Enclosure 1

(Ref. Technical Letter F500-L14-047)

MITRE

Center for Advanced
Aviation System Development

Feasibility of Relocating Military Operations to Querétaro Airport

Preliminary Report

Prepared for

Aeropuertos y Servicios Auxiliares

September 2014

Principal Acronyms and Abbreviations

ACC	Area Control Center
AICM	Mexico City International Airport
APN	APAN VOR/DME
ASA	Aeropuertos y Servicios Auxiliares
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
DME	Distance Measuring Equipment
ESV	Extended Service Volumes
FAM	Fuerza Aérea Mexicana
FL	Flight Level
MEAs	Minimum Enroute Altitudes
MITRE	The MITRE Corporation
MLM	Morelia VOR/DME
MSL	Mean Sea Level
MVAC	Minimum Vectoring Altitude Chart
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México
NM	nautical mile
PBC	Puebla VOR/DME
QET	Querétaro VOR/DME
RNAV	Area Navigation
SENEAM	Servicios a la Navegación en el Espacio Aéreo Mexicano
SFC	Surface
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival Routes
SUA	Special Use Airspace
TEQ	Tequesquitengo VOR/DME
TMA	Terminal Maneuvering Area
VOR	Very High Frequency Omnidirectional Range

1. Introduction

Meetings between The MITRE Corporation (MITRE) and the Fuerza Aérea Mexicana (FAM) that took place in January and February of 2014 resulted in an understanding that Santa Lucía Military Base's (hereafter referred to as Santa Lucía) runway would be closed. This is because Santa Lucía's fixed-wing operations, along with its associated Special Use Airspace (SUA) need to be relocated to avoid interfering with operations at Nuevo Aeropuerto Internacional de la Ciudad de México (NAICM) in nearby Texcoco and at an expanded Toluca Airport (i.e., consisting of a second parallel runway). As a result, all fixed-wing operations will cease at Santa Lucía. Fixed-wing transport operations are to relocate to NAICM. Fixed-wing non-transport military aircraft, such as fighter jets, are to relocate, to another airport, possibly Querétaro Airport (hereafter referred to as Querétaro) or a new airport in the State of Hidalgo. Additionally, all SUAs associated with Santa Lucía operations are to be eliminated.

In mid-February 2014, Aeropuertos y Servicios Auxiliares (ASA) requested that MITRE analyze the feasibility of relocating FAM's fixed-wing non-transport aircraft from Santa Lucía to Querétaro. Included with this feasibility analysis is the design of potential SUAs that would replace existing SUAs that will be eliminated. While this constituted out of scope work under the ASA-MITRE agreement, MITRE understood the importance of the request and performed the feasibility analysis and the associated conceptual airspace design work to support this matter.

Also in mid-February, the MITRE team visited Querétaro to obtain a better understanding of overall operations at the airport, and to examine its potential for accommodating FAM fixed-wing military operations. During the visit, the MITRE team met with airport management officials and went to the Querétaro Air Traffic Control Tower (ATCT) to observe operations and ask questions of controllers regarding Air Traffic Control (ATC) procedures. As a result, MITRE learned of an area on the airport that could potentially accommodate FAM facilities and operations. However, the area in question is limited in size and more investigation by FAM officials and other stakeholders is required to determine the appropriateness of physically locating FAM aircraft and associated support facilities at Querétaro.

The objective of MITRE's feasibility analysis is to determine the principal changes that may be needed to Querétaro's airspace, routes and published arrival and departure procedures to accommodate relocated military fixed-wing operations, while also continuing to accommodate existing and future civil operations.

This report describes MITRE's preliminary feasibility analysis, as defined above. The document is laid out in the following sections:

- Section 1 provides an introduction and the background of the analysis
- Section 2 provides a description of MITRE's approach and methodology used to conduct both the feasibility analysis and the conceptual airspace design work
- Section 3 presents relevant portions of MITRE's previous airspace design work for NAICM
- Section 4 lists the assumptions made as part of this analysis as well as its limitations

- Section 5 presents the results of MITRE's conceptual design of the potential SUAs to support FAM fixed-wing military operations
- Section 6 discusses the results of the feasibility analysis of relocating FAM's fixed-wing military operations to Querétaro
- Section 7 summarizes the results of MITRE's work

It is important to mention that key aeronautical aspects of MITRE's work were discussed with experts from Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) during their visit to MITRE on 5 June 2014. For example, SENEAM and MITRE discussed whether FAM operations, if relocated to Querétaro, would be able to operate within the current Querétaro airspace environment and, if so, what would be needed in the future when traffic demand increased. In addition, MITRE's potential SUA designs were discussed including the rules that exist in Mexico that govern the separation required between SUAs and aircraft on the nominal track of a procedure, airway centerline or when being vectored. SENEAM fundamentally agreed with MITRE's overall SUA analysis and design work, as well as MITRE's approach to examining the integration of FAM operations at Querétaro. SENEAM also agreed with MITRE that planning and coordination with the FAM would need to occur as part of the potential relocation, as well as the location and design of potential SUAs.

2. Approach/Methodology

MITRE's overall approach was to first perform the conceptual design work for the potential SUAs, and then conduct the feasibility analysis and resulting design work for Querétaro. These two tasks follow similar multi-step processes, as described below.

2.1 Conceptual Design of Potential SUAs

- Step One: Determine the factors necessary to develop a preliminary design of potential SUAs for FAM fixed-wing operations. Of primary importance is the necessity to provide FAM with enough airspace to accomplish their missions inside of the SUAs. Note that MITRE has limited information regarding the types of missions that are currently being conducted in the existing SUAs. Therefore, MITRE attempted, where possible, to design potential SUAs that provide an overall volume of airspace comparable to that being provided by the existing SUAs.
- Step Two: Develop a preliminary design of potential SUAs that do not interfere with the arrival and departure traffic to NAICM and an expanded Toluca Airport. The NAICM and expanded Toluca Airport entry and exit waypoints from MITRE's conceptual design that was developed during a previous project were matched with existing airways that were judged to most likely serve those entry and exit waypoints. The required separation between the centerlines of airways or nominal tracks of published procedures and the SUA boundaries was then applied to determine the final placement of the potential SUA boundaries.

- Step Three: Determine the feasibility of the potential SUAs in relation to civil and military operations at Querétaro.[1] Feasibility, in this case, was determined by the accessibility of the SUAs via military corridors that do not interfere with either NAICM or an expanded Toluca Airport. These military corridors would be similar to the military routes used today in that the routes serve both arrival and departure traffic between the SUAs and the base of operations.

2.2 Analysis of Fixed-Wing Military Operations at Querétaro

- Step One: Assess the potential for FAM aircraft to use the existing Querétaro non-radar arrival and departure procedures, including the arrival transitions. The assessment consisted of determining which transitions the aircraft would likely use.
- Step Two: Design bi-directional military corridors for FAM fixed-wing military operations between Querétaro and the potential SUAs. These corridors are designed to transition FAM aircraft between the airport and the potential SUAs and serve both arrival and departure traffic.
- Step Three: Develop conceptual radar-based arrival and departure routes at Querétaro to accommodate future growth. MITRE realizes that at some point in the future Querétaro will need to transition to providing a radar control service as a result of increased traffic demand. In addition, to ensure that the relocation of FAM fixed-wing military operations to Querétaro can be a long-term solution, MITRE designed these potential routes to allow ATC to vector both civil and FAM aircraft to intercept an existing instrument procedure for arrival traffic, or aircraft to depart on a future developed Standard Instrument Departure (SID).
- Step Four: Assess and modify, if necessary, the military corridors designed as part of Step 2 for use in a radar control service environment. This is because both the radar procedures and vectoring would differ significantly from the current non-radar transitions and procedures. MITRE's goal was to design military corridors that would serve both the current non-radar environment as well as a future radar environment.

3. MITRE's Previous Airspace Design Work for NAICM

As part of a previous project, MITRE developed, in close cooperation with SENEAM, a conceptual airspace design of the Mexico Terminal Maneuvering Area (TMA) that would support operations at NAICM, as well as at an expanded Toluca Airport (see MITRE Technical Letter, F500-L12-015 dated 3 July 2012 for details). That work consisted of developing procedures and an airspace design for both NAICM and an expanded Toluca Airport, creating a Minimum Vectoring Altitude Chart (MVAC), and developing a transit or satellite corridor (hereafter referred to as the satellite corridor) to handle the arrival and departure traffic to and

[1] Note that the potential SUAs were also located to serve the four potential new airport sites in the State of Hidalgo that are under consideration. The preliminary findings pertaining to the feasibility of developing a new airport at four potential sites in the State of Hidalgo can be found in Enclosure 4 to Technical Letter F500-L14-033 dated June 2014.

from Cuernavaca Airport, Puebla Airport, and Querétaro (the satellite airports). The satellite corridor that was designed plays an important role in MITRE's feasibility analysis and design work at Querétaro and, therefore, is discussed in more detail in the following section. Of course, the conceptual arrival and departure routes designed by MITRE to support operations at NAICM and an expanded Toluca Airport are also an important consideration. Relevant routes are shown on the figures in Sections 5 and 6.

3.1 Satellite Corridor

To accommodate aircraft wishing to transit through the new TMA, as well as to assist in the management of arrivals and departures from the satellite airports, the above-mentioned MITRE-developed airspace design includes a satellite corridor. This corridor skirts around the outer edges of the new TMA and keeps traffic away from the high congestion areas around NAICM and Toluca Airport. MITRE developed two corridors, one for aircraft using conventional navigational and the other for aircraft using Area Navigation (RNAV). Two new reporting points would need to be established as Very High Frequency Omnidirectional Range (VOR)/Distance Measuring Equipment (DME) positions or the intersection of two VOR radials in the approximate positions shown in Figure 1.

