Enclosure 1

(Referenced in Technical Letter F062-L10-013)

MITRE

Center for Advanced
Aviation System Development

Preliminary Weather Analysis for the Texcoco Area

Prepared for

Dirección General de Aeronáutica Civil
Secretaría de Comunicaciones y Transportes

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1.0 Introduction

Meteorological conditions are an important consideration when determining 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 careful and accurate analysis of prevalent winds at the site is crucial in assessing the appropriateness of potential runway orientations. 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 through the use of on-site weather data obtained from an Automated Weather Observing System (AWOS).

MITRE has also been examining the terminal airspace surrounding Mexico City to determine if there are any potential issues that could impact triple-independent operations at Texcoco. This includes an analysis of potentially adverse interactions between operations at nearby airports that may lead to airspace conflicts and have a negative impact on the capacity of the future airport. This, for example, may apply to interactions between Texcoco and Toluca airports, specifically when both airports are forced to operate in north flow. While these analyses are not complete (i.e., simultaneous north flow approaches at both airports may not cause airspace conflicts after all), MITRE decided to initiate wind data comparisons for overlapping periods at both Texcoco and Toluca in case simultaneous north flow operations prove to be an issue. The assessment, described in the appendix to this report, includes the frequency and duration of occurrences when the wind conditions might cause operations to the north at both airports potentially resulting in airspace interactions.

The information contained in this report is still based on a limited weather data period. At this time, MITRE has received 14 months of reliable wind data, but only 10 months of corresponding ceiling and visibility data due to equipment malfunctions. **While MITRE feels that enough data has been obtained to provide meaningful results at this time in support of aeronautical analyses, results should not be considered final.** MITRE will continue to analyze weather information collected from the Texcoco AWOS throughout the duration of the project in order to provide more robust results. Therefore, it is important that the AWOS continue to be maintained and monthly data transmitted to MITRE for analysis. Updated results will be provided as necessary.

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. The United States (U.S.) Federal Aviation Administration (FAA) prefers 10 years of wind data. In cases where a sufficient amount of data is not available, some agencies allow a substitute weather evaluation. For example, U.S. 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. Airport development should not proceed until adequate wind data are obtained.

A data collection effort took place in the Texcoco area in recent years. While useful, it was partially supported by human-in-the-loop 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. As a result of this, Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) acquired and installed an AWOS in the Texcoco area in late December 2008. 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.

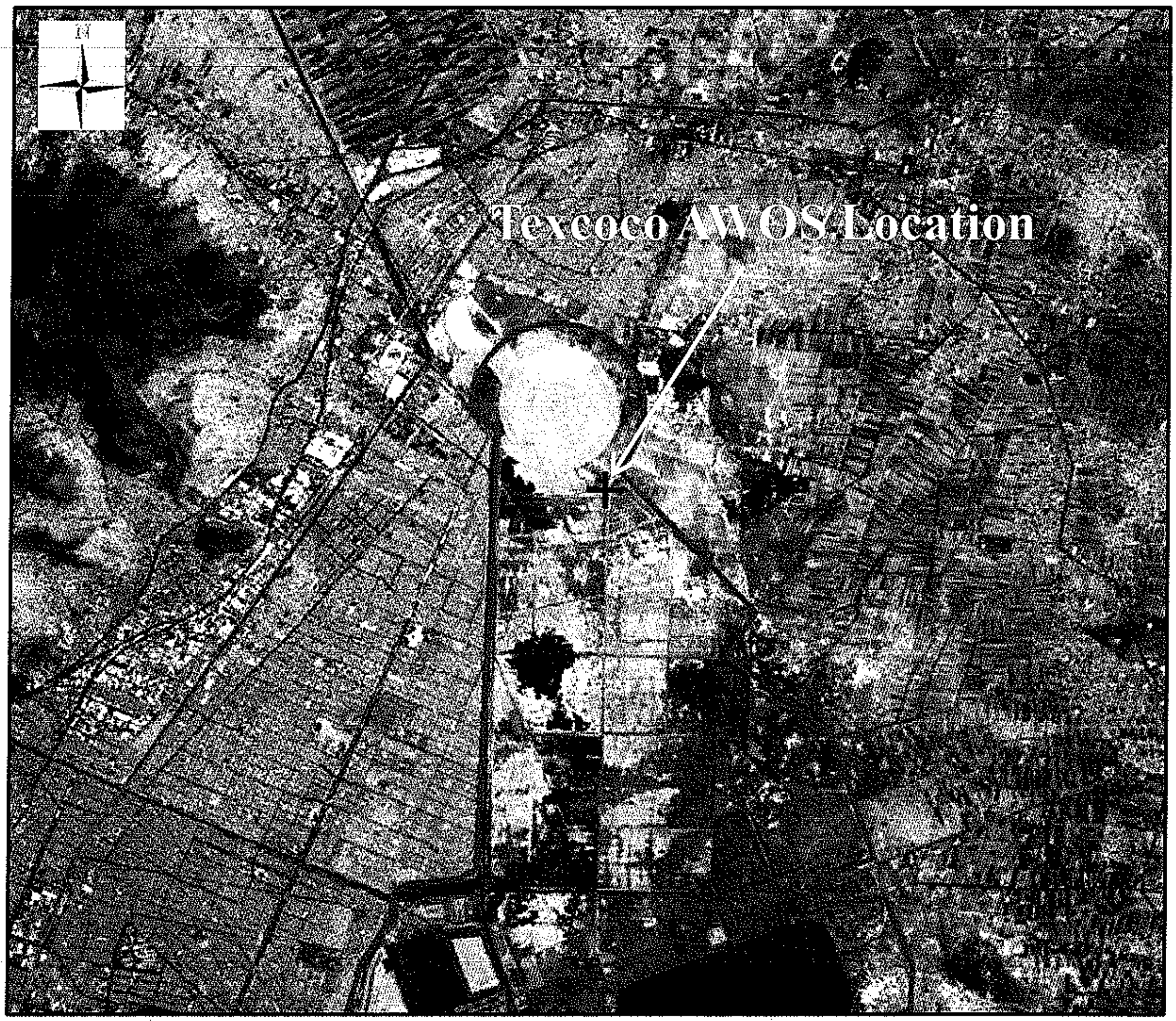

Figure 1. Location of the Texcoco AWOS

Figure 2. Texcoco AWOS under Construction

A specific runway orientation has not yet been determined due to on-going aeronautical analyses that require data on the Santa Lucía Military Base's operational and procedural profile as well as a photogrammetric satellite-based survey. MITRE hopes that the DGAC forwards to MITRE the military base's information very soon and orders the photogrammetry before May 2010. Only this way, albeit on a tight schedule, can the full project be completed within the current presidential administration in Mexico.

Currently, several runway orientations are being considered, and it is not evident as to which one will be selected as numerous aeronautical factors must still be addressed. Specifically, three orientations were chosen on the basis of aeronautical analyses beyond the scope of this report. The three orientations are 002°/182°, 021°/201°, and 034°/214° (based on True North). It is important to emphasize that orientations outside of this range may need to be examined later in the project due to issues yet to be discovered (i.e., obstacles identified through the survey, noise, etc.). Therefore, MITRE will continue to examine weather data to support the determination of a final runway orientation in coordination with other on-going work.

3.0 Data and Assumptions

This section describes the data used in this analysis.

3.1 Texcoco AWOS

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.

MITRE receives data from SENEAM each month. 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. Figure 3 shows a sample of the ceilometer malfunctions denoted by "MM" in the third column. This was reported to SENEAM, and the sensor was replaced in late April 2009.

Unfortunately, a significant amount of data was lost. Figure 4 shows the progressive worsening of the ceilometer data for the January-April time period. Notice the sharp improvement in May 2009. Therefore, MITRE decided to incorporate ceiling data into its subsequent analyses starting 1 May 2009. Since then, with the exception of a minor loss of visibility data (about 5.8 percent) in November 2009, all the sensors have been operating reliably.

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0202 0902201105 SCT026 BKN036        10     012 010 32 008    3035             00D
0203 0902201035 BKN026               10     012 010 32 007    3035             00D
0204 0902201005 BKN110               10     012 010 32 007    3035             00D
0205 0902200935 MM                   10     012 011 33 008    3035             00D
0206 0902200905 MM                   10     013 011 32 008    3035             00D
0207 0902200835 MM                   7      013 011 32 010    3035 8400        00D
0208 0902200805 MM                   7      014 011 32 0110153035 8400        00D
0209 0902200735 MM                   7      014 011 33 012    3036 8400        00D
0210 0902200705 MM                   10     014 010 32 008    3037 8400        00D
0211 0902200635 MM                   10     014 010 05 003    3036 8400        00D
0212 0902200605 MM                   10     014 010 32 004    3038 8400        00D
0213 0902200535 SCT110               10     014 010 35 005    3038 8500        00D
0214 0902200505 BKN032 BKN041 BKN095 10     015 011 32 009    3039 8500        00D
0215 0902200435 SCT032 OVC095        10     015 011 04 013    3038 8500        00D
0216 0902200405 BKN110               10     015 011 05 0200253034 8600        00D
0217 0902200335 OVC090               10     016 011 35 013    3033 8600        00D     LTG DSNT N                              -DZ
0218 0902200305 OVC090               10     016 012 35 0180233035 8600        00D     LTG DSNT W                              -RA
0219 0902200235 SCT013 OVC090        10     016 012 32 0130233034 8800        00D     LTG DSNT NW THRU NE                     -DZ
0220 0902200205 SCT070 OVC090        10     017 012 33 012    3031 8800        00D     LTG DSNT W THRU N
0221 0902200135 OVC100               10     017 012 04 009    3029 8800        00D     LTG DSNT SE W AND NW
0222 0902200105 MM                   10     016 012 01 007    3026 8800 33V04  03D     LTG VCNTY AND DSNT NE SE AND W VCTS-RA
0223 0902200035 MM                   7      016 012 08 012    3025 8800        01D     LTG DSNT ALQS                           -RA
0224 0902200005 MM                   2 1/2  019 009 06 0210303023 9100        00D     LTG DSNT E THRU W                       HZ
0225 0902192335 MM                   5      023 009 04 019    3021 9600        00D     LTG DSNT ALQS                           HZ
0226 0902192305 MM                   10     025 004 35 009    3019 9800        00D     LTG VCNTY AND DSNT E               VCTS
0227 0902192235 MM                   7      027 003 32 0120193019 10000       00D
0228 0902192205 OVC022               10     027 000 27 008    3019 10000       00D
0229 0902192135 OVC022               10     028-001 25 004    3020 10200       00D
0230 0902192105 OVC022               10     027 000 30 006    3021 10000       00D
0231 0902192035 OVC022               10     027 000 16 003    3023 10000       00D
0232 0902192005 OVC022               7      027 001 28 009    3025 9900 24V35  00D
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Figure 3. A Portion of the Texcoco AWOS Data Showing Malfunctions (Denoted as "MM")

