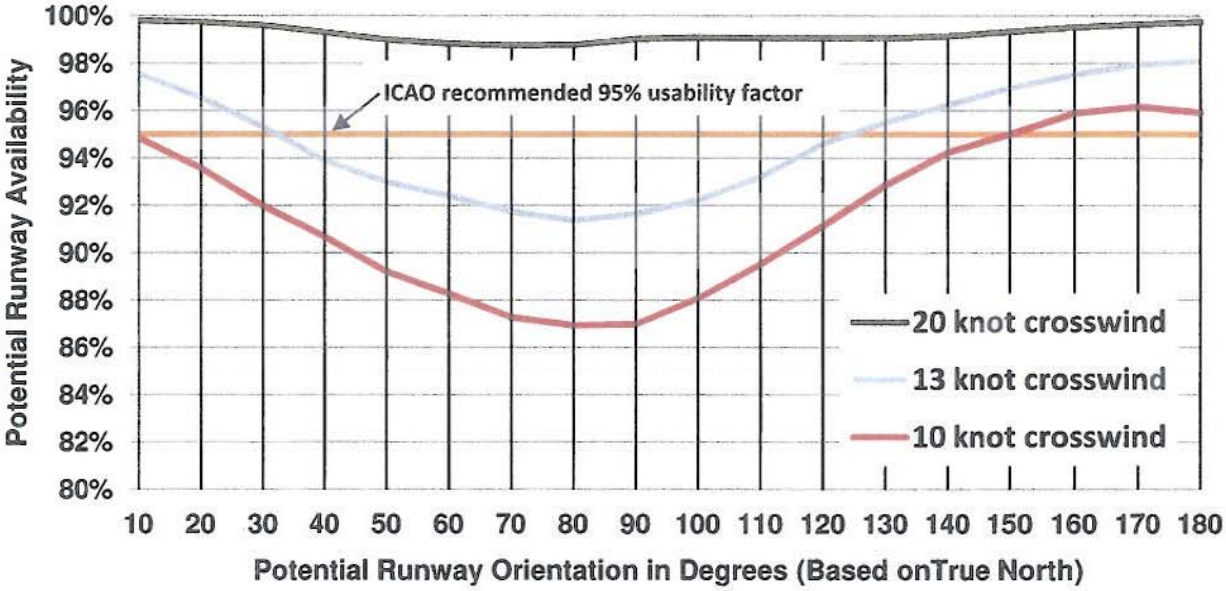


Figure 11. Texcoco AWOS Data: Airport Usability Factor for Potential Runway Orientations (Bi-directional) at Various Crosswind Components (1 January 2009 through 31 May 2009)

5.0 Texcoco and Toluca AWOS Data: Comparative Analysis

The intent of this section is to compare the weather during the same time period at both Texcoco and Toluca to better understand corresponding weather patterns. As a result, the frequency of traffic flows that could result in adverse airspace interactions between Texcoco and Toluca airports can be estimated. Based on separate preliminary analyses, this is of interest only in the northerly flow case.

The comparative analysis considered Toluca AWOS data covering the same period as the Texcoco AWOS data, as shown below:

- Ceiling and visibility – 1 May 2009 through 31 May 2009
- Wind (direction and speed) – 1 January 2009 through 31 May 2009

Figure 12 shows the weather conditions at Texcoco and Toluca for May 2009. Toluca weather had more MMC and H-IMC conditions during this period, however L-IMC conditions

were not observed in either of the locations. VMC conditions occurred more often in Texcoco than in Toluca.