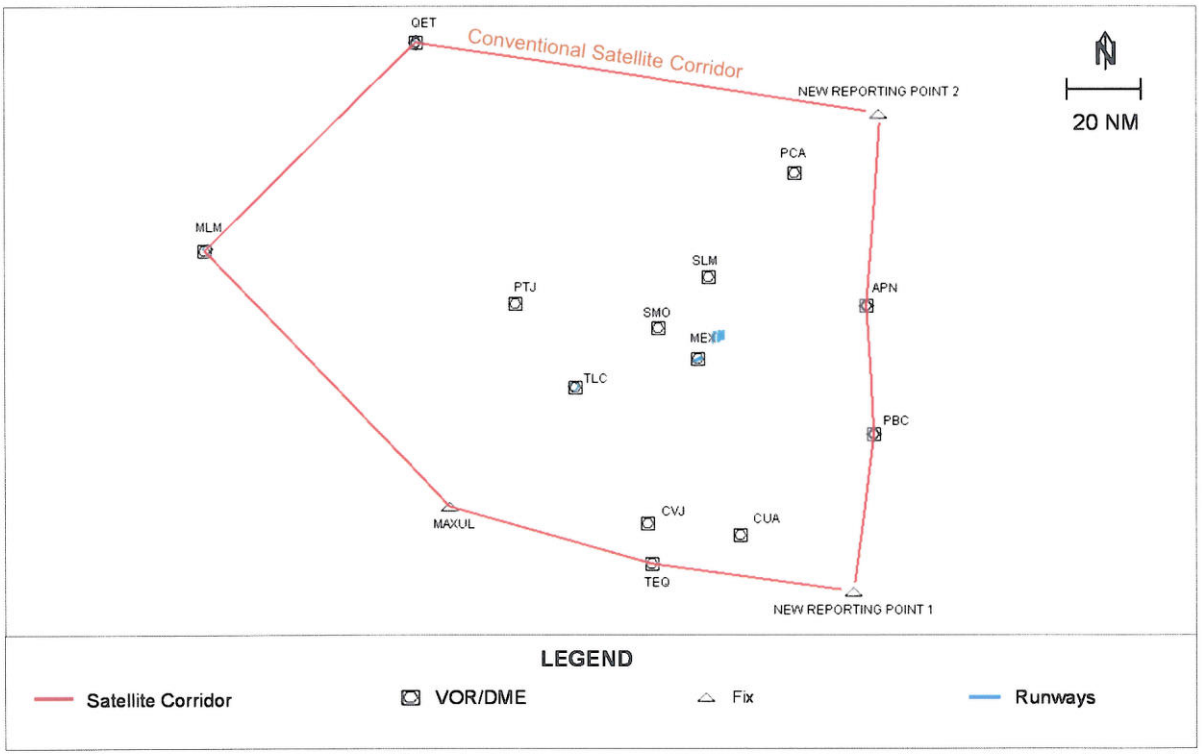

Figure 1. MITRE-Proposed Conventional Satellite Corridor

The satellite corridor shown in Figure 1 above is based on conventional navigation, and would use the following route:

> Querétaro (QET) VOR/DME – Morelia (MLM) VOR/DME – MAXUL – Tequesquitengo (TEQ) VOR/DME – new reporting point 1 – Puebla (PBC) VOR/DME – Apan (APN) VOR/DME – new reporting point 2 – QET VOR/DME.

The satellite corridor would be available between Flight Level (FL) 200 and FL220, and could operate in both directions. These altitudes are above the highest MVAC altitude published, thereby ensuring adequate terrain clearance. Use of different altitudes in the corridor would enable controllers to provide vertical separation between aircraft traveling in opposite directions. The corridor is designed to be below the arrival and departure flows for NAICM and an expanded Toluca Airport.

Aircraft equipped to fly RNAV could utilize a shorter routing over the western part of the new TMA following a route from QET VOR/DME – ANEVU – MAXUL or vice versa, as shown in Figure 2. Alternatively, controllers could provide radar vectors to shorten the routing when traffic and/or workload permits.

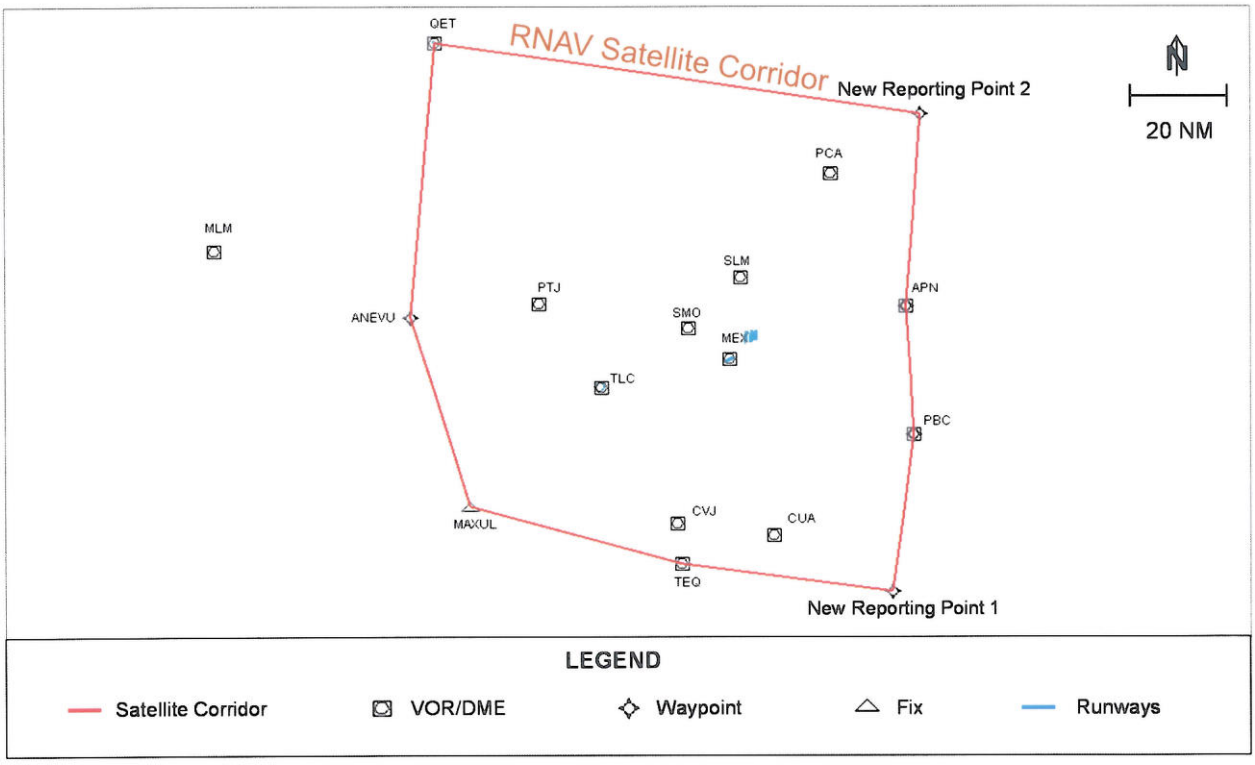

Figure 2. MITRE-Proposed RNAV Satellite Corridor

4. Assumptions and Limitations

This feasibility analysis required MITRE to make a number of assumptions for both the design work, associated with the potential SUAs and the military corridors, as well as the feasibility analysis of relocating FAM operations to Querétaro. These assumptions are described below followed by the limitations of the analysis.

4.1 Key Assumptions

The following key assumptions were made for the design work and the feasibility analysis:

- Querétaro was treated as a satellite airport for the purpose of integrating it into the overall airspace design for the Mexico City basin. Therefore, civil aircraft arriving to and departing from Querétaro will use the satellite corridor when arriving from or departing to the east, south and southwest. In the case where there are arrival and departures to and from the west and north, enroute airways can be used instead of the satellite corridor.
    - In a non-radar environment, civil aircraft that are:
        - Arriving to Querétaro will follow either the satellite corridor or an enroute airway and join the appropriate arrival transition
        - Departing Querétaro will depart on an existing published departure procedure to join either the satellite corridor or an enroute airway where further climb instructions will be issued by ATC
    - In a radar environment, civil aircraft that are:
        - Arriving to Querétaro will be radar vectored from the satellite corridor to the existing final approach course
        - Departing from Querétaro will depart on a new SID to join the satellite corridor or an enroute airway. The SID will terminate at a specific fix on the satellite corridor or on an enroute airway. If necessary, ATC can radar vector the aircraft and issue further climb instructions to the requested cruising altitude.
- FAM aircraft transiting between Querétaro and the potential SUAs will use military corridors, as described in Section 5. FAM arrivals will either follow an arrival transition to the arrival procedure, in a non-radar environment, or be radar vectored to join the arrival pattern, in a radar environment. FAM departures will depart from Querétaro using the same departure procedures or SIDs as the civil aircraft and, depending on the environment, would either join the military corridor or be vectored to the military corridors when they reach the minimum radar vectoring altitude.
- Extended Service Volumes (ESVs) for the VORs may be authorized wherever it is considered necessary
    - The ESVs will ensure that civil and FAM aircraft are able to receive positive course guidance along the satellite and military corridors

- Three-nautical-mile (3-NM) radar separation will be used by ATC between aircraft at Querétaro
    - In particular, radar separation is an essential tool to be used between aircraft on the downwind leg of the potential arrival traffic pattern and other aircraft on the final approach course at Querétaro once operating in a radar environment
- For operations in a radar environment, it will be necessary to provide an Airport Surveillance Radar (ASR) for Querétaro
    - As part of the introduction of radar-based procedures, an appropriate MVAC will need to be developed to allow ATC to radar vector aircraft. Note that MITRE developed a cursory MVAC for Querétaro to assist in the development of the radar vectoring portion of the arrival pattern. See Section 6.2.1. It is important to note, however, that the MVAC used in this study is very preliminary at this stage of the project. A final MVAC will eventually need to be integrated into the above-mentioned NAICM/Toluca MVAC by SENEAM.
- FAM fixed-wing military aircraft are suitably equipped to fly the current civil VOR/DME approach procedures and to be radar vectored in a potential radar environment
- Suitable ATC coordination procedures are to be established between SENEAM and FAM in order to integrate FAM aircraft entering or leaving the potential SUAs with civil flight procedures
- Suitable new instrument procedures (i.e., SIDs and/or Standard Terminal Arrival Routes [STARs]) may be developed when Querétaro starts operating radar-based procedures
- All civil aircraft will be required to remain clear of an active SUA
- Some civil airways may need to be temporarily closed at some or all altitudes when the potential SUA(s) is/are active

4.2 Key Limitations

The following key limitations apply to MITRE's design work and feasibility analysis:

- MITRE's analysis was limited to determining the principal changes that may be needed to Querétaro's airspace, routes and published arrival and departure procedures to accommodate the relocated FAM fixed-wing military operations. Other considerations such as the appropriateness of such a move and its alignment with FAM's operational mission, were considered outside the scope of this study.
- No consideration was given to areas underneath the potential SUAs with regard to noise exposure or other restrictions due to their proximity to population centers

- New transition routes will have to be developed to and from Querétaro to the existing SUAs, which could affect current procedures at Querétaro (especially given the relative proximity of MMR 101W). Mexican aviation authorities should consider this prior to making any specific decision on the timing of the transfer of FAM operations. Furthermore, activation of the potential MITRE-developed SUAs prior to the closing of the existing airport (Mexico City International Airport—AICM) may affect traffic flows to and from AICM. MITRE has not assessed either of these scenarios.
- The potential SUAs have not been evaluated with respect to operations at the existing airport (AICM), as opposed to operations at the new airport (NAICM)
- The potential SUAs are conceptual and are subject to change based on feedback from FAM officials
- The potential economic and operational impact on aircraft operations (e.g., the closure of airways and vectoring of aircraft) considering the location of the potential SUAs in terms of operational efficiency (e.g., added flight time) has not been studied
- Instrument approach or departure procedure design work for Querétaro has not been conducted
- An assessment of the appropriateness of Querétaro's current airport design/layout characteristics or geometry to accommodate FAM's support facilities, including maintenance, has not been conducted

5. Potential SUAs

As previously mentioned, Santa Lucía's runway will need to close, as well as all of its associated SUAs prior to the opening of NAICM. Based on MITRE's previous airspace design work in the Mexico City basin, this includes the closure of the MMR 101E, MMR 101W, MMR 102, and MMR 103 SUAs (see Figure 3) in order to allow for the unimpeded functioning of NAICM and an expanded Toluca Airport. Note that existing SUAs MMR 112 and MMR 100 over and around Santa Lucía also need to be eliminated.

As part of its work in support of ASA, MITRE has been examining potential areas around the Mexico City basin where new SUAs may potentially be located to support FAM fixed-wing military operations. SUAs need to be located in areas that do not interfere with civil air traffic flows when the SUAs are active, especially if those civil airways serve the larger airports around Mexico City, such as NAICM and Toluca Airport.

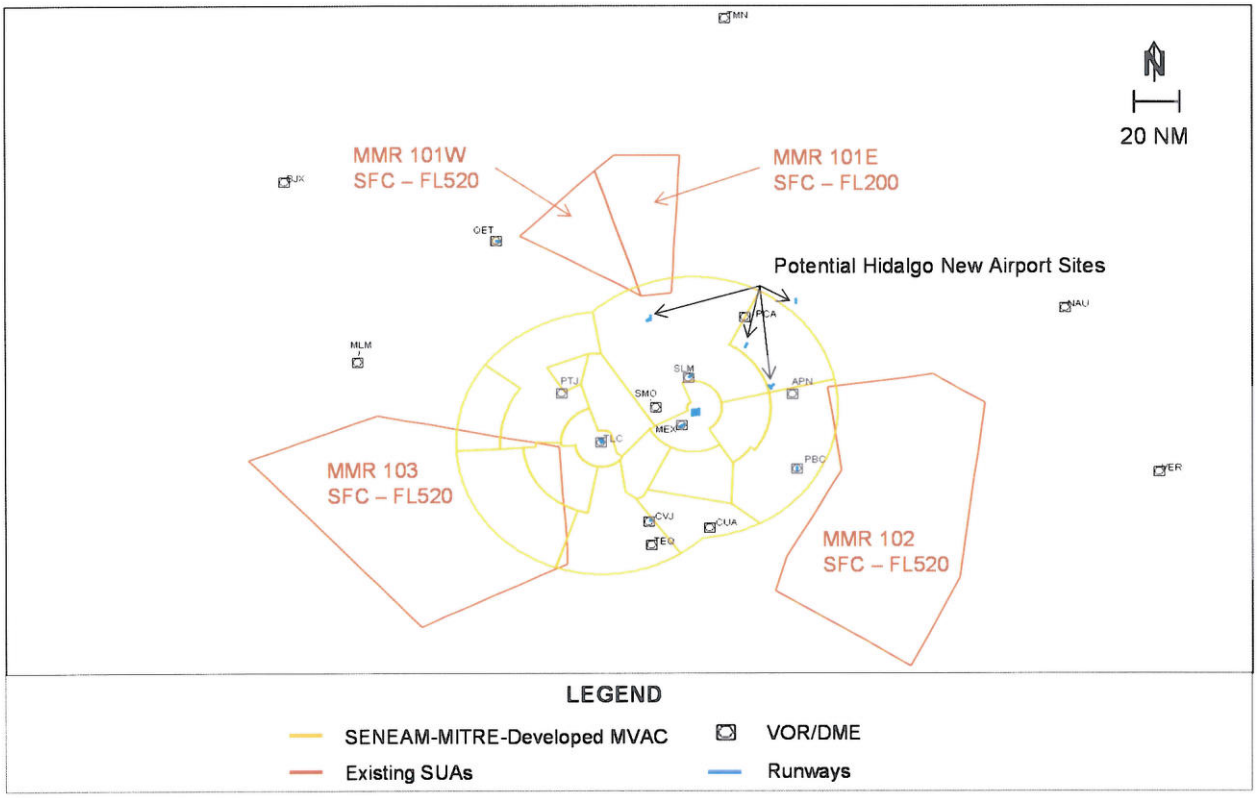

Figure 3. Existing SUAs MMR 101E, MMR 101W, MMR 102, and MMR 103

After consultation with officials from SENEAM concerning the way SUAs are currently handled in Mexico and the minimum distance between SUA boundaries and the centerlines of civil airways or nominal tracks of published procedures (i.e., 10 NM), MITRE developed three potential SUAs (see Figure 4), denoted as the "North SUA", "West SUA", and "East SUA". Each potential SUA contains a Lower SUA and an Upper SUA, as follows:

- North SUA (see Figure 5)
  - Lower SUA extends from the Surface (SFC) to 16,000 feet Mean Sea Level (MSL)
  - Upper SUA extends from the SFC to FL520
- West SUA (see Figure 6)
  - Lower SUA extends from the SFC to FL190
  - Upper SUA extends from the SFC to FL520
- East SUA (see Figure 7)
  - Lower SUA extends from the SFC to FL190
  - Upper SUA extends from the SFC to FL520