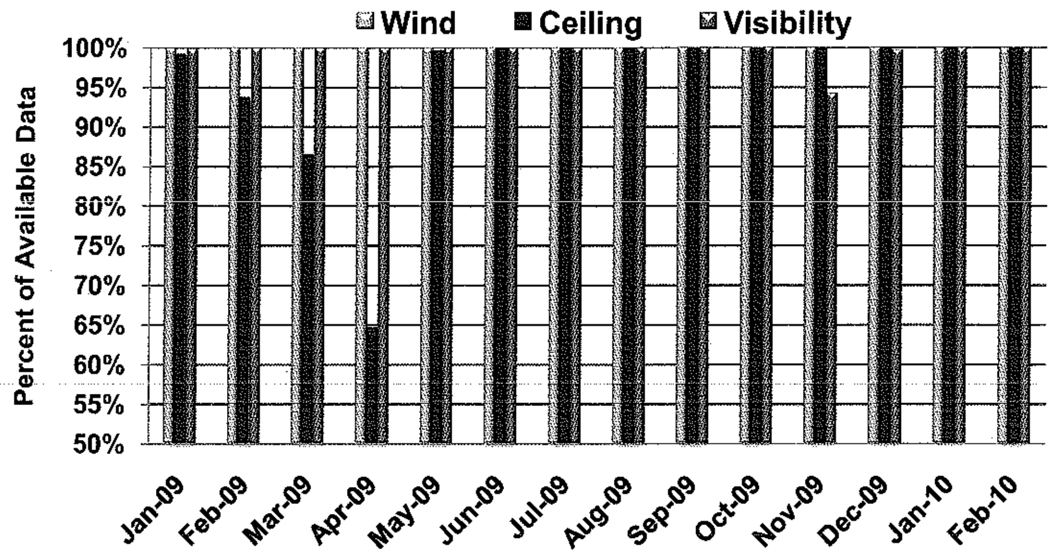

Figure 4. Texcoco AWOS Data Completeness Chart
(1 January 2009 to 28 February 2010)

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

- Ceiling and visibility – 1 May 2009 through 28 February 2010
- Wind (direction and speed) – 1 January 2009 through 28 February 2010

MITRE now has 14 months of reliable wind data (a key factor in determining the appropriateness of runway orientations). It is also important to examine wind conditions under various weather conditions, such as during periods of low ceilings or visibilities. Unfortunately, due to the above-mentioned equipment failures, only 10 months of reliable ceiling and visibility data are available. Nevertheless, the 14 months of wind data alone allows MITRE to obtain a much better understanding of the appropriateness of potential runway orientations currently being examined.

To avoid the loss of data, however, it is critical that no new "restarts" of weather data collection occur. Regular maintenance and checking of the AWOS is necessary to ensure it operates reliably and consistently, since the AWOS will likely continue collecting weather information for several more years. One concern worth reiterating is the all-important grading and drainage work around the Texcoco AWOS that has been pending since its December 2008 installation. Standing water in close proximity of the AWOS may compromise the accuracy of the visibility sensor through evaporation. It is difficult to determine if any of the data received by MITRE so far has been impacted by the lack of proper grading. *Furthermore, the fact that problems may have not happened so far are no guarantee that they will not happen in the future.*

Therefore, MITRE recommends that the grading work around the AWOS be completed to reduce the risks standing water may cause to the accuracy of the data.

3.2 Toluca AWOS

SENEAM regularly provides MITRE with data from the AWOS located at Toluca. To date, data from 1 December 2008 through 28 February 2010 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 had 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

"METAR MMTO 010045Z 06021KT 10SM SKC 19/M07 A3033 RMK HZY="
"METAR MMTO 010145Z 05018KT 10SM SKC 17/M07 A3035 RMK HZY="
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Figure 5. A Portion of the 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) in feet	Visibility (Statute Miles)	Notes
Visual Meteorological Conditions (VMC)	≥ 5000 ft	≥ 5 mi	Conditions during which visual approach procedures would likely be conducted[1]
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 Visual Flight Rules (VFR).

[1] Note that actual ceiling and visibility requirements to conduct simultaneous visual approaches at Texcoco will be established by SENEAM based on operational requirements and may be higher.

4.0 Preliminary Texcoco AWOS Data Analysis

This section describes the results of the preliminary weather analyses of the Texcoco area. In its analyses, MITRE considered the overall weather characteristics of the Texcoco area, the variability of the weather patterns by time of the day, as well as weather seasonality by months. As a result, the analysis emphasizes the periods where wind and weather conditions are more likely to affect operations at Texcoco.

Moreover, where appropriate, MITRE differentiated between typical high-demand operational hours and the hours when the airport is likely to experience lower demand. Based on operations data from the current Mexico City International Airport from 12-18 August 2007 (a relatively high-demand week), MITRE determined that the majority of operations occur between 7:00 and 23:00, approximately 16 hours. (All times in this report are local unless otherwise specified.) Therefore, many of MITRE's analyses, unless otherwise noted, focus on this time period.

The overall weather conditions that occurred in the Texcoco area from 1 May 2009 to 28 February 2010 during the typical high-demand operational hours are shown in Figure 6. The data suggests that VMC and MMC together accounted for 99 percent of the time, of which MMC occurred only 11.5 percent. The analysis shows that low ceiling or visibility conditions that would require CAT I approaches (i.e., H-IMC) occurred only 0.9 percent of the time. L-IMC weather was observed very rarely, only 0.1 percent of the time. Again, the weather results are based on only 10 months of data and, therefore, cannot be treated as representative of overall weather conditions in the Texcoco area.

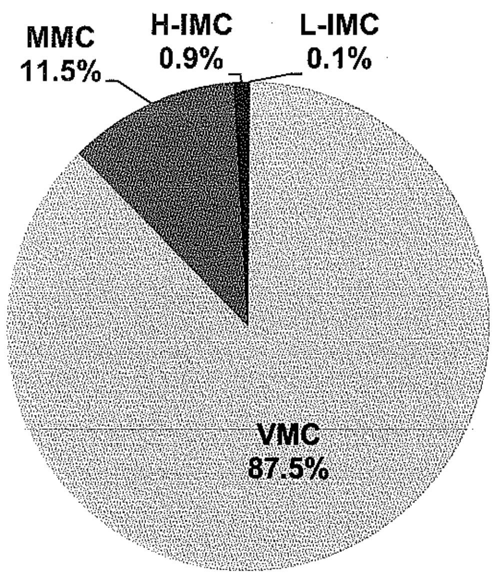

Figure 6. Texcoco AWOS Data: Weather Conditions (7:00-23:00, 1 May 2009 through 28 February 2010)

High variances in weather conditions were observed throughout the day, so the weather fluctuations were analyzed as a function of time of the day (here, in units of half-hour). As shown in Figure 7, the weather was worse during the morning hours than in the afternoon and evening. For example, from 7:00 to 10:00 in the morning, MMC conditions were observed on average about 22 percent of the time, compared to only about 5 percent during the time from 14:00 to 18:00. H-IMC conditions were observed during morning hours, averaging about 3 percent of the time from 7:00 to 10:00. H-IMC conditions were rare during the afternoon and evening hours. L-IMC conditions occurred very rarely, mostly during the early morning hours.

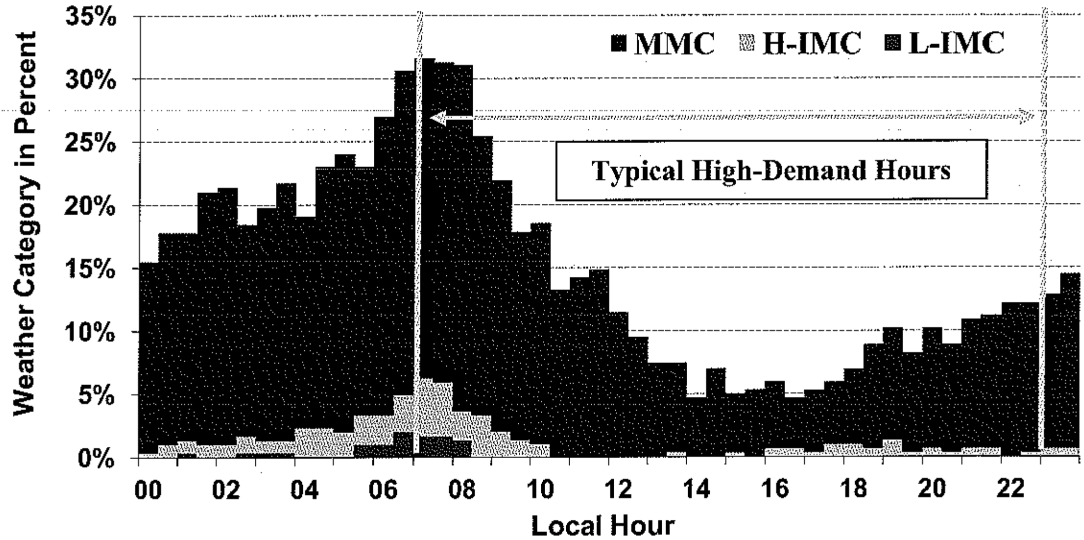

Figure 7. Texcoco AWOS Data: Overall Weather Conditions by Time of the Day (1 May 2009 through 28 February 2010)

Figure 8 shows the weather conditions by month during the typical high-demand hours (7:00-23:00). Poor weather conditions (H-IMC or worse) have been observed in all months analyzed. However, in general, it appears that poor weather conditions are not common. Furthermore, although there appears to be some slight seasonality, there have not yet been periods of poor weather conditions that have persisted for very many days during any one month. Even the higher rates observed during the fall and winter months are low in terms of the number of hours per month affected. For example, during the month of January 2010, L-IMC (i.e., CAT II and CAT III) occurred between the hours of 7:00 and 10:00 approximately 2.3 percent of the time. The conditions occurred on 12 January (CAT II from 7:00 to 8:00), 14 January (CAT III from 7:00 to 7:30) and 31 January (CAT II from 7:00 to 7:30).

