Enclosure 4

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MITRE

Center for Advanced
Aviation System Development

Mexico City Terminal Maneuvering Area Geographical Traffic Distribution Analysis

Preliminary Results

Prepared for

Aeropuertos y Servicios Auxiliares

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Principal Acronyms and Abbreviations

ACC	Area Control Center
MITRE	The MITRE Corporation
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México
SENEAM	Servicios a la Navegación en el Espacio Aéreo Mexicano
TARGETS	Terminal Area Route Generation Evaluation and Traffic Simulation
TMA	Terminal Maneuvering Area

1. Introduction

The MITRE Corporation (MITRE) is assisting the government of Mexico to turn into reality the construction of a new airport for Mexico City, hereinafter referred to as the Nuevo Aeropuerto Internacional de la Ciudad de México (NAICM). Part of the assistance being provided to Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) is to assist in the development of an airspace design for the Mexico City Terminal Maneuvering Area (TMA) and Mexico Area Control Center (ACC) enroute airspace that will permit the introduction of independent approach and departure operations at NAICM. The airspace design developed will accommodate NAICM and Toluca International Airport (hereinafter Toluca). Other nearby satellite airports will be considered as well.

1.1 Purpose and Structure of this Document

The purpose of this document is to provide insight into the current traffic distribution of the existing Aeropuerto Internacional de la Ciudad de México (hereinafter AICM) and Toluca which will assist airspace designers in redesigning the Mexico City TMA and Mexico Upper (Enroute) airspace. As NAICM is a new airport for which no geographical traffic distribution exists, MITRE's airspace analysis for NAICM will consider the geographical traffic distribution from AICM as a surrogate. Understanding the volume and distribution of traffic as well as its origin and destination allows airspace designers to develop a more optimized airspace design. Specifically, the information is helpful in determining the number of routes necessary for the traffic volume and in assigning routes to runways for balancing operations.

This document is structured as follows:

- Section 2 contains a description of the methodology MITRE used to determine the geographical traffic distribution for AICM and Toluca.
- Section 3 provides the results from MITRE's previous geographical traffic distribution analysis based on data provided by SENEAM for a busy day in 2007 (13 July 2007, as selected by SENEAM).

  Geographical traffic distribution analysis results based on data provided by SENEAM for a busy week in 2015 (25 through 31 January, as selected by SENEAM) are also provided.

  In addition, this section compares the geographical traffic distribution results between the two different traffic data periods to show how the distribution has changed.
- Section 4 summarizes the analysis findings.

2. Geographical Traffic Distribution Methodology

The methodology used for the analysis has five steps. The results from the analysis are shown as traffic counts and the percentage of total traffic for AICM and Toluca. These two airports represent the airports with the most influence on the airspace redesign for a new Mexico

City TMA. A graphical depiction of the methodology's five steps is shown in Figure 1, followed by a textual description of each of the steps.