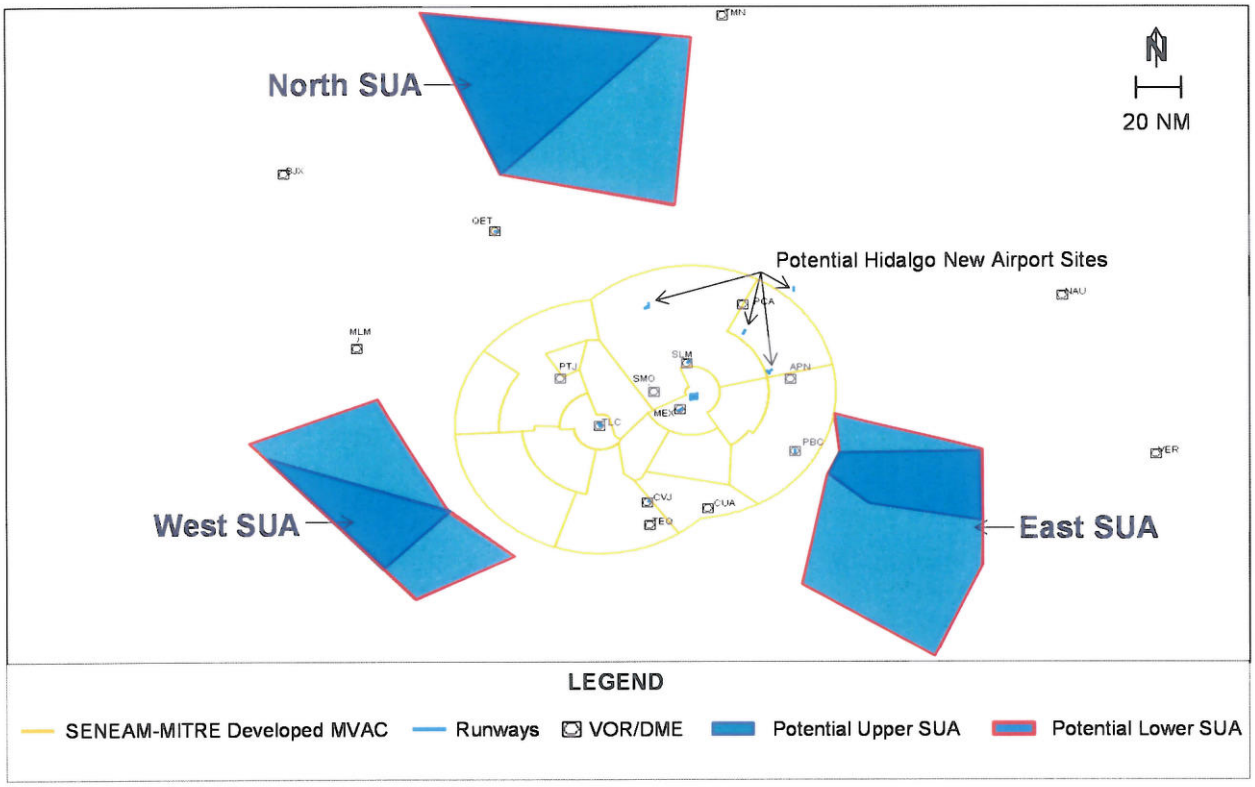

Figure 4. Potential SUAs to Support FAM Fixed-Wing Military Operations

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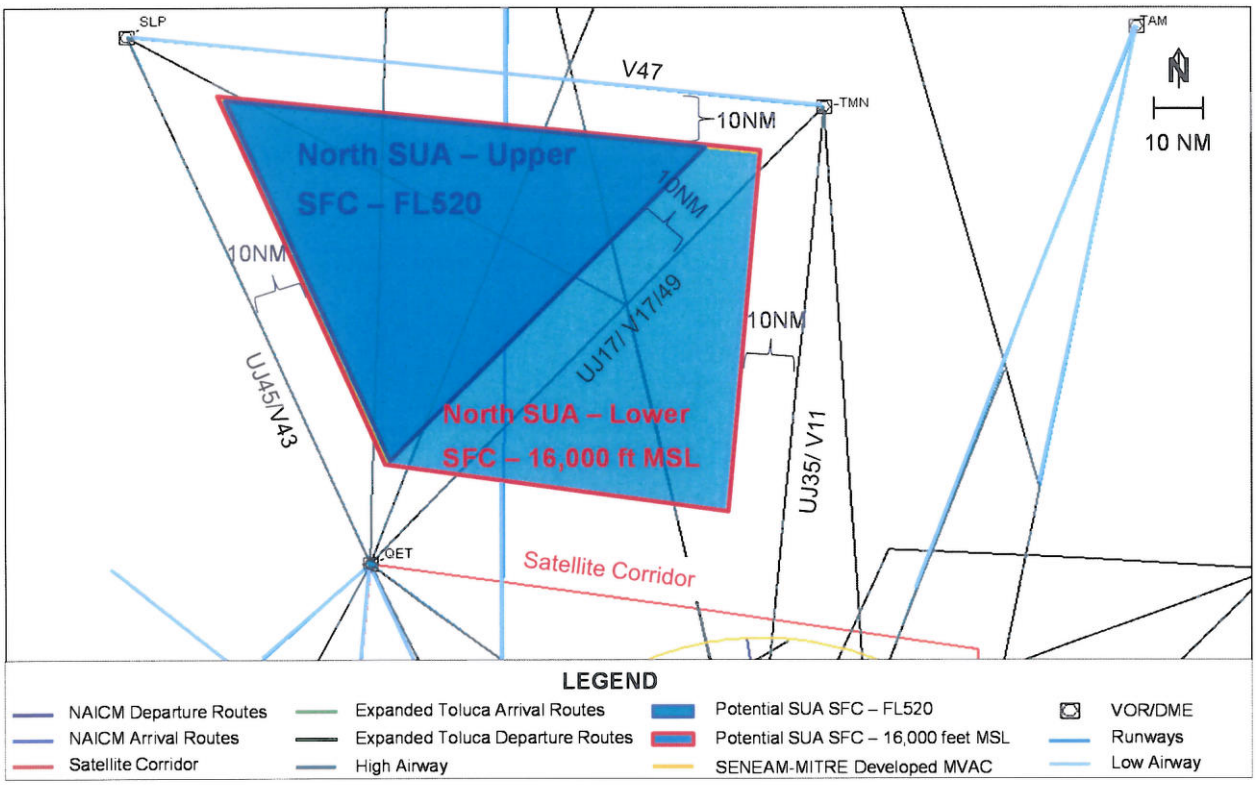

Figure 5. Potential North SUA

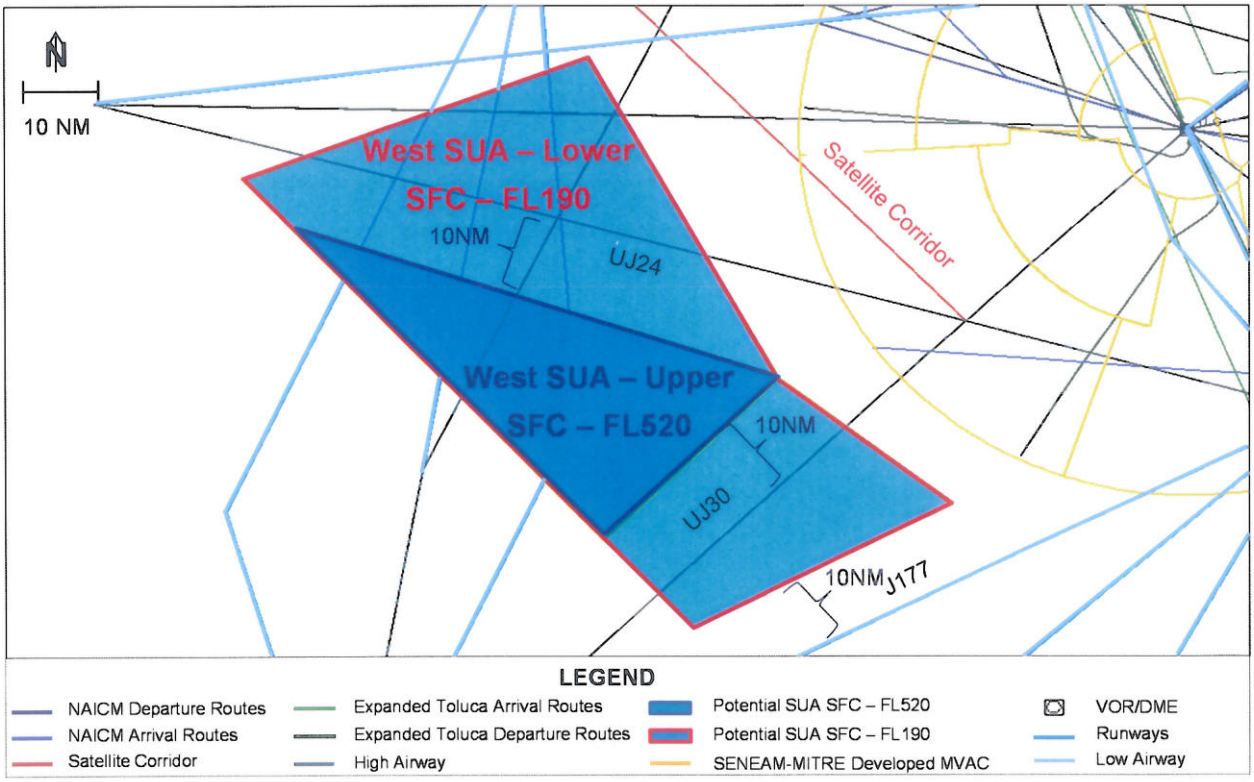

Figure 6. Potential West SUA

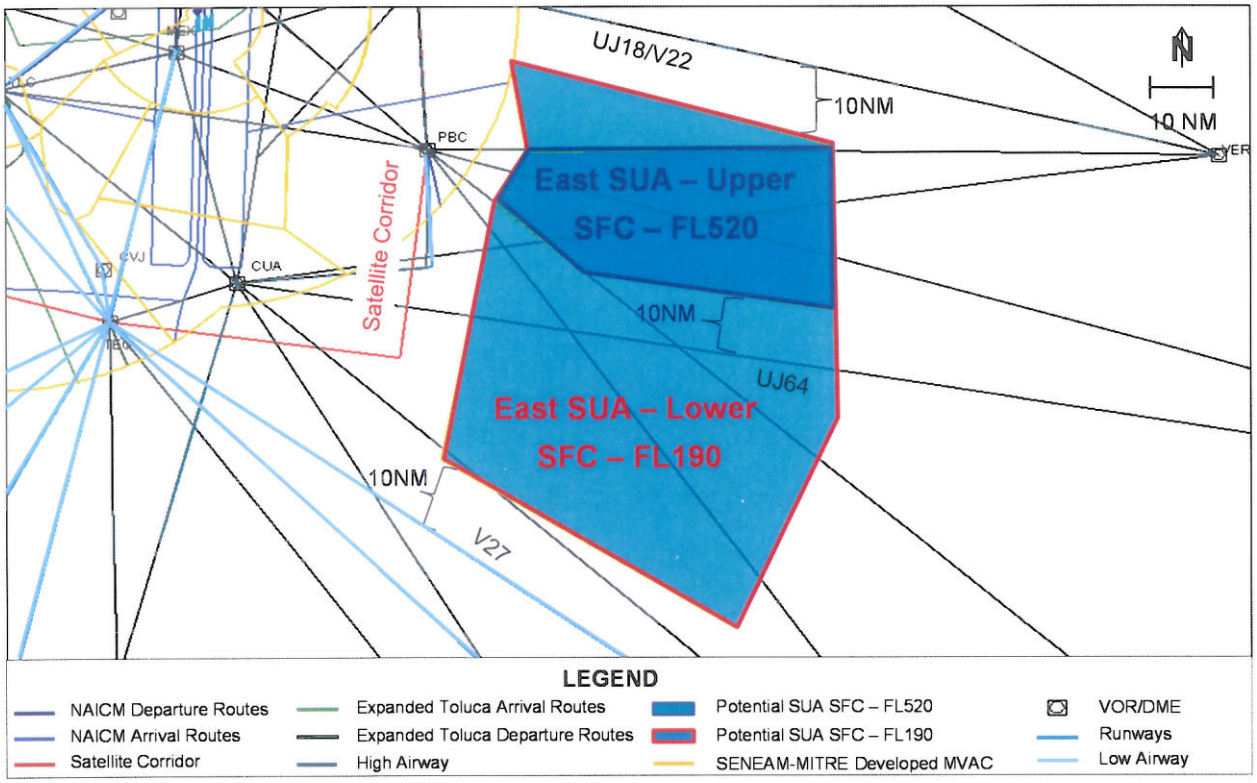

Figure 7. Potential East SUA

Each of the Upper and Lower SUAs can be activated individually or in combination with its adjacent SUA to permit low or low and high altitude operations. Note that the Lower SUAs (shown with a red outline and shaded a light blue color), for either the North, West or East SUAs, encompass all of the airspace within the wider lateral boundaries shown in the figures, and vertically from the SFC to an upper altitude called a ceiling. The ceilings of the Lower SUAs were designed to be lower than the Minimum Enroute Altitudes (MEAs) of the upper airways serving the civil approach and departure procedures for NAICM and an expanded Toluca Airport. The Upper SUAs encompass the lateral limits shown with a dark blue outline and shaded a darker blue color. These Upper SUAs are partially coincident with their adjacent Lower SUA and extend vertically from the SFC to FL520, allowing for low- and high-altitude maneuvers. It should be noted that a portion of the Upper SUA and the Lower SUA overlap from the SFC to the ceiling of the Lower SUA which was done to allow for the low- and high-altitude maneuvers in the Upper SUA without activating all of the Lower SUA. Further partitioning or sectorization of the SUAs, as well as the naming given to these volumes of airspace, can be done by the FAM to suit their needs.

When any of the SUAs are activated, all civil aircraft will be required to remain clear of that airspace. ATC will ensure that civil aircraft are vectored around the airspace or assigned appropriate altitudes or airways to avoid penetrating the protected airspace around the active SUAs. The activation of a SUA may require some airways to be closed, either completely or at certain altitudes.