The percentage of time that CAT II and CAT III conditions occur at Texcoco is very low (i.e., 0.1 percent overall). However, they do occur at times during high-demand operational periods, but not for more than an hour or so. Winds during these periods were light and usually did not exceed the 10 kt crosswind limitation associated with CAT II and CAT III approaches. Therefore, if CAT II and CAT III procedures were required at Texcoco, crosswind limitations should not be an issue. It is important to mention that this information is based on a very small data sample and that conditions could be worse. MITRE will ultimately need confirmation from Mexican meteorologists on whether the period being analyzed appears to be "typical" for the area. Given all of the above, MITRE recommends that weather observations continue for as long a period as possible in order to determine if CAT II and/or CAT III procedures are necessary.

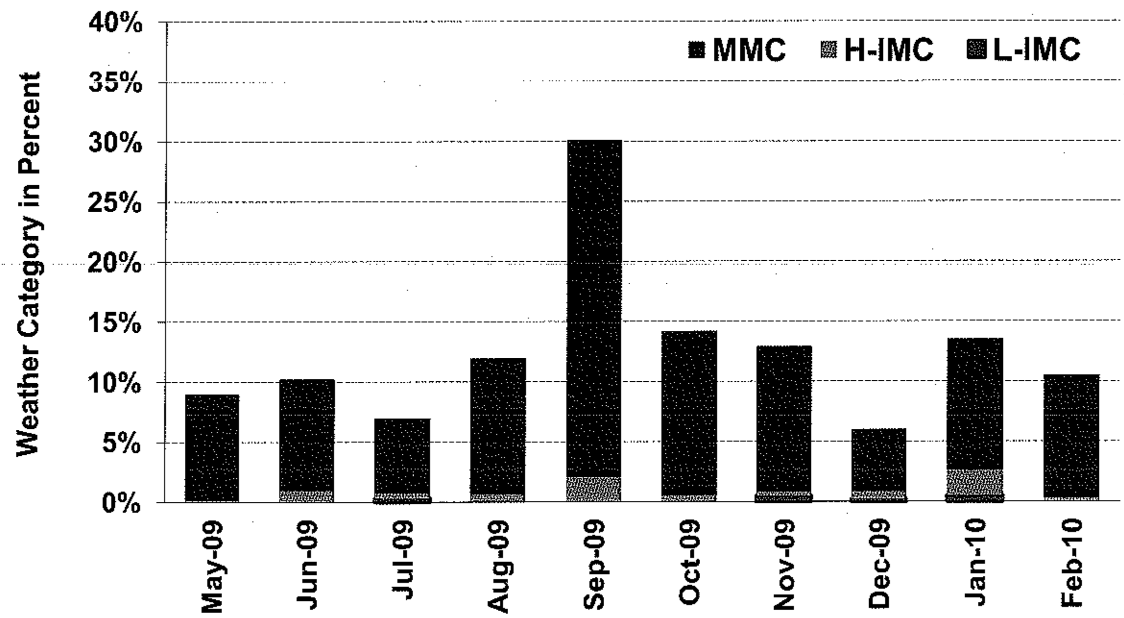

Figure 8. Texcoco AWOS Data: Overall Weather Conditions by Month (7:00-23:00, 1 May 2009 through 28 February 2010) [2]

MITRE's analysis of the wind conditions at the Texcoco area is based on AWOS data from 1 January 2009 through 28 February 2010 (14 months). Wind direction and wind speed influence the orientation of runways and its usage. For example, aircraft can safely takeoff and land with crosswinds until they exceed a specific crosswind limitation component. Those limits depend on several factors such as the type of aircraft, weather conditions, and airline operational procedures. Tailwinds are also an important consideration as they influence runway direction usage (e.g., north flow or south flow). For example, aircraft typically can land with as much as a 5-kt tailwind component. However, when that tailwind component is exceeded the runway direction usage would likely switch to the opposite runway end.

Wind speed and direction tend to fluctuate during the day, so it is important to analyze wind patterns as a function of the time of the day, especially during likely high-demand airport hours. It is also important to consider the prevalence of wind gusts. Therefore, MITRE considered gusts in its wind analyses.

Figure 9 shows the percentage of time that winds are coming from a particular direction. For example, during the nighttime (shown in the chart on the left for the hours between 23:00 and

[2] Due to the malfunctioning of the ceilometer in the months of January through April 2009, those months are not shown in the chart.

7:00), winds that are 5 kt or stronger (shown in blue bars) come most frequently from the northwest. Specifically, they come from the 330° direction about 8 percent of the time and from the 340° and 320° directions about 5.5 percent of the time.

As shown in Figure 9, Texcoco winds tend to be milder, rarely exceeding 10 kt during nighttime hours when the airport would likely be experiencing a low volume of traffic (i.e., 23:00 to 7:00), but much stronger during typical high-demand hours (i.e., 7:00 to 23:00). The results show that for the period under consideration, winds occurred predominantly from the north-northwest, north, and north-northeast. Additionally, during typical high-demand operational hours, strong winds from the south-southeast occurred frequently.

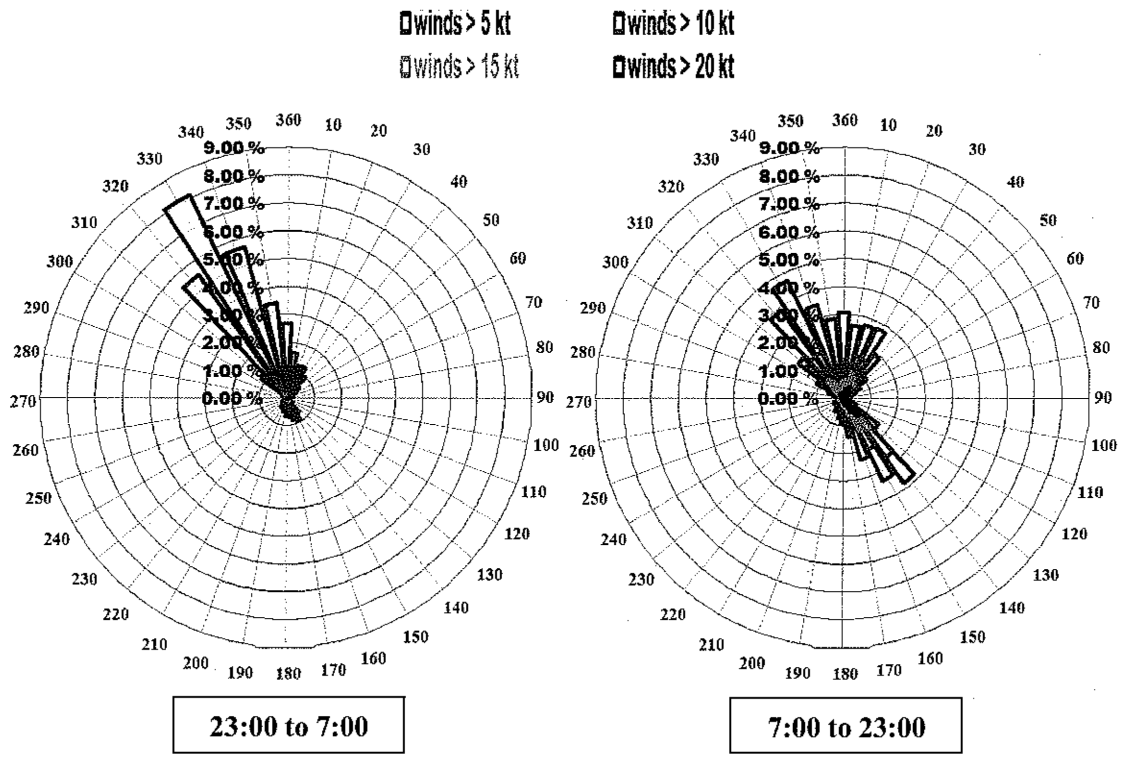

Figure 9. Texcoco AWOS Data: Meteorological Wind Rose Showing Prevailing Winds (1 January 2009 through 28 February 2010)

Winds 5 kt and less (i.e., calm winds) were common at Texcoco during typical high-demand hours, occurring about 47 percent of the time. This is an important consideration due to the fact that aircraft can typically operate in either direction when the winds are approximately 5 kt and less. Subsequently, winds that are greater than 5 kt occurred more than half of the time during the typical high-demand hours. These are the wind speeds that play a key role in determining the impact of winds on aircraft operations (e.g., crosswinds) and runway usage (e.g., tailwinds). Strong winds (20 kt and higher) occurred 5.4 percent of the time and most of them were wind gusts. 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 the typical high-demand hours from 1 January 2009 through 28 February 2010.

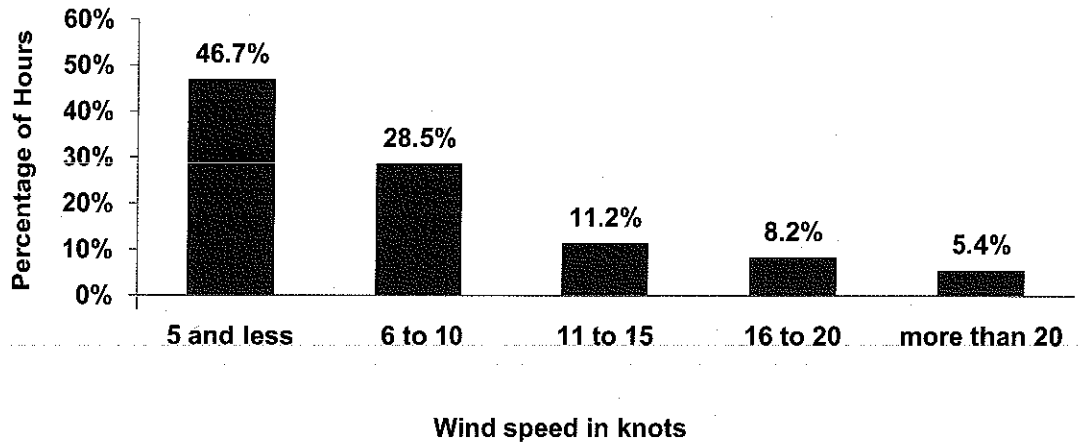

Figure 10. Texcoco AWOS Data: Wind Speed (7:00 – 23:00, 1 January 2009 through 28 February 2010)

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 limitation exceeds 20 kt in the case of aircraft whose reference field length[3] is 1500 m or more (e.g., large and heavy jet aircraft). The majority of aircraft envisioned to operate at a new Texcoco airport are large and heavy air carrier aircraft, which for ICAO planning purposes fall under the 20 kt crosswind component limitation factor. A 13 kt crosswind component limitation should be used in the case of aircraft whose reference field length is less than 1500 m but equal to or more than 1200 m (e.g., large general aviation aircraft and turboprop aircraft), and 10 kt in the case of aircraft whose reference field length is less than 1200 m (i.e., small general aviation aircraft).