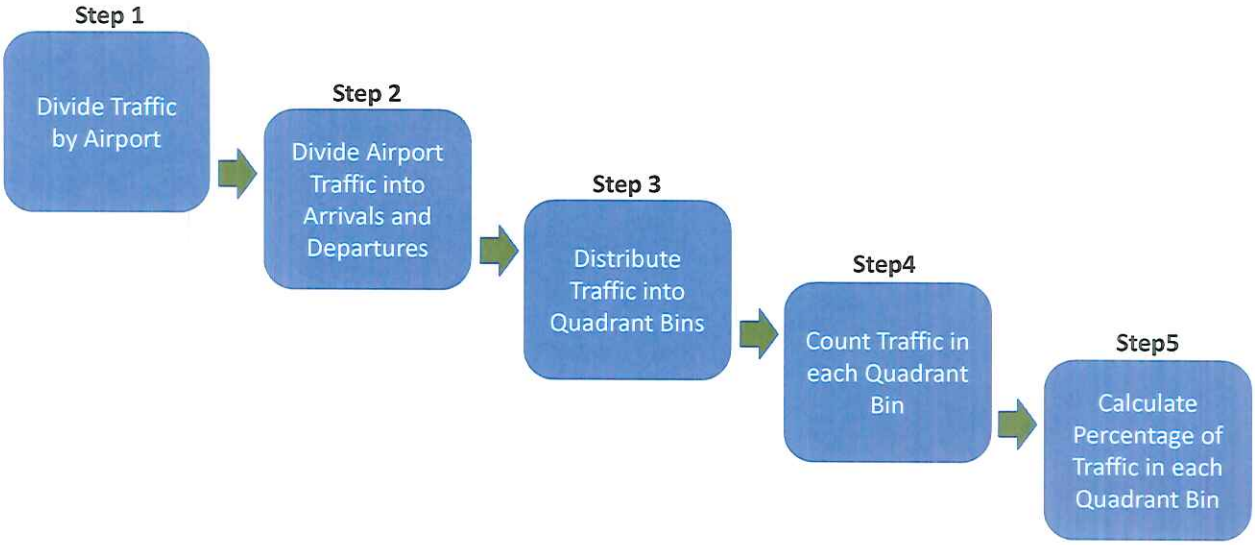


Figure 1. Geographical Traffic Distribution Methodology

Each of the steps in the methodology are described below:

Step 1: The traffic statistics considered by MITRE include fixed-wing aircraft flights to and from public airports. The traffic statistics were divided into groups based on the arrival and departure airports inside the Mexico City TMA, specifically AICM and Toluca. For this step, any flight that either arrived or departed AICM or Toluca was divided and placed into either the AICM group or the Toluca group.

Step 2: Each of the AICM and Toluca groups from Step 1 were further divided between arrival and departure traffic operations. This step provided the total number of arrival and departure operations for each individual airport which was later used to determine the traffic distribution based on percentages of total arrivals or departures for each airport.

Step 3: Based on the arrival and departure traffic groups for AICM and Toluca, the arrival and departure airports were extracted from the traffic data and imported into MITRE's Terminal Area Route Generation Evaluation and Traffic Simulation (TARGETS) tool. For each individual flight, the origination and destination airports were connected with a "city-pair connector line", which represented the geographic location of where the flight was coming from or going to. The result was a collection of city-pair connector lines that indicate direct paths between the individual city pair combinations. For this analysis, the actual route of flight was not needed as the objective was to determine the city pair geographic locations and not the actual route the aircraft flew.

Next, projection lines centered on each airport were drawn to divide the Mexico City TMA into quadrants, north-east, east-north, east-south, south-east, south-west, west-south, west-north, and north-west, as shown in Figure 2.

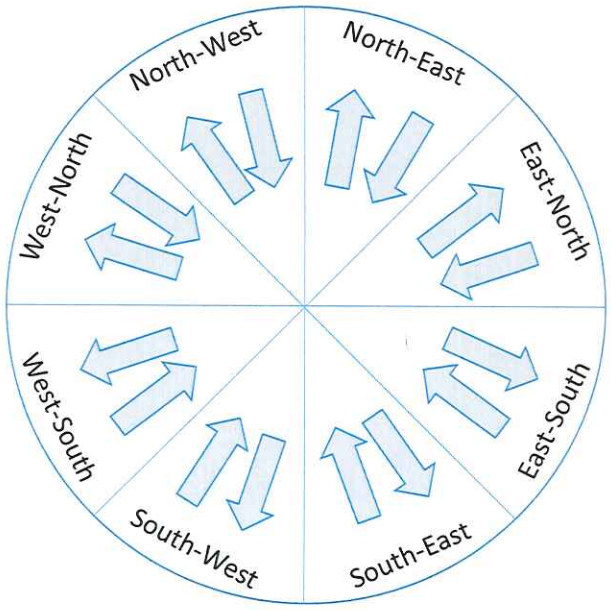


Figure 2. Quadrant Divisions

Any city-pair connector line contained inside the space between the projection lines was counted in that quadrant bin total. For example, if an individual flight departed AICM and went to one of the airports in Europe the city-pair connector line would fall into the east-north quadrant and would be counted in this quadrant's bin total. For flights that overlaid directly on the projection lines, a judgment call was made as to which quadrant the flight belonged. This was done for all AICM and Toluca arrival and departure flights. Therefore, each quadrant bin would have a set of arrival flights for AICM, a set of departure flights for AICM, a set of arrival flights for Toluca, and a set of departure flights for Toluca.