It should be noted, that once NAICM and an expanded Toluca Airport become operational, high-traffic volumes can be expected along certain routes and within certain sectors of airspace. Therefore, it is critical that both civil and FAM operations be coordinated and that FAM aircraft adhere strictly to the boundaries of the SUA to ensure the safety of both types of operations.

6. Feasibility Analysis of Relocating FAM Fixed-Wing Military Operations to Querétaro

MITRE used the above-mentioned potential SUAs in its feasibility analysis of relocating FAM fixed-wing military operations to Querétaro. However, it should be noted that these potential SUAs are preliminary and subject to change. Further discussions are needed with the relevant Mexican aviation authorities and especially with FAM officials and experts before moving towards a more detailed and final design.

Military corridors were developed to transfer aircraft between Querétaro and the potential SUAs. These military corridors primarily follow the satellite corridor that was developed as part of MITRE's previous airspace design work, and the FAM fixed-wing aircraft are expected to fly in the same block of altitudes as the civil aircraft. This expectation could require ATC to tactically resolve potential conflicts if aircraft are flying at different speeds.

MITRE has analyzed both current non-radar transitions and procedures, as well as a potential scenario where radar services are provided at Querétaro. The introduction of radar services at Querétaro will depend on when traffic demand levels reach a point where the current non-radar procedures are causing unacceptable delays in normal operations and/or to enhance safety as necessary. At that time, the arrival and departure procedures will need to be modified to take advantage of the new capabilities of a radar environment (i.e., vectoring and more direct routing). The results of the feasibility analysis for both the current non-radar and potential radar environment at Querétaro are described below.

6.1 Current Non-Radar Control Services at Querétaro

The impact of relocating FAM fixed-wing military operations to Querétaro may affect the number of operations per day that the airport handles and, as a result, the workload of ATC. Currently, every departing aircraft requires Querétaro ATCT personnel to call via telephone the Mexico Area Control Center (ACC) for a departure release, which generates coordination workload for ATC not only at the Querétaro ATCT, but also for the ACC personnel. Conversely, as an arrival into Querétaro is received from the ACC and joins a non-radar arrival procedure, ATC must ensure that there is adequate separation between arrivals on the procedure (i.e., generally only one aircraft is allowed on the procedure at a time with all other arrival aircraft put into holding procedures). FAM aircraft would need to be integrated with the civil aircraft on the non-radar arrival and departure procedures and be subject to the same limitations. The additional workload due to either the arrival or departure aircraft or both will eventually limit the number of aircraft that can be handled at Querétaro without causing unacceptable delays.

The transitioning of FAM fixed-wing military operations to and from the potential SUAs is another aspect that must be considered. Currently, FAM fixed-wing aircraft use routes that

transition aircraft between Santa Lucía and the existing SUAs (i.e., MMR 101E, MMR 101W, MMR 102, and MMR 103). MITRE followed the same concept when developing military corridors that allow FAM fixed-wing military operations to transition between Querétaro and the MITRE-developed potential SUAs.

6.1.1 Querétaro Operating in the Runway 27 Direction

When Querétaro is operating in the Runway 27 direction, aircraft transitioning to the potential North SUA would fly the VITOS 1 BRAVO departure which ends inside the Lower North SUA at VITOS. As a result, a military corridor is not required to transition FAM aircraft from Querétaro to the North SUA. Aircraft returning from the potential North SUA would use the VITOS or GAVIA transitions and then execute the VOR/DME 2 Runway 27 arrival procedure, again not requiring a military corridor.

The East and West SUAs are farther away from Querétaro and would require military corridors to transition FAM aircraft. As a result, MITRE designed bi-directional military corridors to transition FAM fixed-wing aircraft to and from the East and West SUAs.

Aircraft going to the potential East SUA would depart the airport and join the Querétaro 2 BRAVO departure procedure, then join the military corridor to the potential East SUA, circumventing the heavy traffic areas around NAICM and Toluca Airport. Aircraft returning from the potential East SUA would follow the military corridor to the satellite corridor and then join the final approach course to land at Querétaro.

Aircraft going to the potential West SUA would depart the airport on the XOSAS 1 departure procedure to XOSAS and then join the military corridor to enter the West SUA. Aircraft returning from the potential West SUA would use the military corridor then join the satellite corridor to the QET VOR/DME before executing the VOR/DME 1 Runway 27 arrival procedure to land at Querétaro.

Figure 8 shows a depiction of the military corridors when Querétaro is operating in the Runway 27 direction, as well as the civil transitions and procedures that would likely be used by FAM fixed-wing aircraft. The military corridors are shown in a grey-shaded teal line with teal aircraft representing how FAM aircraft would use the current arrival transitions, departure procedures and the military corridors.

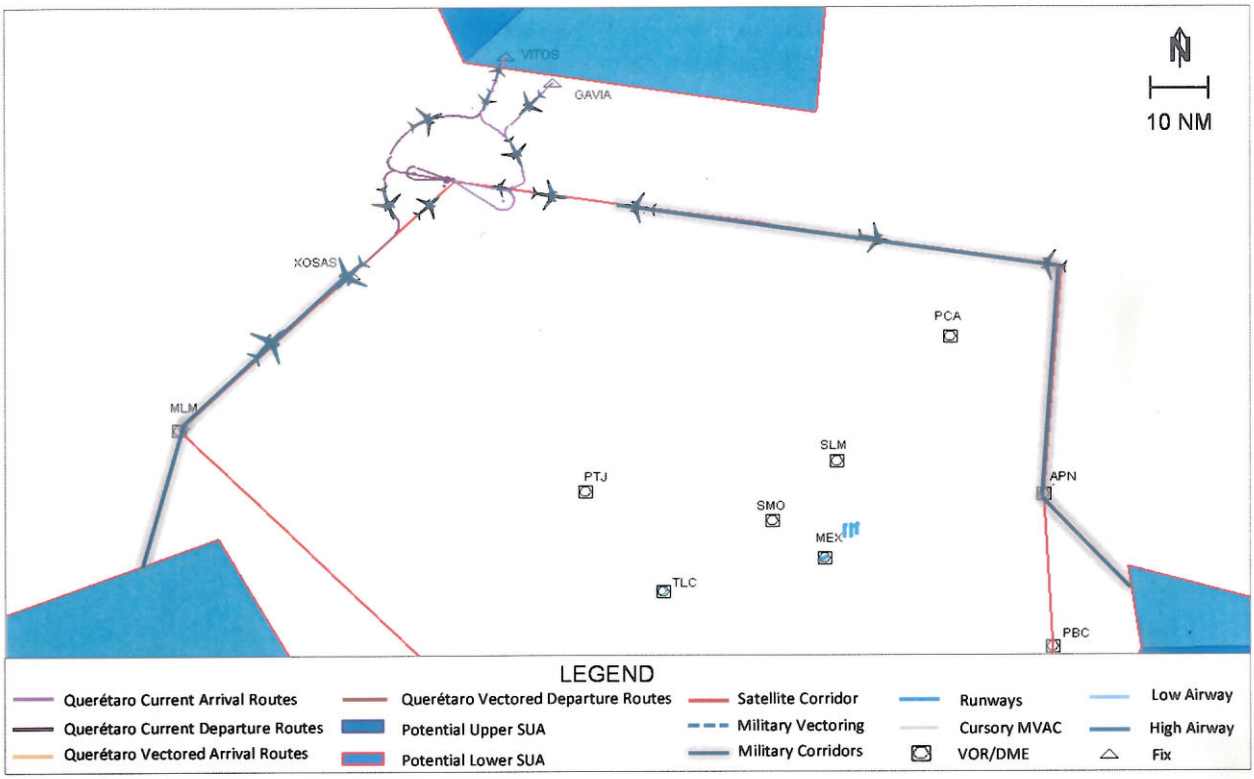

Figure 8. Military Corridors and Runway 27 Operations

6.1.2 Querétaro Operating in the Runway 09 Direction

When Querétaro is operating in the Runway 09 direction, aircraft going to the potential North SUA would depart Querétaro using the VITOS 1 ALPHA departure procedure, which ends inside the lower section of the potential North SUA at VITOS. Similar to Runway 27 operations, FAM aircraft using this departure procedure would not need to use a military corridor to circumvent the heavy traffic areas to the southeast. Returning aircraft would use the VITOS transition of the VOR/DME 2 Runway 09 arrival procedure and land at the airport, again with no military corridor necessary.

For the potential East and West SUAs, use of the military corridors are necessary to separate FAM aircraft from the heavy traffic areas as those designed for when Querétaro is operating in the Runway 27 direction. For the potential East SUA, FAM aircraft would depart the airport using the Querétaro 2 ALPHA departure procedure and join the military corridor to the east. Flights returning from the potential East SUA would follow the military corridor then join the satellite corridor to QET and execute the VOR/DME 1 Runway 09 arrival procedure from the VITOS or GAVIA transition to land at Querétaro.

When the potential West SUA is being used, departing FAM aircraft would use the Querétaro 2 ALPHA departure, which turns back to QET, then join the satellite corridor before joining the military corridor to the potential West SUA. Aircraft returning from the West SUA would follow the military corridor to XOSAS and execute the VOR/DME 2 Runway 09 arrival procedure to land at Querétaro.

The civil arrival and departure procedures that FAM aircraft would likely use to the potential North SUA along with the military corridors to the potential East and West SUAs are depicted in Figure 9.