For planning purposes, 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 intends to serve. The 95 percent criterion is applicable to all conditions of weather (denoted in this section as "All Weather" conditions). It is also important to examine wind conditions during other weather conditions, especially periods of poor weather (i.e., IFR).

It is important to note, however, that air carrier aircraft can typically operate with much higher crosswind component limitations than those mentioned above. For example, some air carrier aircraft, depending on the airline operating practices and other considerations (e.g., weather, aircraft type, etc.), can operate with a crosswind component limitation of 25 kt or higher during most weather conditions. During poor weather conditions, however, crosswind

[3] 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.

percent usability factor. It is important to mention that these poor weather conditions only occurred for nine hours during the period being analyzed (considering a 16-hour day), which is a very small amount of data and, therefore, not appropriate for deriving any conclusions.

The runway usability variations shown in Table 2 can be explained by the relative positions of runways to the prevailing winds that occur during those weather conditions. The meteorological wind roses in Figure 12 show the prevailing winds during All Weather conditions at Texcoco relative to the three different runway orientations being considered (i.e., 002°/182°, 021°/201°, and 034°/214°). The runway oriented 002°/182° is more aligned with the prevailing northern and southeastern winds than runways oriented 021°/201°and 034°/214°. As a result, aircraft operating on runways oriented to the north-northeast and northeast would be affected more by a higher percentage of 10- to 20-kt crosswinds.

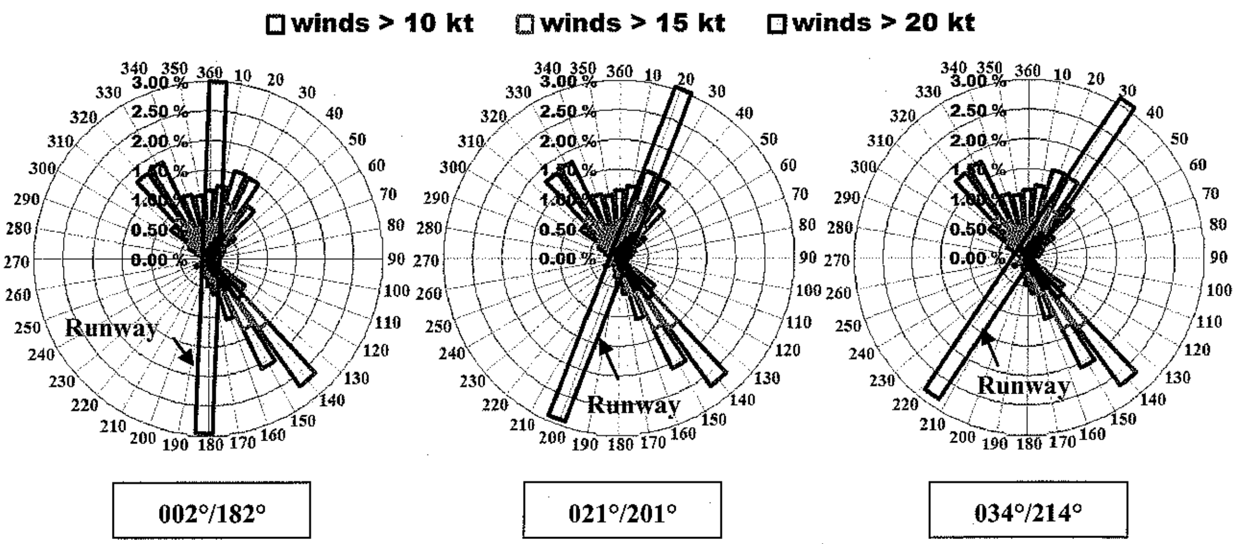

Figure 12. Texcoco AWOS Data: Meteorological Wind Roses Showing Various Orientations (7:00 - 23:00, 1 January 2009 through 28 February 2010)

Figure 13 provides the tailwind component distribution by runway ends for each of the runway orientations during typical high-demand hours. For this analysis, MITRE assumed aircraft could land with maximum of a 5-kt tailwind component. The figure shows that for Runway 002°/182°, north flow operations (due to tailwinds exceeding 5 kt for Runway 182°) could have occurred approximately 30 percent of the time, compared to approximately 16 percent of the time for south flow operations (due to tailwinds exceeding 5 kt for Runway 002°). Approximately 54 percent of the time either direction could have been used.

For Runway 021°/201°, north flow operations could have occurred approximately 27 percent of the time, compared to approximately 14 percent of the time for south flow operations. Approximately 59 percent of the time either direction could have been used.

For Runway 034°/214°, north flow operations could have occurred approximately 21 percent of the time, compared to approximately 10 percent of the time for south flow operations. Approximately 69 percent of the time either direction could have been used.

It is interesting to mention that Runway 034°/214° could provide greater flexibility in selecting which runway direction can be used since 69 percent of the time the winds are either calm or within the 5 kt tailwind component limits for either direction. However, it is important to mention that this runway experiences more direct crosswinds than the other runways.

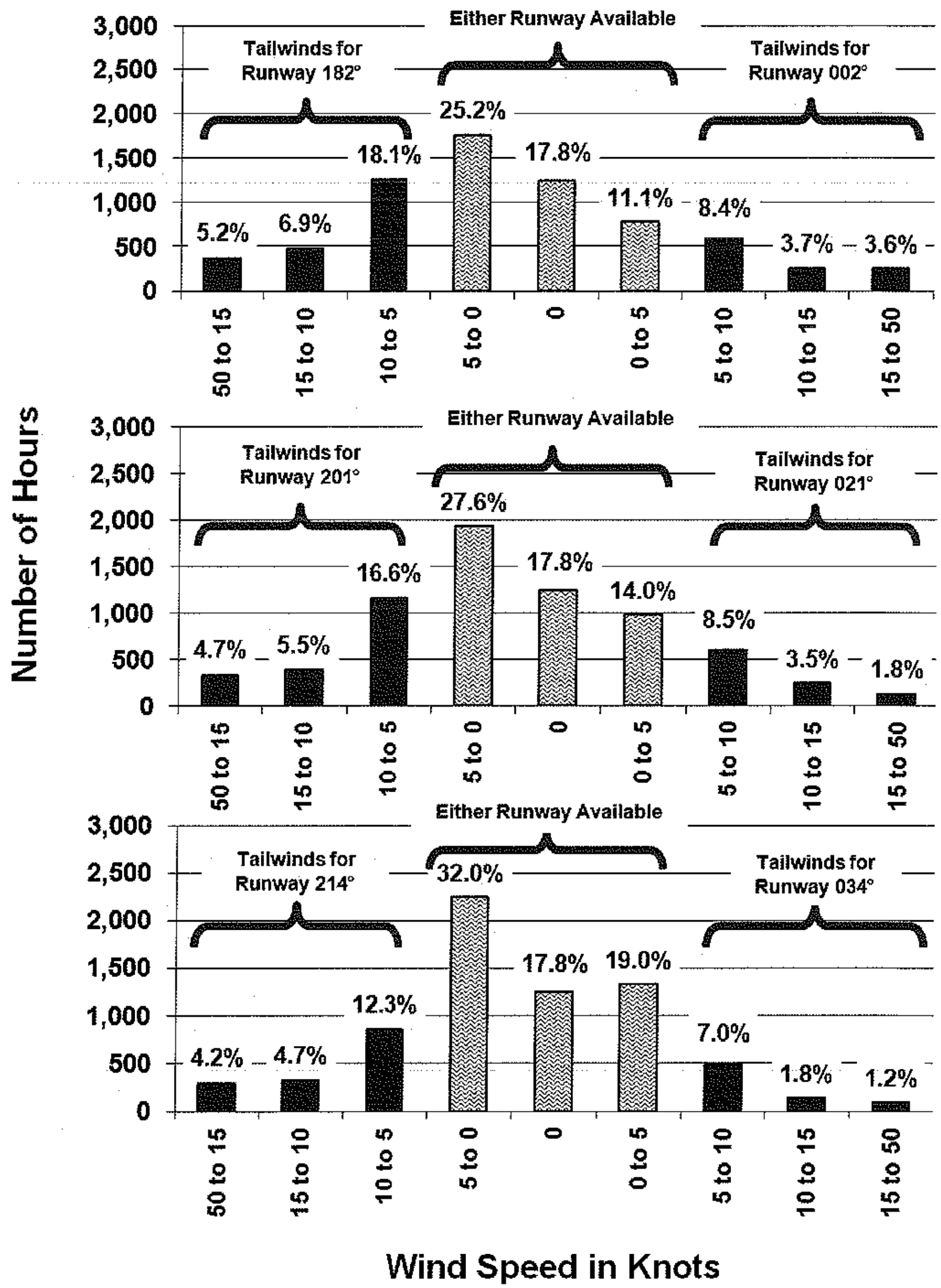

Figure 13. Texcoco AWOS Data: Tailwind Component Distribution by Runway Orientation (7:00 – 23:00, 1 January 2009 through 28 February 2010)

5.0 Preliminary Conclusions

Based on slightly more than one year of wind data (i.e., 14 months) and slightly less than one year of ceiling and visibility data (i.e., 10 months) collected from the on-site AWOS station at Texcoco, the weather in the area appears to be suitable for air carrier operations. Furthermore, the weather conditions do not appear to be erratic or unpredictable. A local meteorologist should confirm whether conditions are also typical.

Overall, the weather conditions during high-demand hours were good approximately 99 percent of the time. Even during the month that experienced the most L-IMC weather (i.e., requiring CAT II or III approach procedures to be conducted), those conditions only occurred for a few hours.

All three orientations examined (002°/182°, 021°/201°, and 034°/214°) provide at least 98 percent wind coverage considering a 20-kt crosswind component limitation (i.e., applicable to air carrier operations) during All Weather conditions. Therefore, appropriate wind coverage exists for air carrier operations for runways located within the range of orientations currently being evaluated at Texcoco.

Smaller, lighter aircraft (e.g., small general aviation aircraft) with lower crosswind component limitations, however, could at times be impacted by crosswinds. For example, considering a 13-kt crosswind limitation, only the runway oriented 002°/182° had a usability factor slightly above 95 percent during VFR and All Weather conditions. No runway orientation meets the 95 percent usability criteria at a 10-kt crosswind limitation criterion. Nevertheless, it is important to remember that most aircraft can operate with crosswind limits higher than those used by ICAO for planning purposes.