Step 4: The individual city-pair connector lines in each quadrant bin were counted, based on airport and type of operation (arrival or departure). The resulting total were counts of AICM arrival and departure traffic, as well as counts of Toluca arrival and departure traffic for each quadrant bin.

Step 5: The traffic distribution percentage was calculated by dividing each airport's arrival and departure quadrant bin counts from Step 4 by the total airport arrival and departure counts from Step 2. For example, the traffic distribution percentage calculation for traffic from the eastern United States and Europe arriving to AICM is the count of city-pair connector lines contained in the east-north quadrant created in Step 4, divided by the total number of arrival operations at AICM determined in Step 2. This calculation was completed for each airport's arrival and departure quadrant bins.

3. Results from MITRE's Traffic Distribution Analysis

This section presents the results from the traffic distribution analysis. The individual traffic distribution counts and percentages are presented first, followed by a comparison between the

two different time periods to determine whether the traffic increased, decreased or remained the same within each quadrant.

3.1 Geographical Traffic Distribution Results for 2007

As previously mentioned, the geographical traffic distribution analysis for 2007 was based on data that was obtained from SENEAM for 13 July 2007. These data were given to MITRE for a previous project and provides a baseline for comparison purposes. Figure 3 shows the projection lines (in black) with the counts for each airport embedded in the arrow diagrams. Figure 4 shows the percentages which are the results of a calculation of each quadrant's city-pair-connector line counts divided by the total type of traffic (i.e., arrival or departure) for each count of city-pair connector lines for each airport. Although Figures 3 and 4 show one set of projection lines, the city-pair connector line groupings were actually derived from projection lines centered on AICM and again for Toluca.