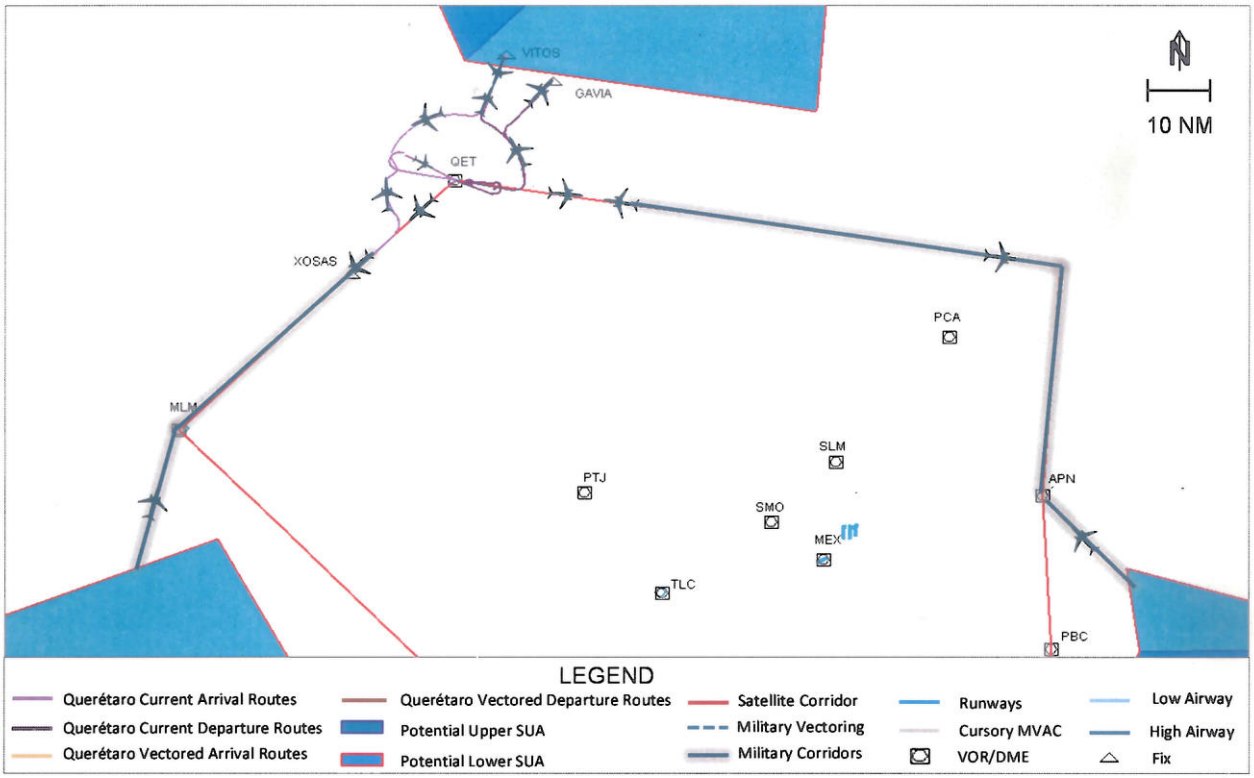

Figure 9. Military Corridors and Runway 09 Operations

6.1.3 Impact to Querétaro Procedures when NAICM Opens

The previous airspace work MITRE conducted for NAICM and an expanded Toluca Airport requires the modification of some existing procedures at Querétaro. These modifications would be designed and implemented as part of a total redesign of the airspace in and around the whole Mexico City basin as NAICM opens for operations. The modifications only affect those procedures and transitions that connect to airways transiting the congested airspace associated with NAICM and Toluca Airport. The following sections describe these modifications and the impact that they would have on the Querétaro arrival and departure procedures.

The current arrival procedures at Querétaro use a typical non-radar "turn-back" concept, as well as a 12 NM DME arc that merges the aircraft from multiple transitions to join a final approach course. The current departure procedures require aircraft to fly straight ahead for 7 NM before either turning back to the airport and following the remainder of the departure procedure or joining a 12 NM DME arc from the airport to join an enroute airway. As previously mentioned, the future non-radar operational concept would be for FAM fixed-wing military aircraft to follow the same transitions and procedures as the civil aircraft when arriving

and departing Querétaro. In this way, both civil and FAM aircraft would be integrated and sequenced in the overall traffic flow to and from the airport.

When NAICM becomes operational, the current Querétaro arrival transitions affected for Runway 27 are KOBEK and ROSMA on the VOR/DME 2 arrival procedure. All of the remaining arrival transitions would be operational and would allow aircraft to either join the satellite corridor or enroute airways to the west or north.

Figure 10 shows the arrival transitions for Runway 27 and the modification of the VOR/DME 2 arrival procedure (the elimination of the KOBEK and ROSMA transitions) to be made due to the NAICM and expanded Toluca Airport designs, as well as the other arrival transitions for Runway 27 that are not affected. The arrival transitions in Figure 10 for Querétaro are shown in a magenta color with the fixes that give the transitions their names. The KOBEK and ROSMA arrival transitions are shown with a red "x" along with a red shaded area that depicts the heavy traffic area that Querétaro aircraft need to avoid.

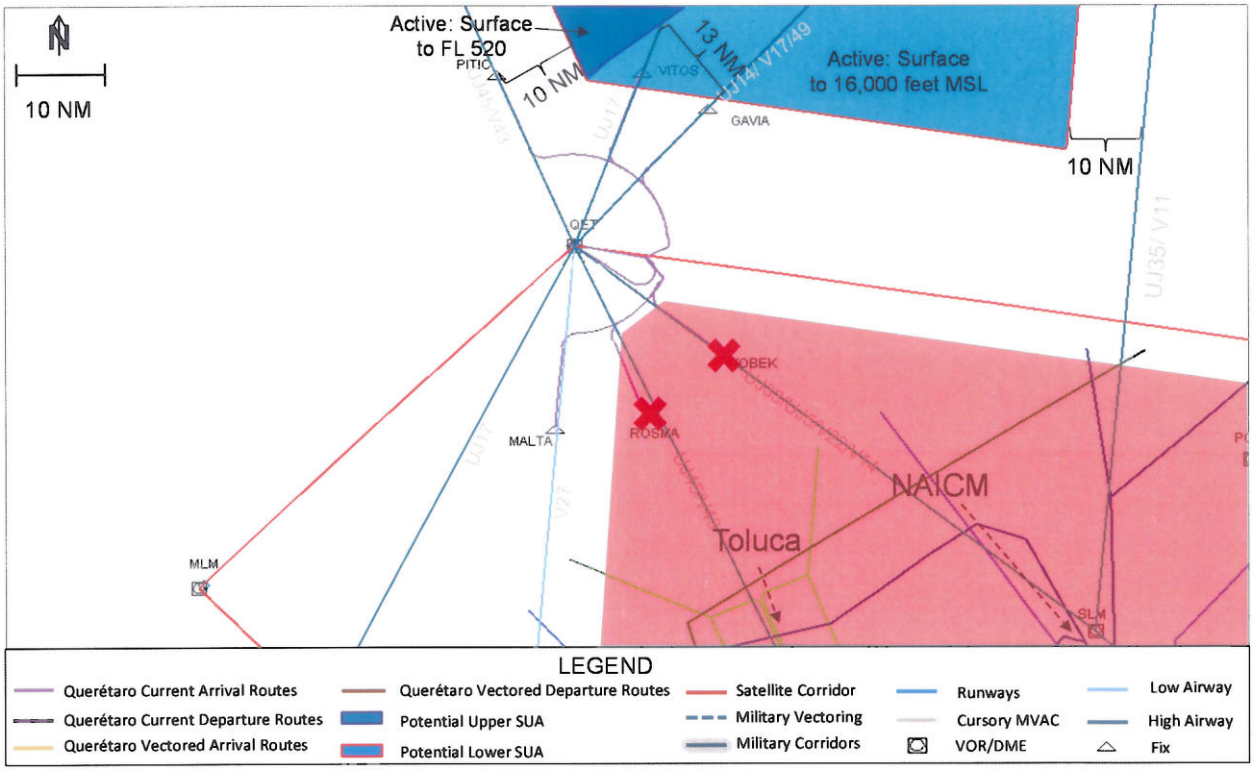

Figure 10. Querétaro Runway 27 Arrival Transitions Considering NAICM and an Expanded Toluca Airport

Querétaro arrival traffic from the south would use the MALTA transition to the VOR/DME 2 Runway 27 arrival procedure. From the southwest, Querétaro arrival traffic would join the satellite corridor from MLM VOR/DME to use the VOR/DME 1 turn-back procedure for Runway 27. Flights from the northwest, north, and northeast would join the PITIC, VITOS, and GAVIA transitions, respectively, while traffic from the east would join the final approach course

for the VOR/DME 2 Runway 27 arrival procedure from the satellite corridor for a straight-in approach. Traffic from the southeast would be directed to join the satellite corridor and then follow the traffic from the east to join the final approach course.

None of the Runway 27 departures, shown in Figure 11, would be affected as a result of the MITRE-developed NAICM and an expanded Toluca Airport airspace design. The departures to the southwest and east would join the satellite corridor from the departure procedures while the rest of the departure traffic would join enroute airways.

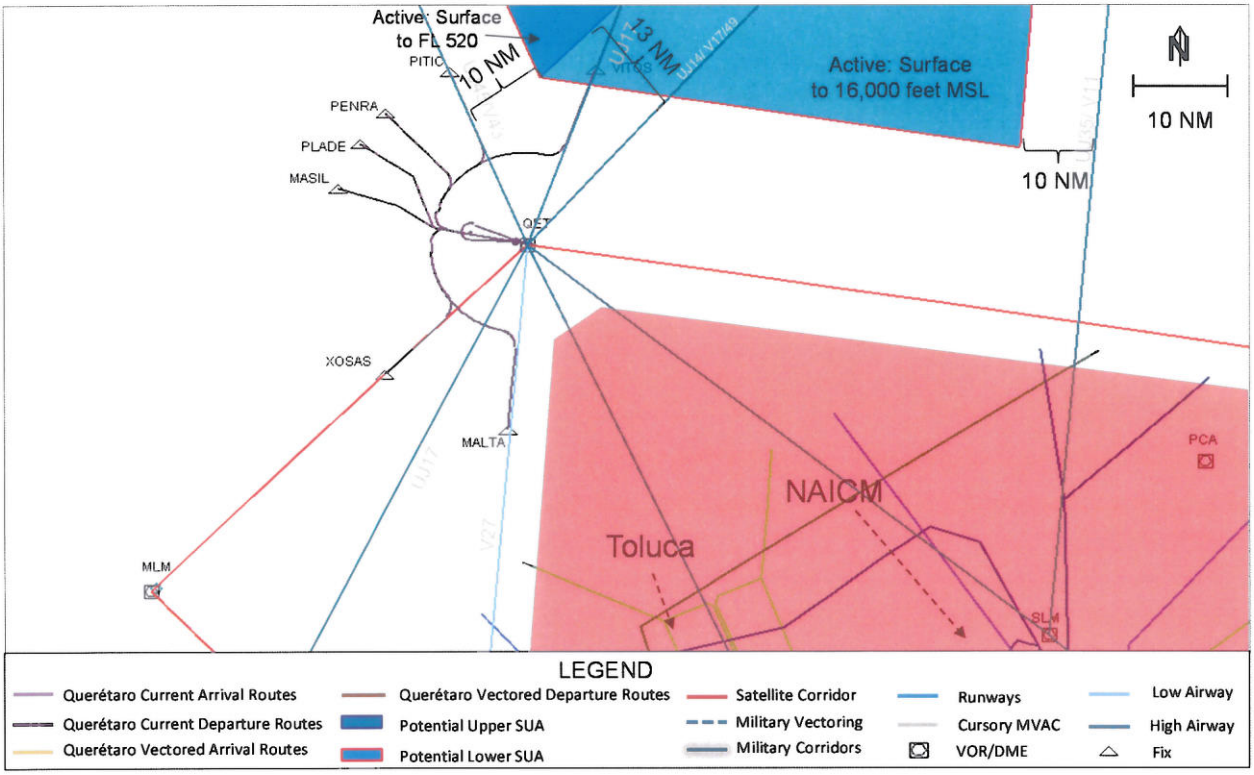

Figure 11. Querétaro Runway 27 Departure Procedures Considering NAICM and an Expanded Toluca Airport