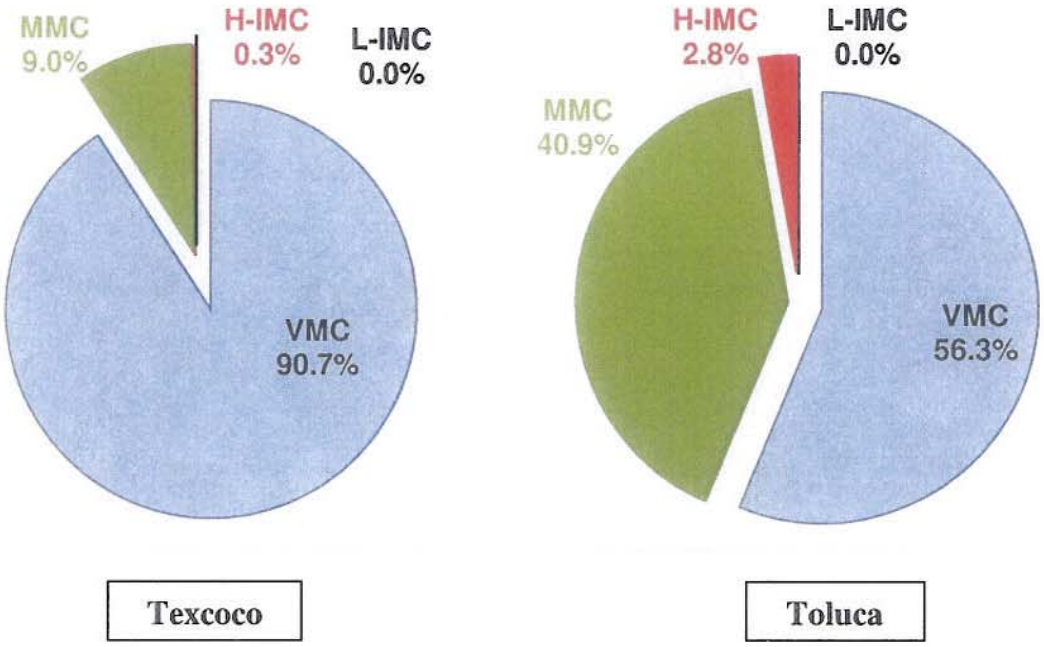
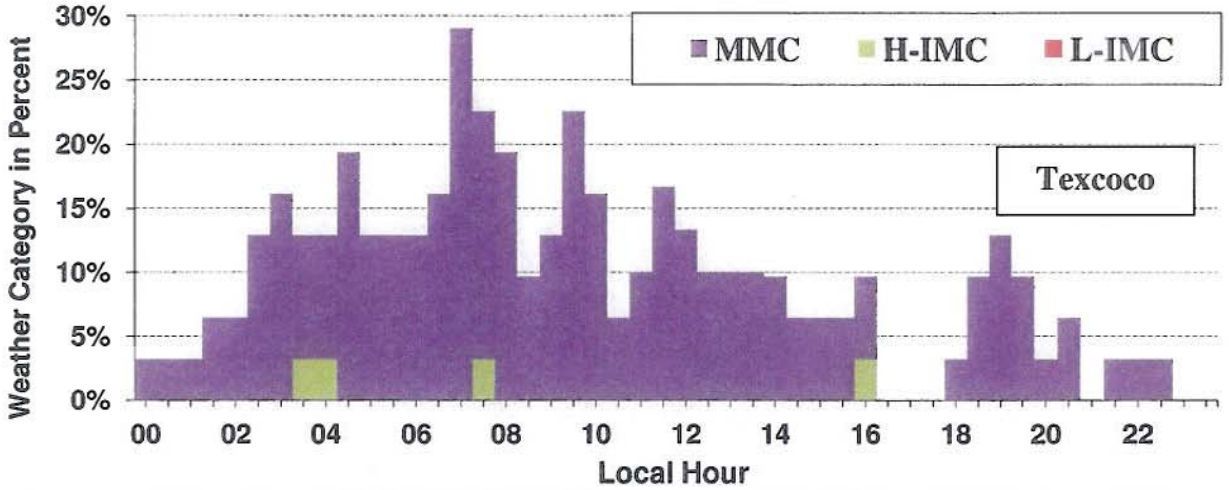


Figure 12. Texcoco vs. Toluca AWOS Data: Weather Conditions (May 2009)

When analyzing the hourly weather distribution, it appears that MMC weather is more evenly distributed throughout the day in Toluca than in Texcoco. H-IMC conditions were observed in Toluca during morning and late afternoon hours. Those are also the times of the day when MMC conditions are common (see Figure 13).