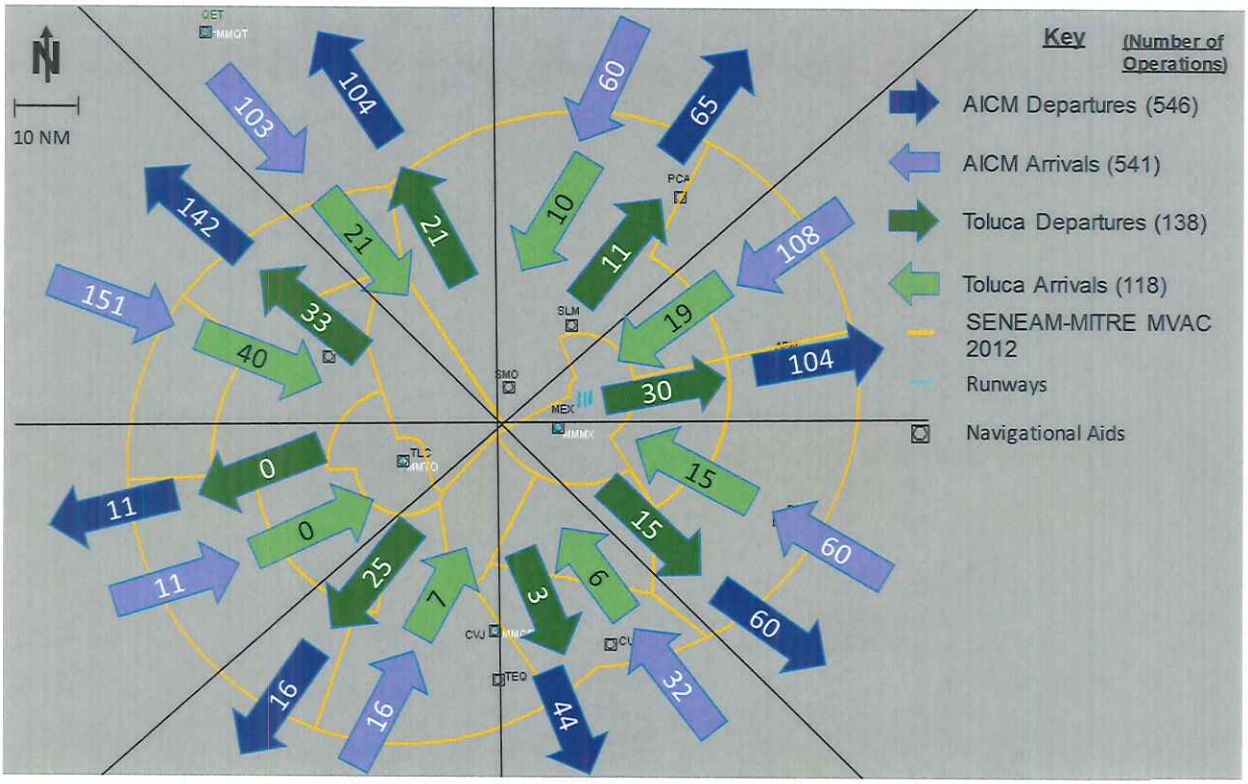
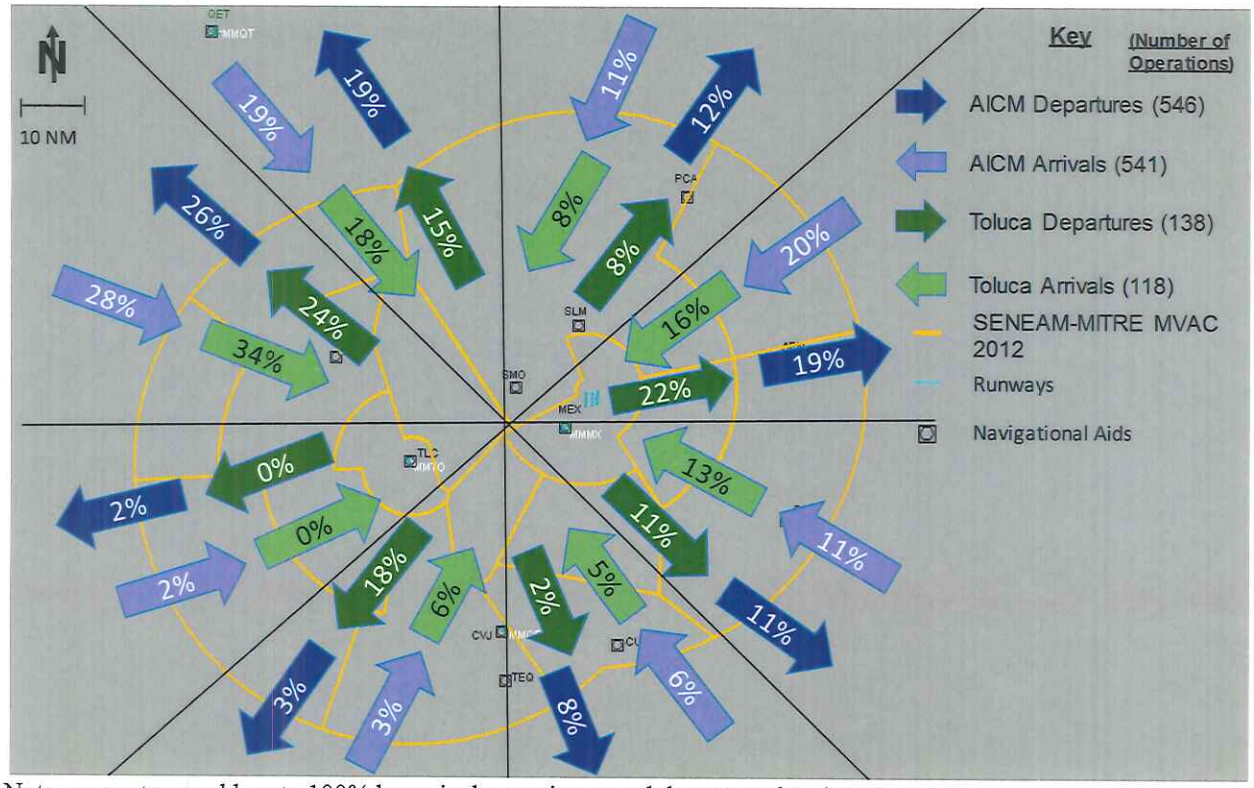