Overall, among the orientations examined at this time, the runway oriented 002°/182° would be most aligned with the prevailing northern and southeastern winds, and would provide better wind coverage than the runways oriented 021°/201° and 034°/214°. Due to the prevailing winds, north flow operations are likely to be used more than south flow operations. However, either north flow or south flow can be used a high percentage of the time (approximately 54 to 69 percent of the time depending on the runway orientation). This can be an important factor if a preferential flow is desired for operational purposes (i.e., capacity reasons caused by potential airspace interactions or to avoid noise exposure).

No conclusions are being provided on the meteorological work concerning Toluca (see the appendix to this report). This is because further aeronautical analyses about the potential interaction between Texcoco and Toluca aircraft flows need to be completed. However, the appendix was included to report on additional on-going work.

Again, it is important to emphasize that these preliminary results are based on a very short period of time (i.e., 14 months of wind data and 10 months of ceiling and visibility data) and, therefore, should not be considered as final.

MITRE recommends that weather monitoring and analysis continue in coordination with other on-going aeronautical studies (e.g., airspace and procedure design, Santa Lucía Military Base interaction, noise, etc.) that will eventually lead to the determination of a final runway orientation.

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 to ensure that data is not compromised.

Appendix

A-1. Texcoco and Toluca AWOS Data: Comparative Analysis

MITRE has also been examining the terminal airspace surrounding Mexico City to determine if there are any potential issues that could impact triple-independent operations at Texcoco. This includes an analysis of potentially adverse interactions between operations at nearby airports that may lead to airspace conflicts and have a negative impact on the capacity of the future airport. This, for example, may apply to interactions between Texcoco and Toluca airports, specifically when both airports are forced to operate in north flow. While these analyses are not complete (i.e., simultaneous north flow approaches at both airports may not cause airspace conflicts after all), MITRE decided to initiate wind data comparisons for overlapping periods at both Texcoco and Toluca in case simultaneous north flow operations prove to be an issue.

The intent of this appendix is to compare the weather during the same time periods at both Texcoco and Toluca to better understand the corresponding weather patterns and their possible impact on airport operations. For this purpose, MITRE analyzed Toluca AWOS data to determine the frequency, as well as the hourly and monthly distribution of bad weather conditions at the airport. The wind patterns are also analyzed to determine the prevailing wind velocities and distribution during typical high-demand hours, assumed to be 7:00-23:00. The results were then compared and contrasted with the corresponding weather results at Texcoco.

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 28 February 2010
- Wind (direction and speed) – 1 January 2009 through 28 February 2010

Figure A-1 shows the weather conditions at Texcoco and Toluca from 1 May 2009 through 28 February 2010 during typical high-demand hours. The same weather categories used for the analysis of Texcoco weather were used for Toluca (see Table 1 of the main report). Overall, weather conditions at Toluca were significantly worse than at Texcoco. For example, Toluca experienced 6.4 percent of H-IMC weather, compared to only 0.9 percent at Texcoco. The MMC weather at Toluca accounted for 38.6 percent of the time, while it was 11.5 percent at Texcoco. The L-IMC weather was also higher at Toluca than at Texcoco.

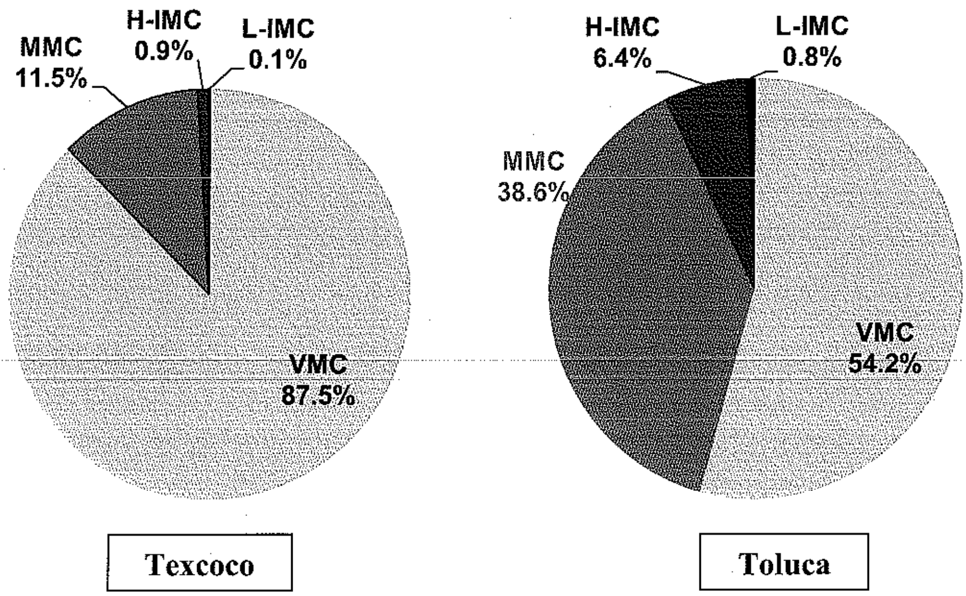

Figure A-1. Texcoco vs. Toluca AWOS Data: Weather Conditions (7:00-23:00, 1 May 2009 through 28 February 2010)

Unlike Texcoco, MMC weather was very common at Toluca in the late afternoon hours. H-IMC and L-IMC conditions were observed much more frequently at Toluca, especially during the morning hours (see Figure A-2).

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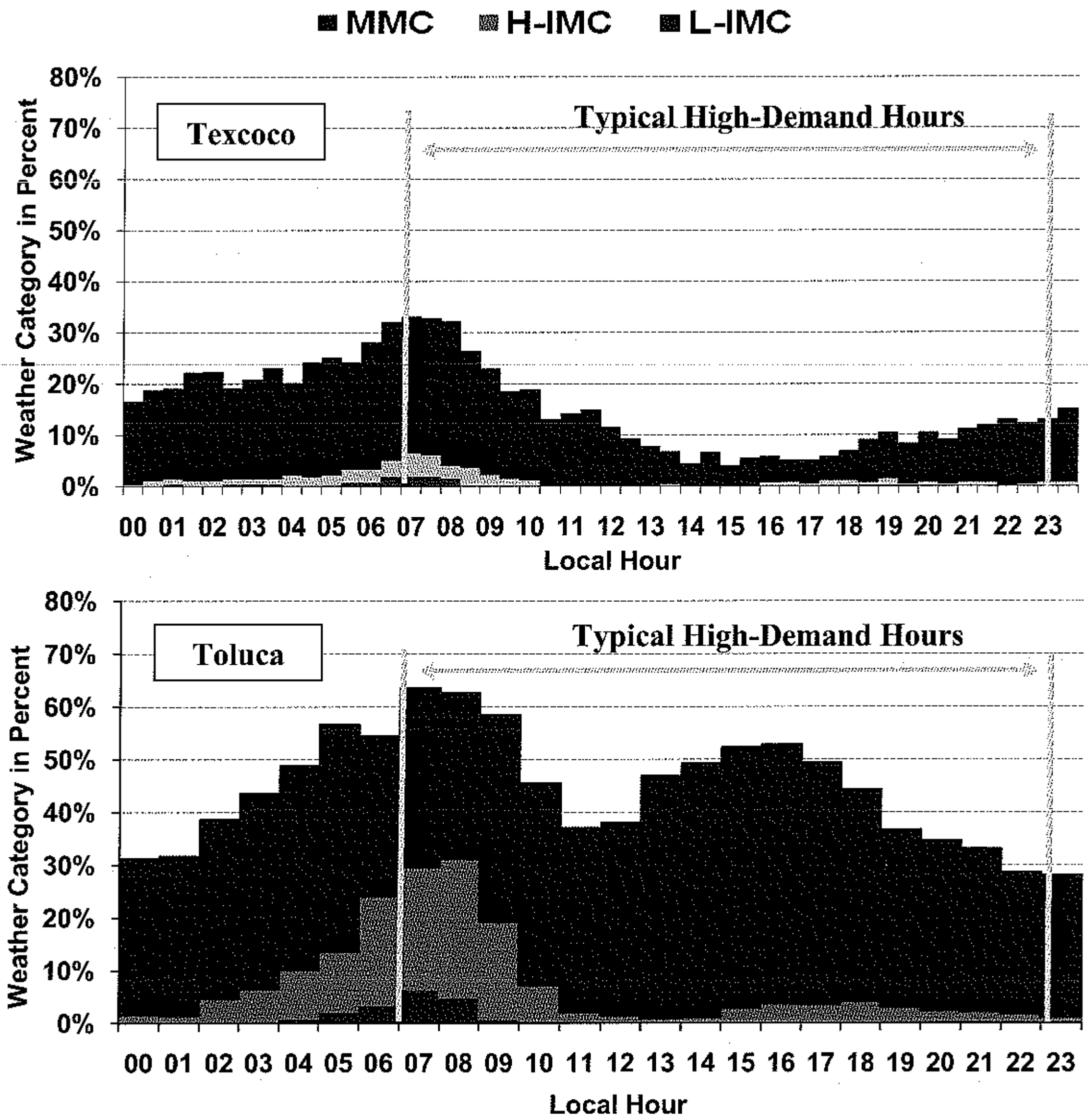
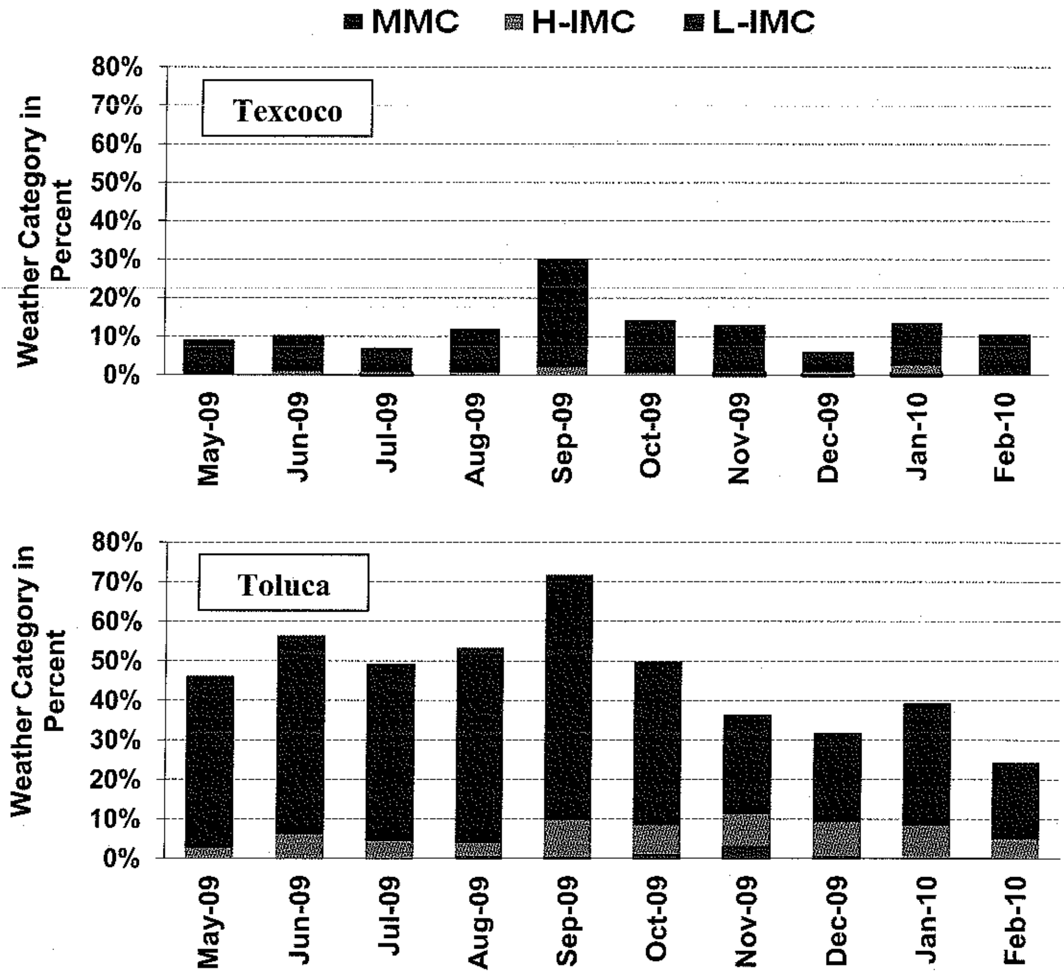