The wind analysis of the two sites indicates that the winds in Texcoco are stronger and more frequent than in Toluca. Winds with speeds less than 10 kt occur about 81 percent of the time in Texcoco. By contrast, in Toluca winds with speeds less than 10 kt occur about 88 percent of the time. Winds lighter than 20 kt occurred more than 96.1 percent of the time in Texcoco versus 99.9 percent of the time in Toluca (see Figure 14).

MITRE also developed wind roses for both sites for the same time periods to compare the frequencies, speeds, and directions of the winds to better understand potential traffic flows that might occur in the same direction and at the same time. For example, if strong winds (exceeding a 5-knot tailwind component) occur from the north at Toluca, as well as from the north at Texcoco, then traffic flows at both locations most likely will be to the north (i.e., into the wind). It is important to understand the likelihood of this occurring since it appears that there could be some adverse airspace interaction when traffic at both Toluca and at new airport in Texcoco are operating to the north at the same time. Figure 15 shows wind roses for Toluca and Texcoco (the latter wind rose was shown earlier). Note that in a significant number of occurrences the wind directions for Toluca and Texcoco are opposite. The question is whether wind directions are opposite at the same time or not. This was investigated and summarized below.



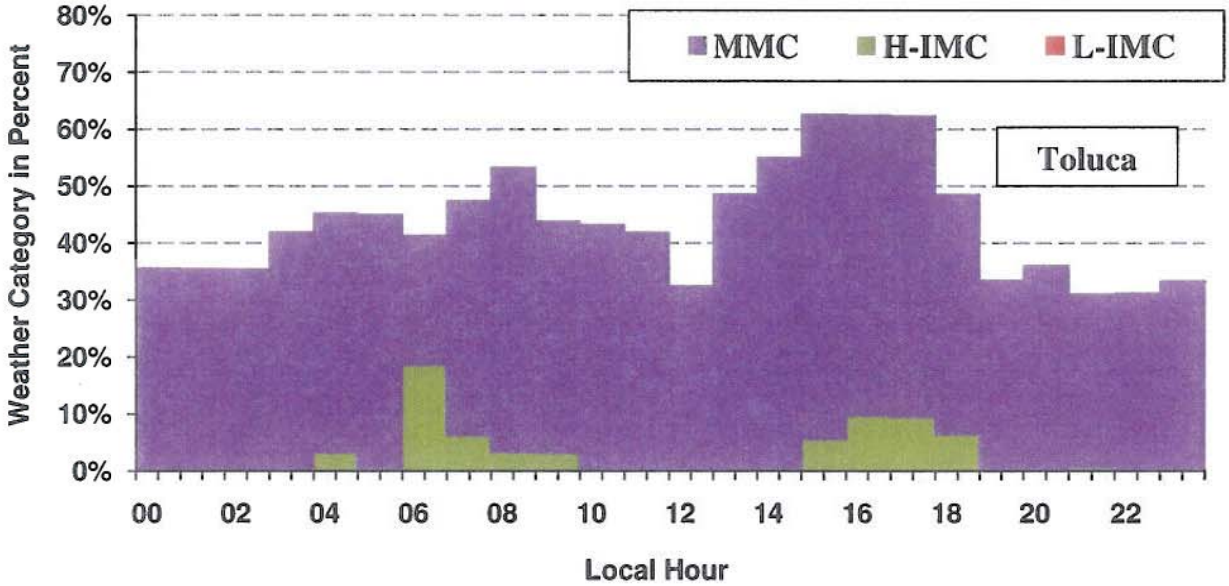
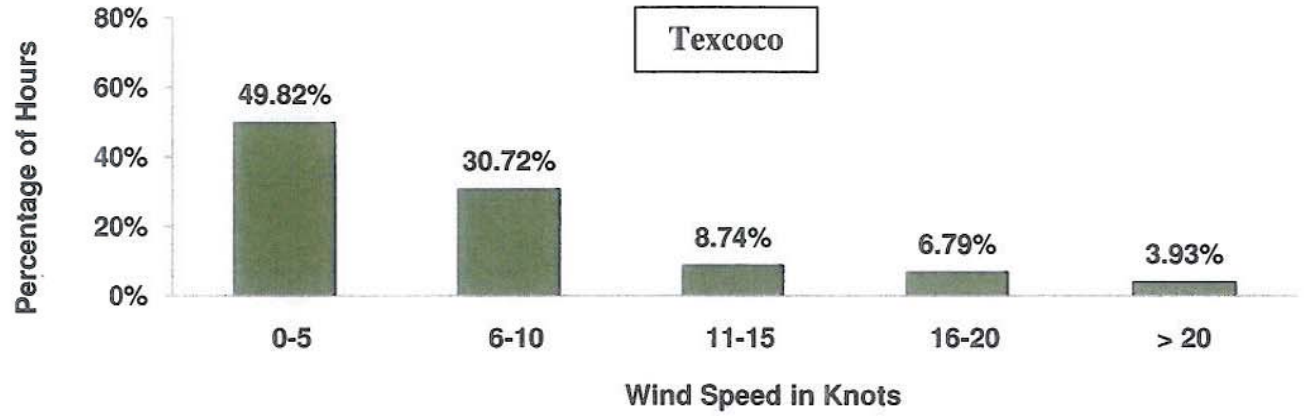