Figure 3. Counts of City-Pair Connector Lines by Quadrant (2007 Data)



Note: percentages add up to 100% by arrivals per airport and departures by airport.

Figure 4. Percentage of City-Pair Connector Lines by Quadrant (2007 Data)

The analysis showed that most of the traffic to and from both AICM and Toluca were flying to and from airports located from the west-north quadrant through to the east-south quadrant of the Mexico City area, including the quadrants in-between. AICM experienced the highest percentages of arrival and departure traffic in the west-north, north-west, and the east-north quadrants. Toluca also experienced larger traffic volumes in the same quadrants for both arrival and departure traffic as AICM. The south-west quadrant for Toluca, showed a large volume of departure traffic where the traffic for AICM was low. The busiest quadrant was the west-north quadrant, which was traffic to and from the western United States and northwestern Mexico followed by the east-north quadrant with traffic to and from the Yucatán Peninsula, eastern United States, and Europe.

3.2 Geographical Traffic Distribution Results for 2015

The traffic data that MITRE received from SENEAM for 2015 consisted of a busy week of traffic from 25 through 31 January. In order to compare the 2015 data with the 2007 traffic data, MITRE developed a one-day average for the number of arrival and departure traffic counts for each airport. This average was then used for the quadrant counts and percentages for the arrival and departure traffic for each airport, as well as for the comparison analysis.

Figure 5 shows the count of city-pair connector lines that were mapped to each quadrant while Figure 6 shows the resulting percentages.