Note: The Texcoco graph (top) is the same as in Figure 7 of the main body of this report: however it was scaled in this figure to be comparable to the Toluca graph (bottom).

Figure A-2. Texcoco vs. Toluca AWOS Data: Weather Conditions by Hour (1 May 2009 through 28 February 2010)

The monthly distribution of weather conditions at Toluca during typical high-demand hours, presented in Figure A-3, shows that H-IMC weather occurred in all months, reaching the peak of 9.5 percent in September 2009. By contrast, the peak H-IMC weather at Texcoco was in January 2010, occurring only 2.2 percent of the time. At Toluca, L-IMC weather was observed in June 2009 through January 2010, reaching the peak of 3.3 percent in November 2009 (compared to the highest L-IMC weather occurrence of 0.5 percent at Texcoco in January 2010). MMC weather was very common in all the months at Toluca, reaching the peak of 60 percent in September 2009. MMC weather was also the highest in September at Texcoco, although it occurred only about 28 percent of the time. Figure A-3 shows the monthly distribution of weather conditions at Toluca and Texcoco.



Note: The Texcoco graph (top) is the same as in Figure 8 of the main body of this report: however it was scaled in this figure to be comparable to the Toluca graph (bottom).

Figure A-3. Texcoco vs. Toluca AWOS Data: Weather Conditions by Month (7:00 – 23:00, 1 May 2009 through 28 February 2010)

It is also important to mention that Toluca experiences fog during key operational hours of the morning during several months of the year (fall and winter months), which can severely impact operations. The yellow vertical bars in Figure A-4 highlight the distribution of weather conditions in the morning hours (7:00-10:00, by half-hour intervals) from August through December 2009 (the months with more frequent bad weather conditions). The L-IMC conditions frequently occurred during these hours. For example, from 7:00 to 8:00 in the morning, the L-IMC weather during those months was observed more than 11 percent of the time. During these extremely poor weather conditions (i.e., fog) Toluca operations are likely to be conducted in a southerly flow (wind permitting) as only Runway 15 has CAT II/III approach procedures. Winds are typically calm during the extremely poor weather conditions at Toluca.

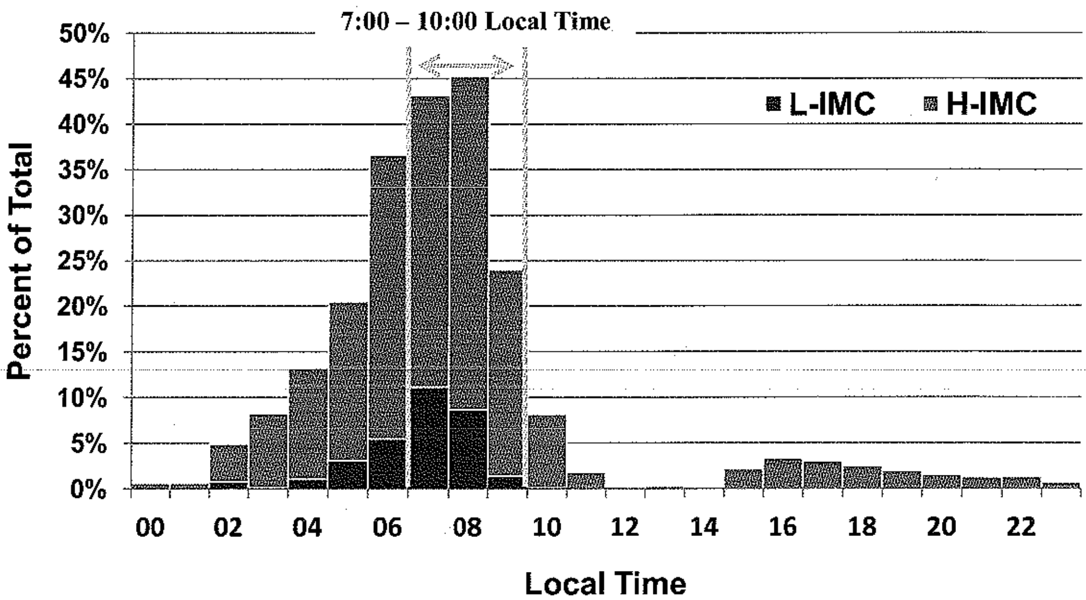


Figure A-4. Toluca H-IMC and L-IMC Weather Conditions by Time of the Day (August - December 2009)

Due to the proximity of the Texcoco and Toluca airports, the frequency and directions of the future traffic flows could potentially result in adverse airspace interactions. Based on separate preliminary analyses, MITRE determined that airspace interactions could exist when Texcoco is conducting independent operations to the north while at the same time an expanded Toluca (i.e., with a new parallel runway) is also conducting dependent or independent operations to the north. Therefore, the wind coverage is being analyzed in both airports during various weather conditions to determine the percentage of the time both airports have to operate simultaneously in a north flow due to wind conditions.

First, the wind velocities and directions at both airports were examined. As was the case with the Texcoco wind analysis, gusts were also considered in the Toluca wind analysis. The wind analysis of the two sites indicates that winds at Texcoco have higher velocity and occur more frequently than at Toluca during the typical high-demand hours. For example, winds exceeding 15 kt were observed about 14 percent of the time at Texcoco compared to only about 3 percent at Toluca. Winds with a speed of 10 kt or less occur about 75 percent of the time at Texcoco compared to 83 percent at Toluca. Winds 20 kt or less occurred almost 95 percent of the time at Texcoco compared to almost 100 percent of the time at Toluca. Finally, winds of 5 kt or less that most likely would allow either runway direction to be used occurred about 47 percent of the time at Texcoco and 54 percent of the time at Toluca (see Figure A-5).

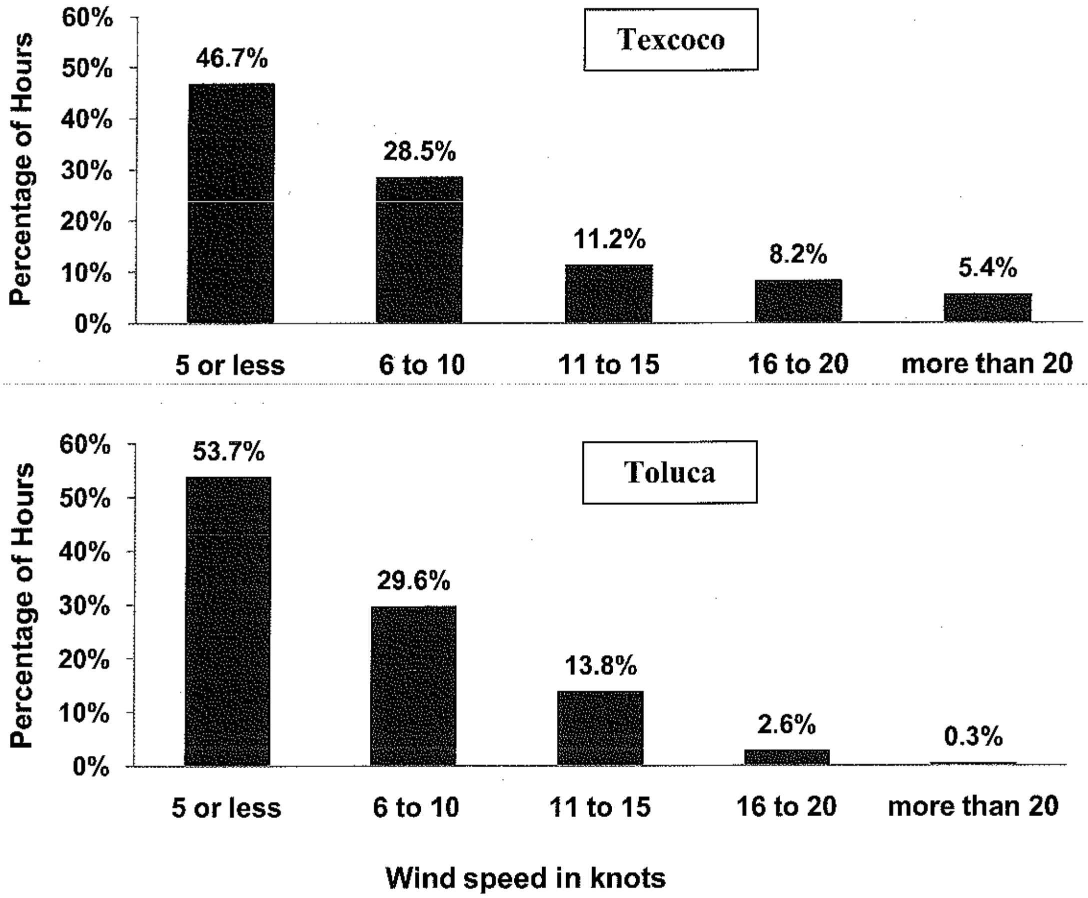


Figure A-5. Texcoco vs. Toluca AWOS Data: Wind Speeds (7:00 – 23:00, 1 January through 28 February 2010)

Next, MITRE developed meteorological wind roses for both sites to compare the speeds, direction, and the frequencies of occurrence of the winds to better understand potential traffic flows that might occur in the same direction. Figure A-6 shows the prevailing wind environment at Toluca and Texcoco during the typical high-demand hours.