Figure 13. Texcoco vs. Toluca AWOS Data: Weather Conditions by Hour (May 2009)



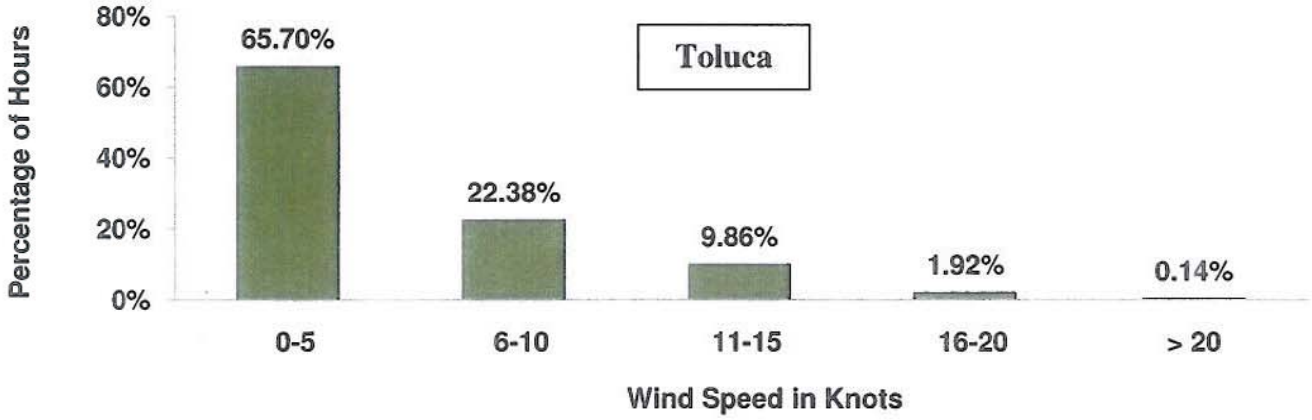


Figure 14. Texcoco vs. Toluca AWOS Data: Wind Speeds (1 January through 31 May 2009)