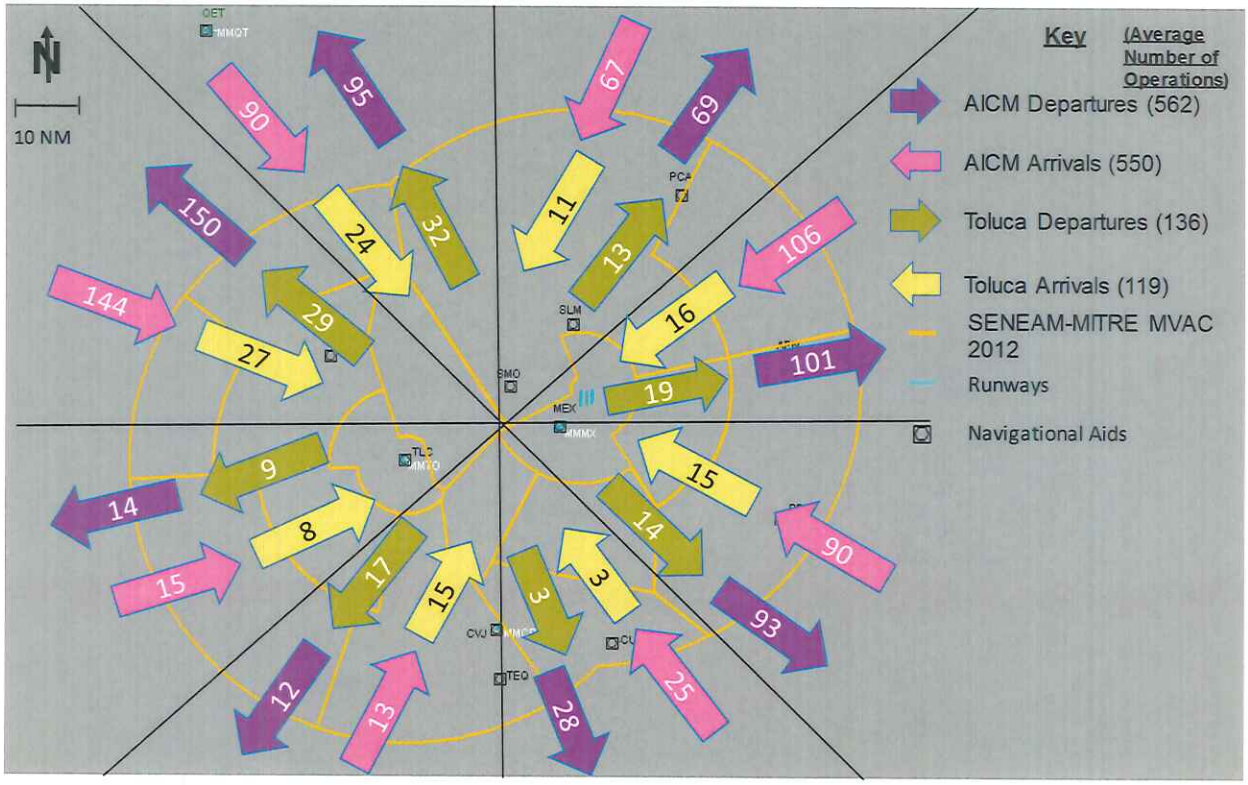


Figure 5. Counts of City-Pair Connector Lines by Quadrant (2015 Data)

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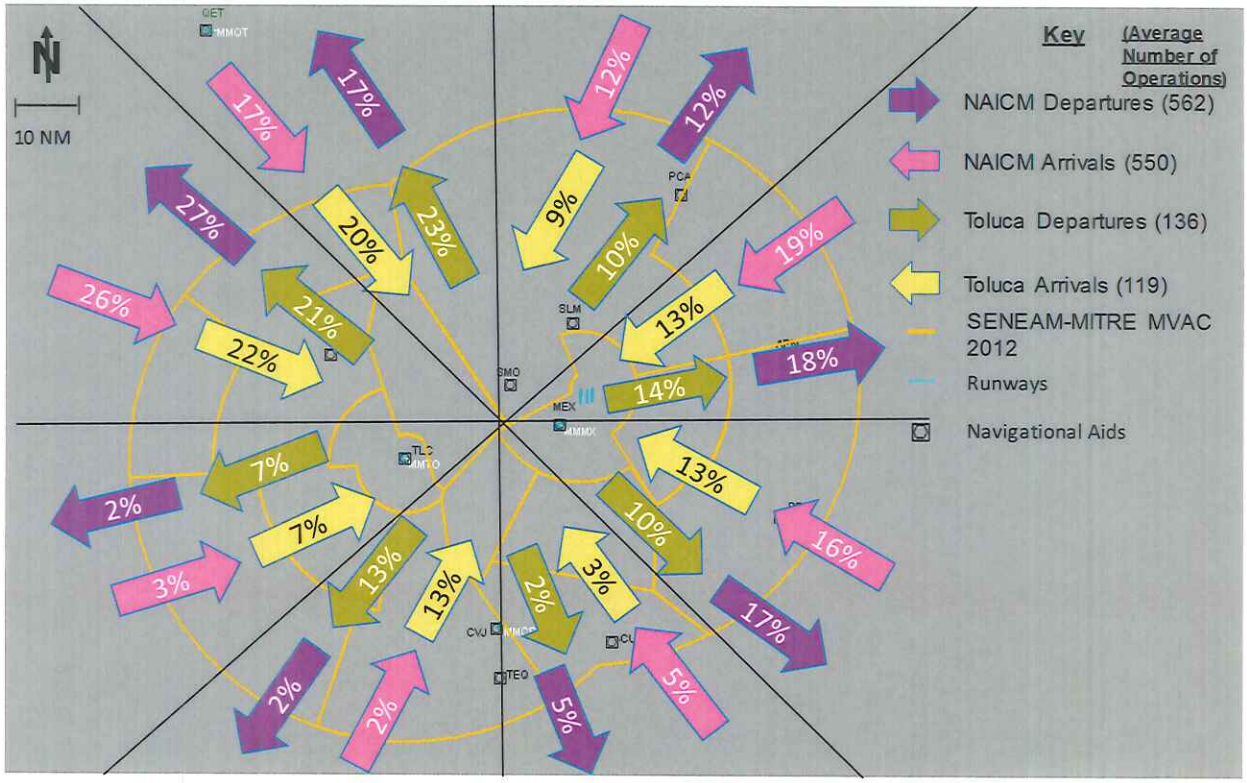