The Querétaro departure procedures for Runway 09 that currently end at the KOBEK and ROSMA fixes would also be affected. Figure 12 shows the departure procedures for Runway 09 in purple with the fixes marking the end of the procedures. The KOBEK 1 and ROSMA 1 departure procedures are shown with a red "x" and a red shaded area indicating that this is the heavy traffic area that Querétaro traffic must avoid.

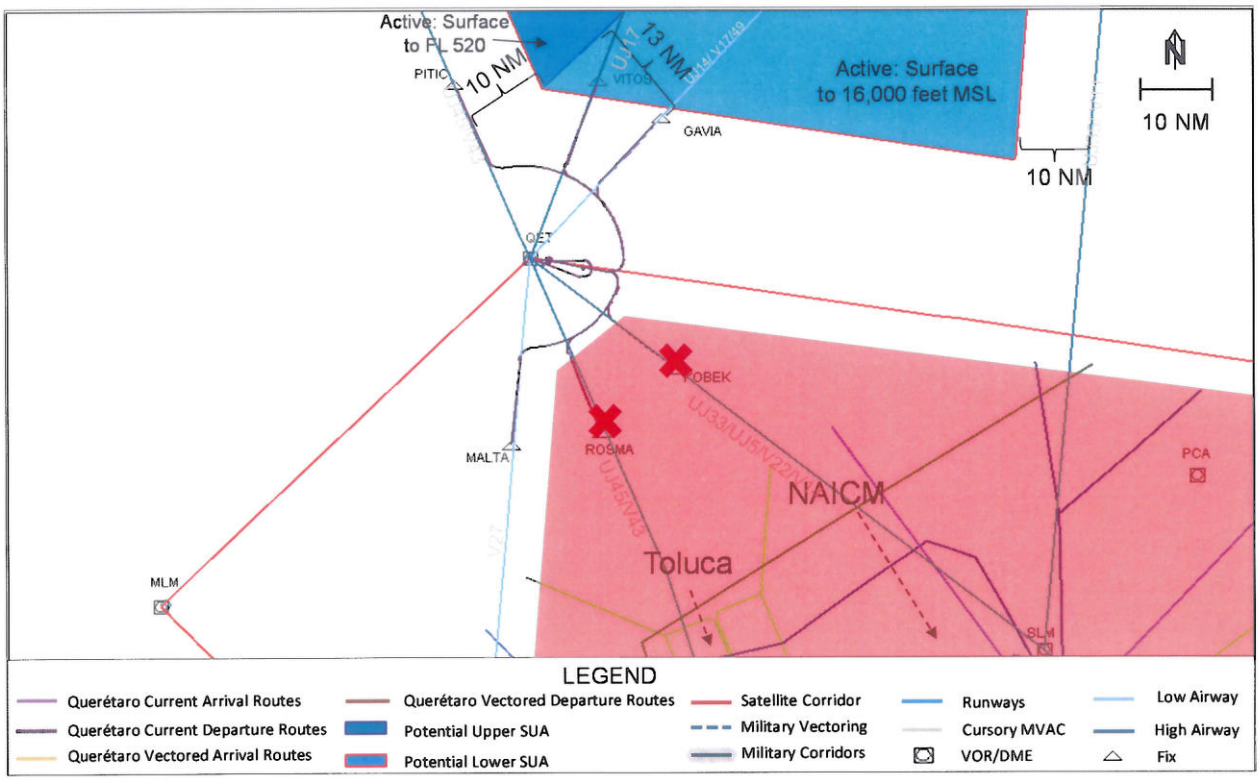

Figure 12. Querétaro Runway 09 Departure Procedures Considering NAICM and an Expanded Toluca Airport

For the rest of the Querétaro departure procedures for Runway 09, aircraft will follow a departure procedure and join either the satellite corridor or an enroute airway depending on their route of flight after executing the appropriate departure procedure.

Similar to the Querétaro Runway 27 departure procedures, none of the current Runway 09 arrival transitions and procedures, shown in Figure 13, would be affected. However, the arrival flows would change as the aircraft would be arriving from different directions. Flights from the southwest and south would use the XOSAS transition from the satellite corridor and the MALTA transition from the V27 enroute airway, respectively. Flights from the west and north would use the FRESA, MASIL, PLADE, PENRA, PITIC, and VITOS transitions, the same as today. Aircraft from the northeast, east and southeast would use the satellite corridor and join the VOR/DME 1 Runway 09 arrival procedure.

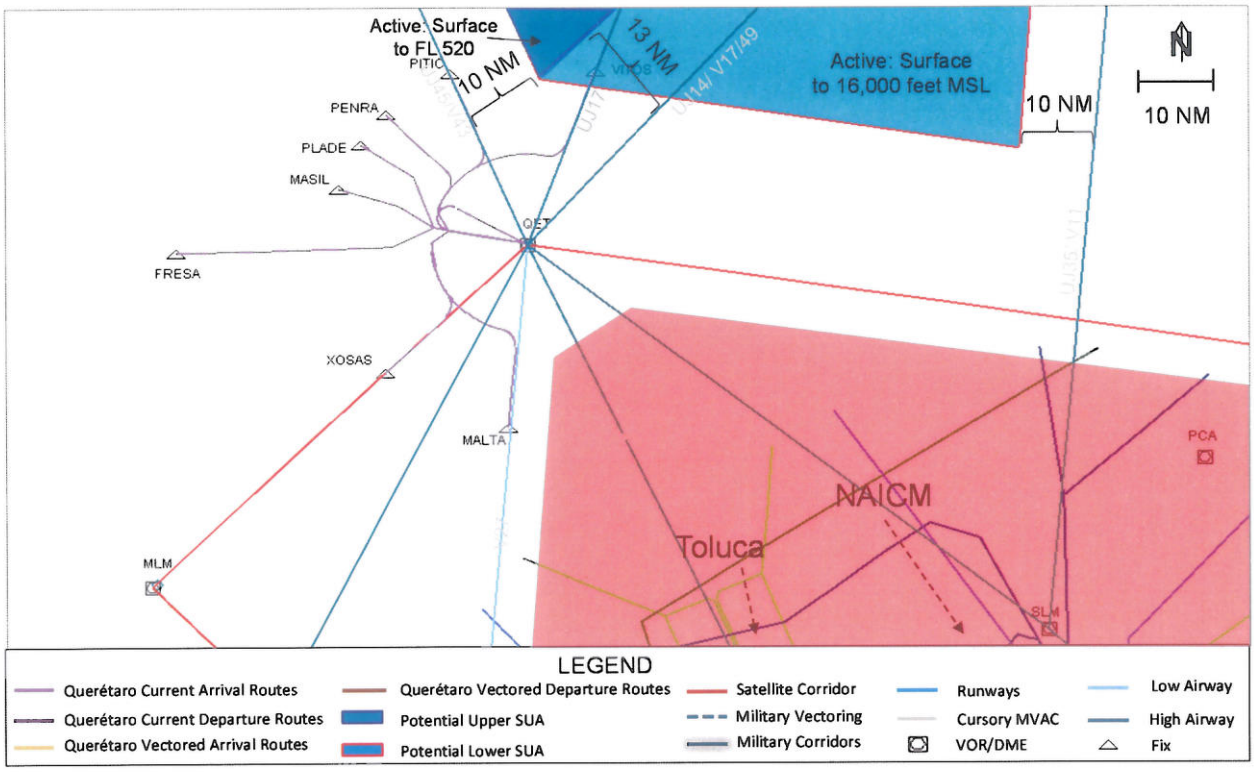

Figure 13. Querétaro Runway 09 Arrival Transitions Considering NAICM and an Expanded Toluca Airport

It is important to mention that none of the necessary modifications to the VOR/DME 2 Runway 27 arrival procedure (elimination of the KOBEK and ROSMA arrival transitions) or the KOBEK 1 and ROSMA 1 departure procedures for Runway 09 would affect capacity at Querétaro. The flights currently using these SIDs and arrival transitions will, when NAICM opens, be directed to use the satellite corridor and different arrival and departure procedures, in order to remain clear of the congested Mexico City basin airspace.

6.1.4 Impact to Querétaro Procedures by the Potential North Upper SUA

MITRE located and designed the North Upper SUA so that it would not interfere with NAICM or expanded Toluca Airport operations. For example, the design of the North SUA takes into account the 10 NM minimum required separation between the airways, satellite corridor, arrival transitions and departure procedures serving NAICM and an expanded Toluca Airport.

At Querétaro, the arrival transitions and departure procedures over VITOS and Airway UJ17 were the only procedures that were not protected by the 10 NM separation requirement when the North Upper SUA, which extends up to FL520, is active. However, when only the North Lower SUA is active, which extends up to 16,000 feet MSL, the aircraft on UJ17, the VITOS arrival transitions or the VITOS departure procedures are above the 16,000 feet MSL Lower SUA ceiling and, therefore, are not affected.