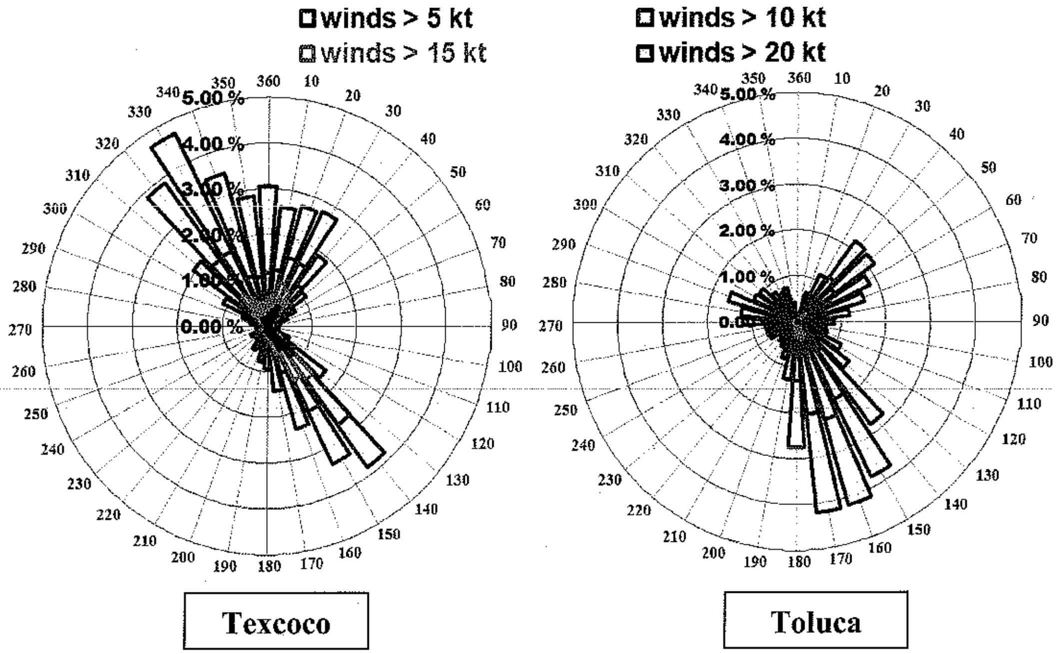


Figure A-6. Texcoco vs. Toluca AWOS Data: Meteorological Wind Rose Showing Prevailing Winds (7:00 – 23:00, 1 January 2009 through 28 February 2010)

Note that in a significant number of occurrences the wind directions at Toluca and Texcoco are coinciding. For example, at both sites, the winds frequently occur from northeast, sometimes at velocities higher than 5 kt. The meteorological wind roses, however, do not show the winds that are occurring at the same time. The results of the simultaneous wind analysis are provided in the section below.

A-2. Texcoco and Toluca AWOS Data: Simultaneous North Flow Analysis

As previously mentioned, MITRE determined that airspace interactions could exist when Texcoco is conducting independent operations to the north while at the same time an expanded Toluca (i.e., with a new parallel runway) is also conducting dependent or independent operations to the north. Although wind condition is not the only parameter that could dictate north flow operations at the airports, it is certainly an important consideration. When the runway orientation at Texcoco is determined and various aeronautical analyses have advanced farther (e.g., airspace, procedures, noise, etc.), other operational issues could be identified that might influence the preferred flow of operations at the airports.

The analysis below is based on wind conditions only. It assumes that the operations at both airports are ***forced*** to occur in a north flow if the winds coming from the north of the airports create a tailwind component exceeding 5 kt for runway orientation 157° at Toluca and runway orientations 182° and 214° at Texcoco. More specifically, the analysis estimates the frequencies of the forced north flow operations at both airports, as well as the percentage of the time the forced north flow operations at both airports occurred simultaneously during the typical high-demand hours (i.e., from 7:00 to 23:00) since this is when potential airspace interactions may occur. (Keep in mind that all mentioned runway orientations are based on true north to coincide with the format of the wind data for analytical purposes.)

In general, winds that would force north flow operations were more frequent at Texcoco than Toluca. Since strong winds at Texcoco were often observed to come from the north and north-northwest, north flow operations are expected to be more frequent for runway orientation 002°/182° than the runway orientation 034°/214°. At Toluca, on the other hand, strong winds are more common from the south-southeast, so north flow operations are expected less frequently (see the wind rose in Figure A-6 of the previous section).

Figure A-7 shows the monthly distribution of forced north flow operations at Toluca and Texcoco (runway orientations 002°/182° and 034°/214°) from 1 January 2009 to 28 February 2010. Winds that would force north flow operations at Texcoco were less frequent in December 2009 through February 2010 for runway orientations 002°/182° and 034°/214°. On average for all months, the winds that would force Texcoco runway orientation 002°/182° to operate in a north flow occurred about 29 percent of the time, and only 20 percent of the time for runway orientation 034°/214°. Winds that would force north flow operations at Toluca occurred on average about 9 percent of the time, ranging from about 1.5 percent of the time in August 2009 to about 14.4 percent of the time in March 2009.

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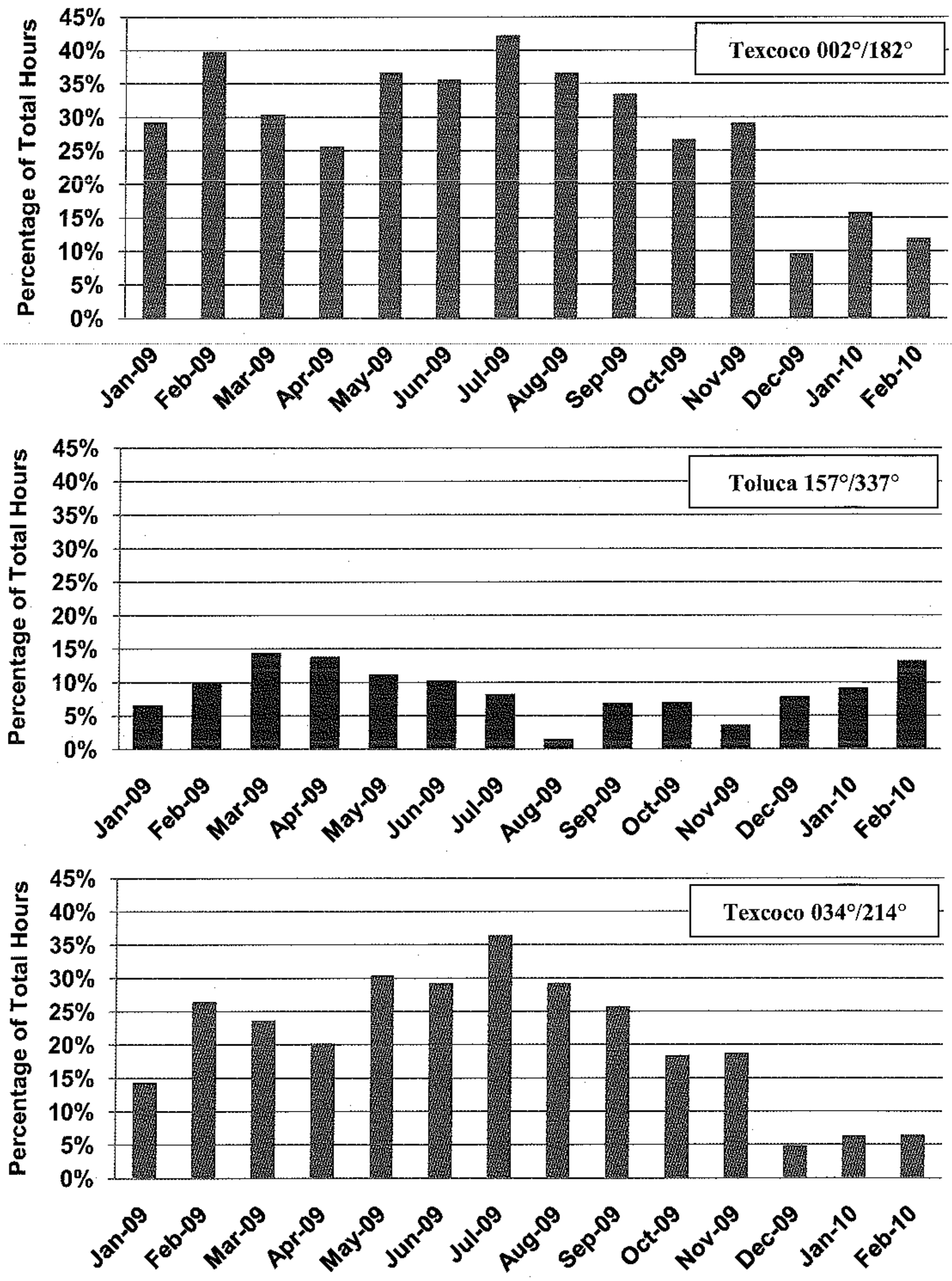


Figure A-7. Toluca and Texcoco AWOS Data: Percentage of North Flow Operations for Texcoco Runway Orientations 002°/182° and 034°/214°, and Toluca 157°/337° (7:00 - 23:00, 1 January 2009 to 28 February 2010)

At the same time, it is important to understand how often north flow operations would have to occur simultaneously at both airports during typical high-demand hours. Figure A-8 shows the frequency distribution of those occurrences between Toluca and Texcoco runway orientations 002°/182° and 034°/214°. On average for all months, the simultaneous north flow operations at Toluca and Texcoco runway 002°/182° would have been necessary about 3.7 percent of the time, however the range of the occurrences varied from 0.2 percent in August 2009 to 6.3 percent in July 2009. Simultaneous north flow operations at Toluca and Texcoco runway 034°/214° would have been necessary on average about 2.8 percent of the time, ranging from 0.4 percent in August 2009 to 5.7 percent in February 2009.