Note: percentages add up to 100% by arrivals per airport and departures by airport.

Figure 6. Percentage of City-Pair Connector Lines by Quadrant (2015 Data)

Similar to the 2007 traffic, the analysis showed that most of the traffic to and from both AICM and Toluca were flying to and from airports located from the west-north quadrant through to the east-south quadrant of the Mexico City area, including the quadrants in-between. The same quadrants that were the busiest in the 2007 traffic data continued to be the busiest quadrants in the 2015 traffic data.

3.3 Comparison Analysis Between the Geographical Traffic Distributions

MITRE compared the two different data sets to determine if there was any significant change in the distribution of traffic over the eight intervening years. To calculate the increase or decrease in each quadrant's aircraft count, MITRE started with the count of 2015 city-pair connector lines for each quadrant and subtracted the corresponding 2007 city-pair connector line counts for the same quadrant. If the resulting value was positive, then the traffic volume for that quadrant increased. A resulting negative value represents a decrease in volume of traffic. Figure 7 shows the results of the calculation for each quadrant.

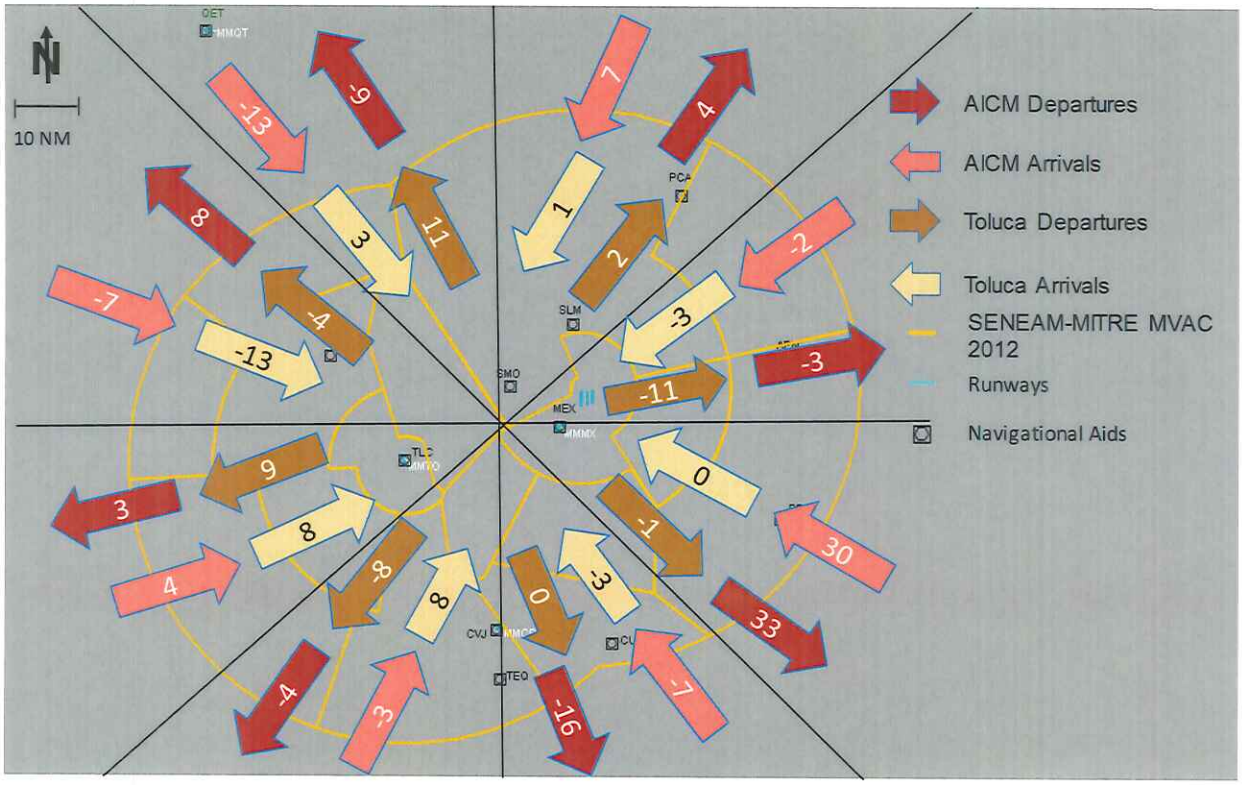

Figure 7. Count Increase/Decrease Change between 2007 and 2015 Data per Quadrant for AICM and Toluca

The resulting calculation shows a large traffic count increase in the east-south quadrant for AICM for both arrival and departure traffic (i.e., flights to and from Central America and eastern South America) followed by an increase in the north-east quadrant (i.e., flights to and from the central United States). There is a significant decrease in the AICM departure traffic count in the south-east quadrant (i.e., flights to western South America). For the arrival traffic, there was a significant decrease in the AICM traffic counts from the north-west quadrant (i.e., flights from the western United States and northwest Mexico).