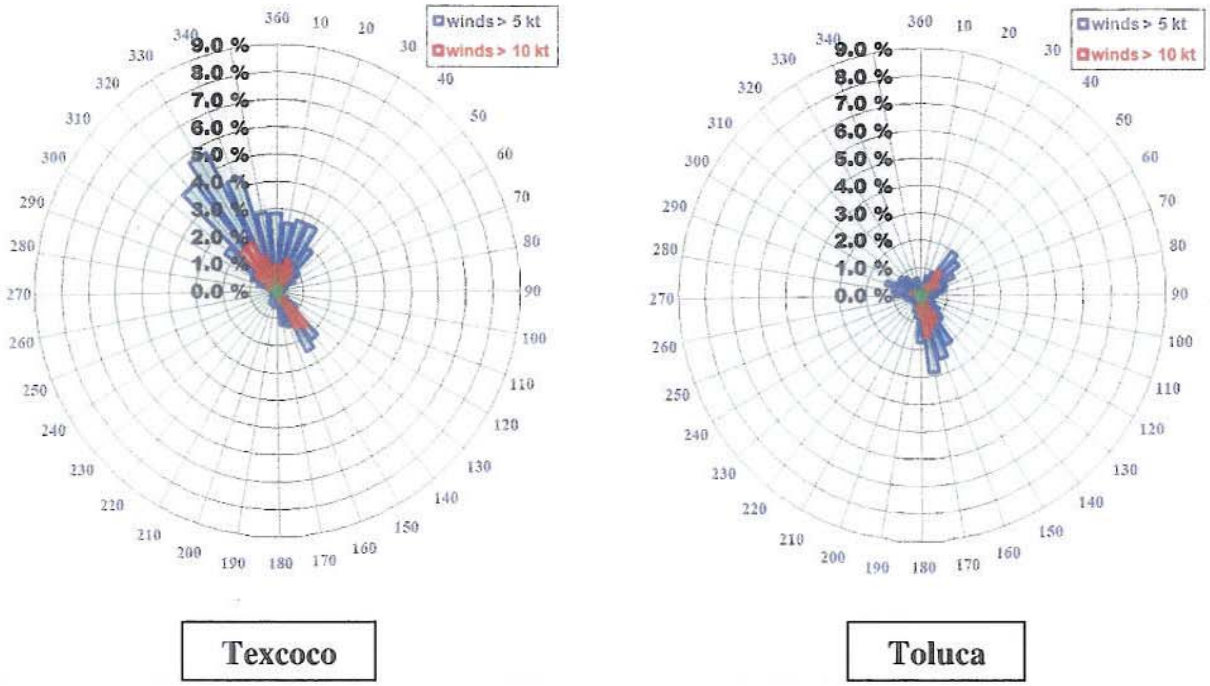
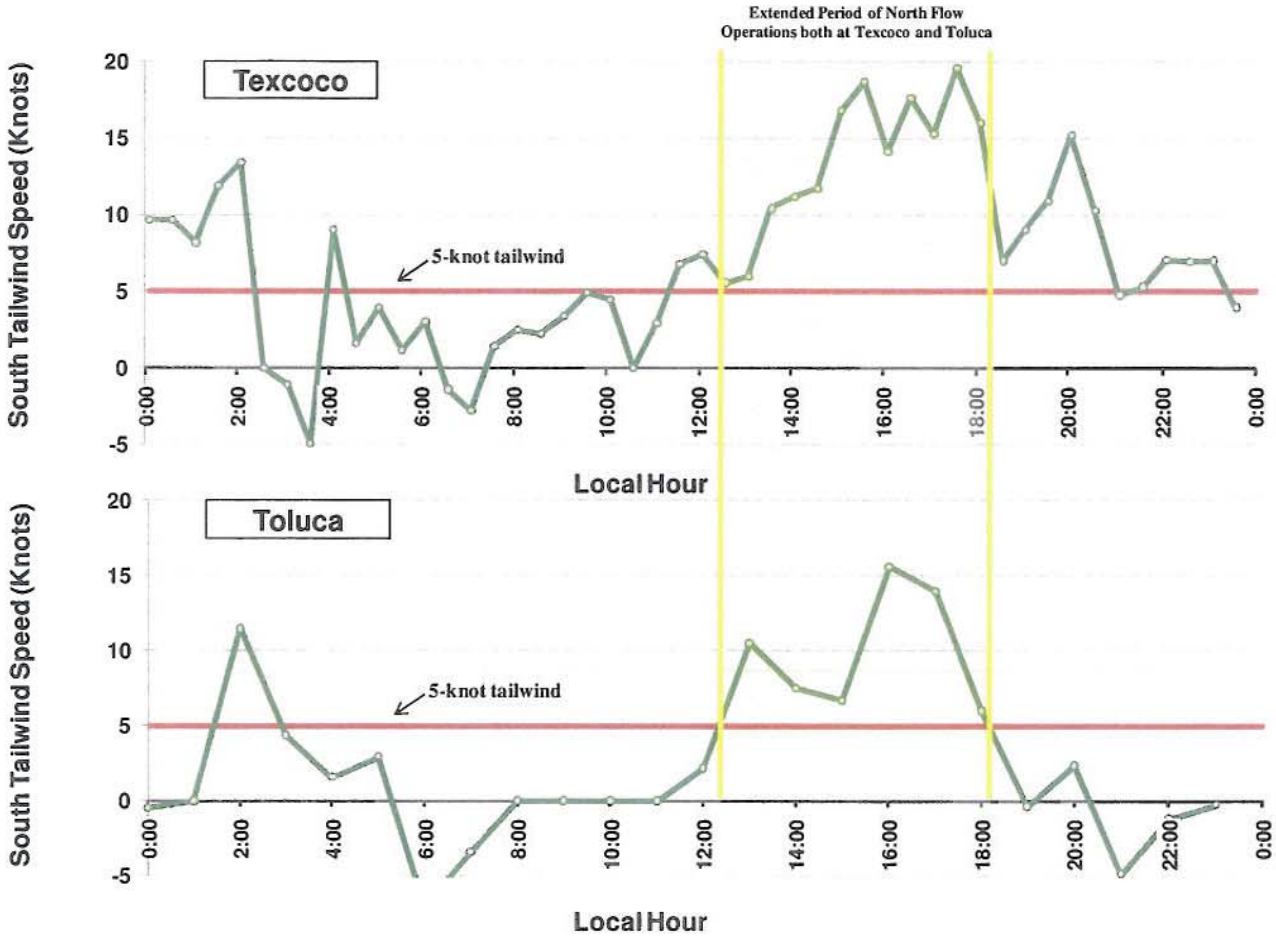