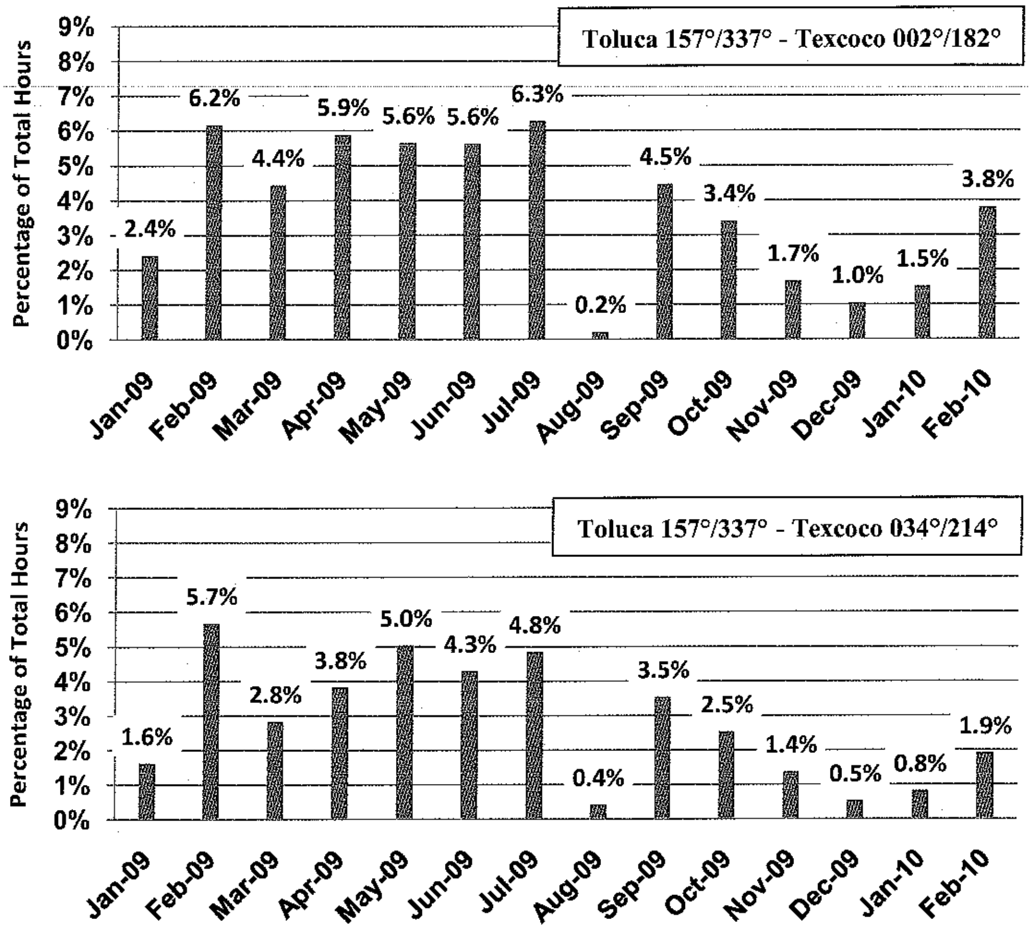
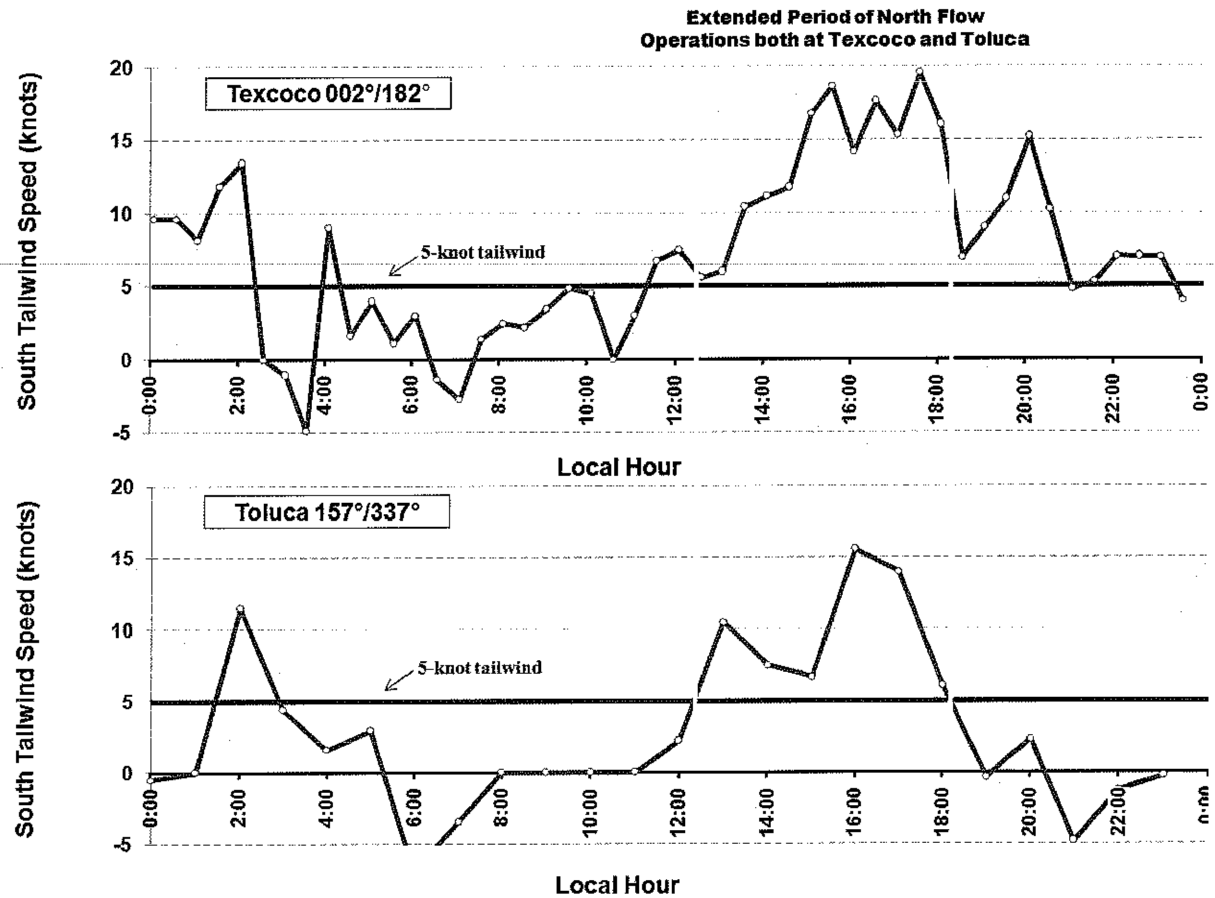


Figure A-8. Texcoco vs. Toluca AWOS Data: Percentage of Simultaneous North Flow Operations Required For Texcoco Runway Orientations 002°/182° and 034°/214°, and Toluca 157°/337° (07:00 - 23:00, 1 January 2009 to 28 February 2010)

An example of a day when operations at Toluca and Texcoco would likely need to be to the north is shown in Figure A-9. On 21 April 2009, winds that were strong enough to dictate north flow operations (i.e., south flow tailwind component exceeding 5 kt) at Texcoco (runway orientation 002°/182°) occurred from approximately 11:30 to 23:30. In comparison, winds that were strong enough to dictate north flow operations in Toluca on the same day occurred from approximately 12:00 to 18:00. In this situation, both airports are likely to operate in a north flow configuration, which could result in potential airspace interactions. (It is important to remember that airspace analyses of the Mexico City area are ongoing, and it may be determined that simultaneous north flow approaches at both airports may not cause airspace conflicts after all.)



Notes:

1. Texcoco south flow tailwinds were calculated based on the 002°/182° runway orientation.

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 would be able to operate to the south since the tailwind component is within limits (i.e., 5 kt or less). 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).

Figure A-9. Texcoco vs. Toluca AWOS Data: Simultaneous North Flow Operations at Texcoco Runway Orientation 002°/182° and Toluca Runway 157°/337° on 21 April 2009

It should be noted, however, that days like the one discussed above, with more than six hours of forced simultaneous north flow operations, do not appear to be common. The analysis shows that simultaneous north flow operations rarely last more than two hours continuously. Figure A-10 shows the monthly distribution of percentage of time the north flow simultaneous operations at Toluca and Texcoco (runway orientation 002°/182° in this case) lasted for at least one, two or three hours continuously. The analysis is done for the typical high-demand hours from 7:00 to 23:00. Similar patterns were observed when analyzing Texcoco runway orientation 034°/214° and the Toluca runway.

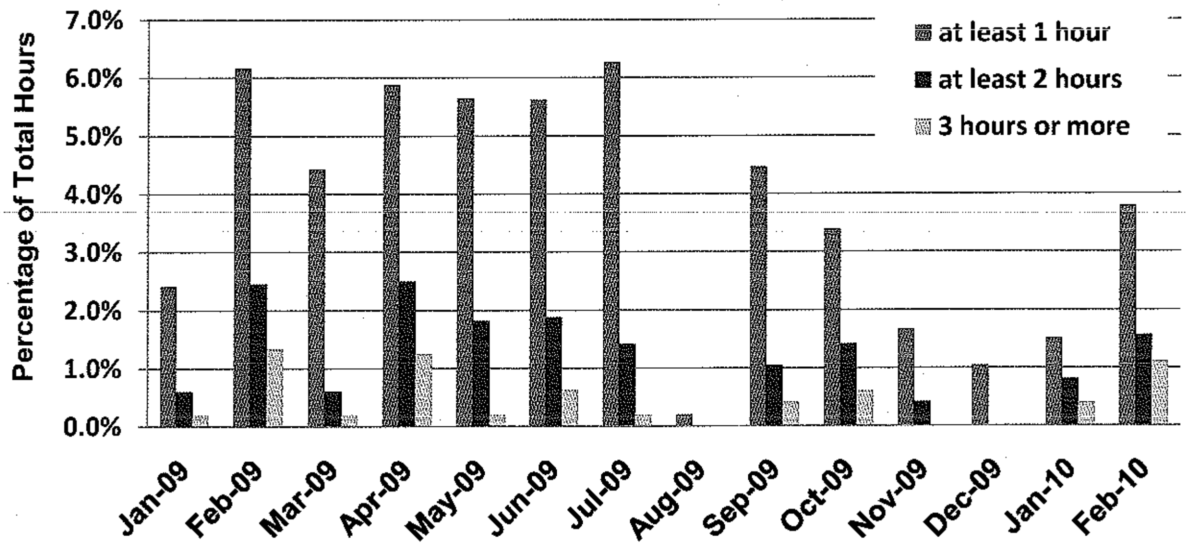


Figure A-10. Texcoco vs. Toluca AWOS Data: Percentage of Simultaneous North Flow Operations at Texcoco Runway Orientation 002°/182° and Toluca Runway 157°/337°, Monthly Distribution (07:00 - 23:00, 1 January 2009 to 28 February 2010)