For Toluca, the significant decrease in arrival traffic was from the west-north quadrant (i.e., flights from the west coast of the United States). There was an increase in both the Toluca arrival and departure traffic counts from the west-south quadrant (i.e., flights to and from western Mexico). For Toluca arrival traffic, the quadrants showing an increase in counts were the north-west and the south-west and the west-south quadrants. The north-west quadrant represents Toluca traffic from the western United States and northwest Mexico while the south-west quadrant represents traffic mainly from Acapulco International Airport. For departure traffic, the most significant increase was from the north-west quadrant (i.e., flights to the western United States and northwest Mexico).

It is necessary to recall that a number of significant changes have occurred in the aviation market in the Mexico City basin between July 2007 and January 2015. Most significant is

closing of Mexicana Airlines in August 2010, and the subsequent opening up of slots at AICM that allowed many flights operated by Interjet and Volaris to transfer from Toluca to AICM. These new airlines are low-cost carriers, which could have also changed the market segments and destinations being served to/from AICM. All these events will also have influenced these changes in traffic distribution.

The comparison analysis was done for the actual traffic counts only to keep the comparison simple.

4. Summary

MITRE analyzed the operational traffic provided by SENEAM for the week in January 2015 and compared it to the traffic distribution analysis that was conducted for a previous project based on data from a day in 2007. In comparison, there appears to be some notable changes in the distribution of the traffic. The largest increase in AICM arrival and departure traffic was the traffic to and from Central America and eastern South America airports. For Toluca, the largest increase in arrival traffic volume was from airports in western Mexico and Acapulco and for departure traffic going to the western United States and northwest Mexico. The shifts in traffic distribution could be due to seasonal affects or due to a real shift in traffic patterns. This traffic distribution analysis provides valuable information to the airspace designers in redesigning the new Mexico City TMA and the surrounding enroute airspace.