Figure 15. Texcoco vs. Toluca AWOS Data: Wind Roses (1 January through 31 May 2009)

A detailed comparative wind analysis showed that there are days when operations at Toluca and Texcoco could both be to the north (i.e., north flow). An example of such a day is shown in Figure 16. On 21 April 2009, winds that were strong enough to dictate north flow operations (i.e., south flow tailwinds exceeding 5 kt for planning purposes) occurred in Texcoco from 11:30 to 23:30. In comparison, winds that were strong enough to dictate north flow operations occurred in Toluca from 12:00 to 18:00. In situations like this one, both airports are likely to operate in a north flow configuration, which may result in adverse airspace interactions.

Although days like the one discussed above do not appear to be common (recall that this is based only on a five-month period), times when both airports may be operating in north flow at the same time do occur. More detailed analyses must be conducted when additional data is obtained to determine the frequency and duration of such occurrences.



Notes:

1. Texcoco south flow tailwinds were calculated based on a hypothetical 2-degree (true north) parallel runway orientation. MITRE is examining other orientations at Texcoco. Results will likely vary for different orientations.
2. The green line represents the tailwind speed aircraft would experience if they were operating in a southerly flow at Texcoco and Toluca. The horizontal red line represents the 5-kt tailwind component limit. When the green line is below the red line, aircraft likely would operate to the south since the tailwind component is within limits (i.e., less than 5 kt). However, when the green line is above the red line, aircraft most likely would need to operate to the north due to high tailwinds (i.e., more than 5 kt) if operating to the south.

Figure 16. Texcoco vs. Toluca AWOS Data: Tailwind Component by Hour (21 April 2009)

6.0 Next Steps

The foregoing analysis is a first step in an extensive series of cumulative weather analyses that are to be performed throughout the project. The first complete year will be of particular importance, as if it proves to be non erratic, it will produce representative patterns of the longer trend.

The results of the analysis are not being summarized as that may give the erroneous impression that conclusions are being reached. However, what is certain is the all-important value of the analysis, especially given potential adverse interactions between traffic flows associated with the existing airport at Toluca and a potential new one at Texcoco.

Finally, it is worth reiterating the importance of keeping the weather equipment well maintained. Likewise, it is critical that the authorities complete pending grading and drainage work around the Texcoco AWOS before the June rains begin to ensure that data is not compromised.