The relationship between the VITOS transition (marked with a red "x") and the North Upper SUA (highlighted in red) is shown in Figures 14 and 15 for Querétaro operating in the Runway 27 direction and the Runway 09 direction, respectively, along with the remaining transitions.

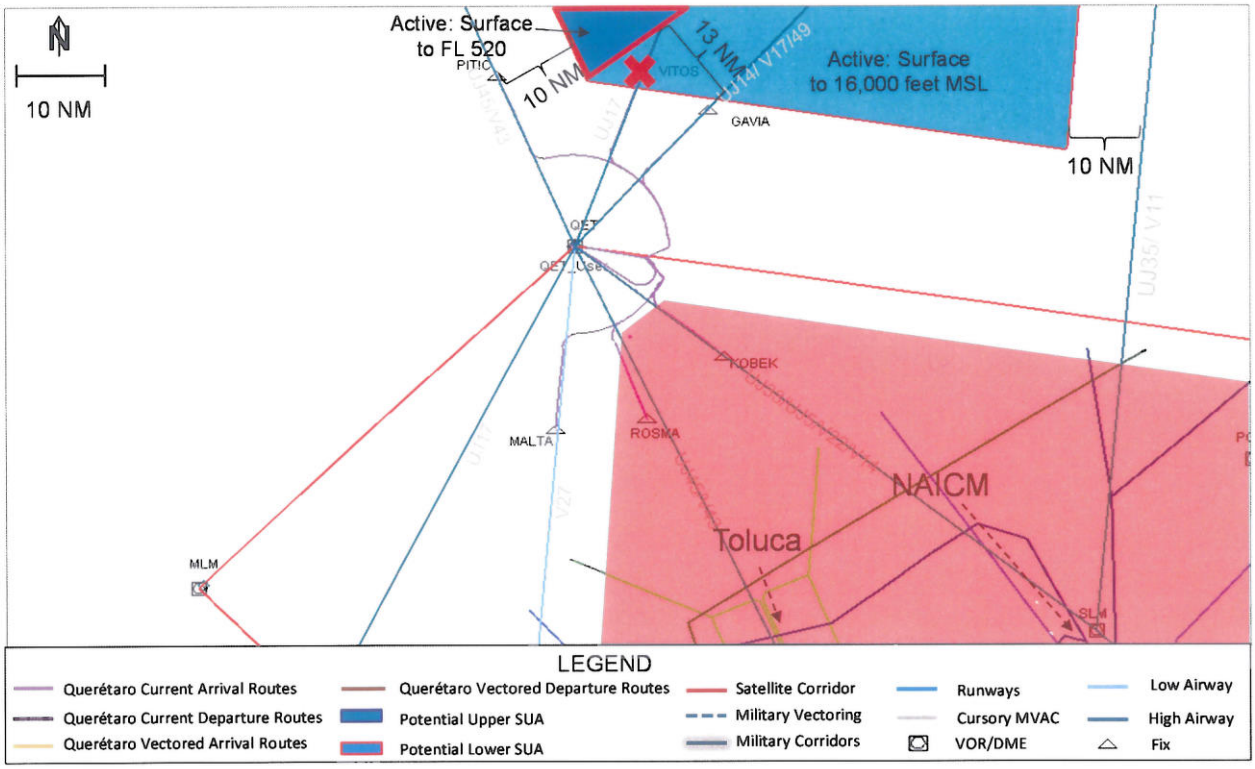

Figure 14. Querétaro VITOS Runway 27 Arrival Transition and the North Upper SUA

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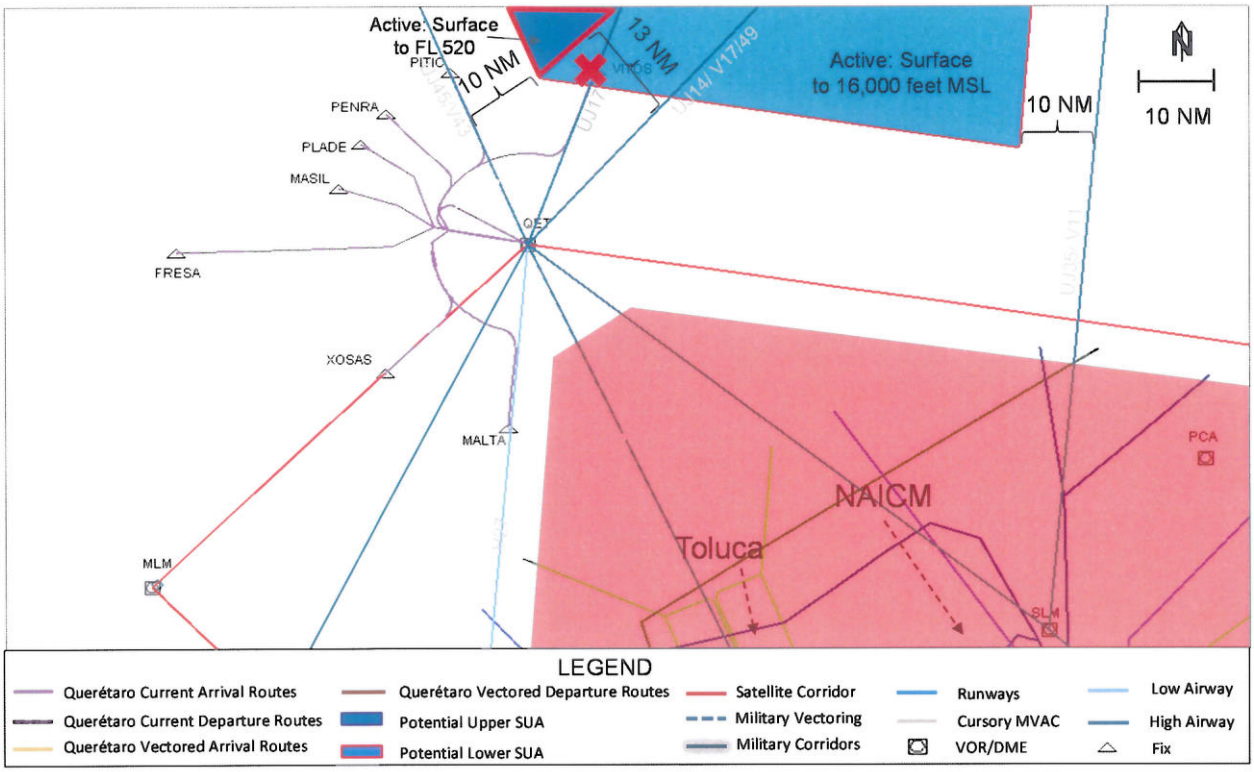

Figure 15. Querétaro VITOS Runway 09 Arrival Transition and the North Upper SUA

For Querétaro departing aircraft, the VITOS 1B departure procedure for Runway 27 and the VITOS 1A departure procedure for Runway 09 are both affected when the North Upper SUA is active, as shown in Figures 16 and 17, respectively. Similar to Figures 14 and 15, the affected procedures are marked with a red "x" to indicate that the procedure would not be usable when the North Upper SUA is active. The North Upper SUA is highlighted in red to indicate the partial lateral boundaries of the Upper SUA. In addition, Figures 16 and 17 also show the other departure procedures for completeness.

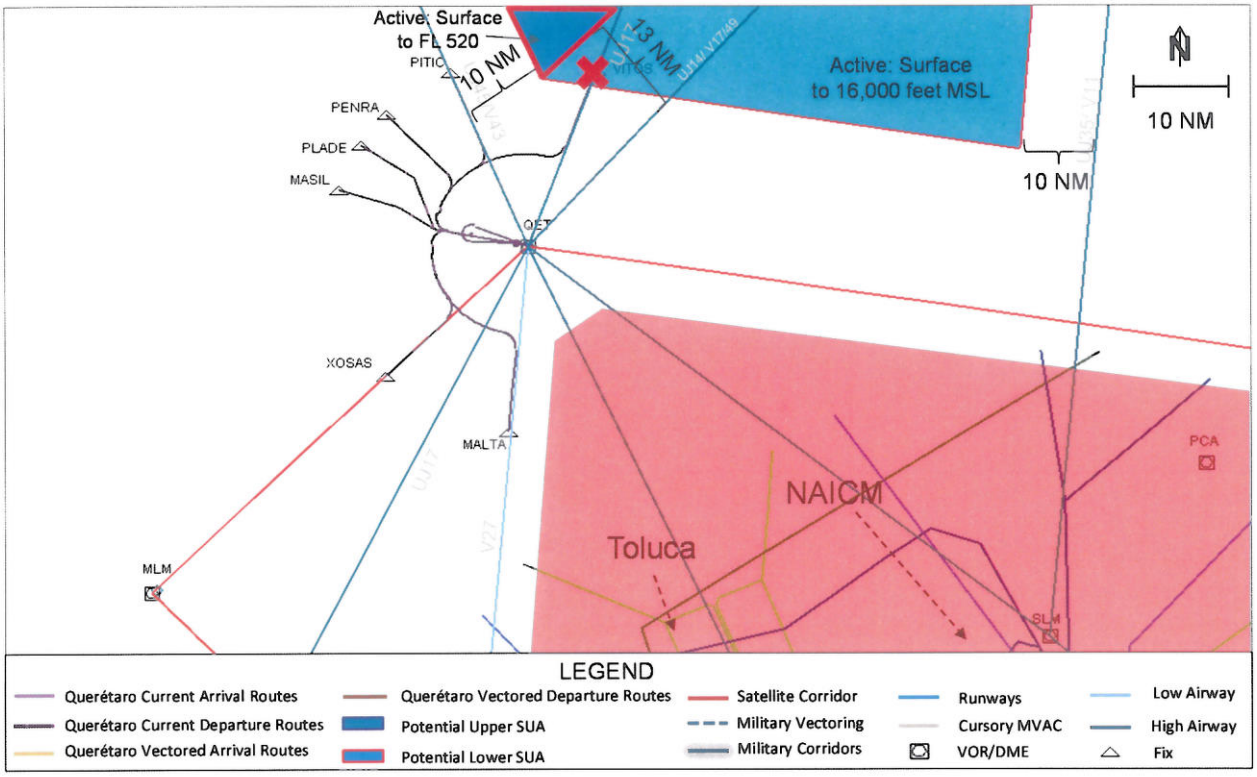

Figure 16. Querétaro VITOS Runway 27 Departure Procedure and the North Upper SUA

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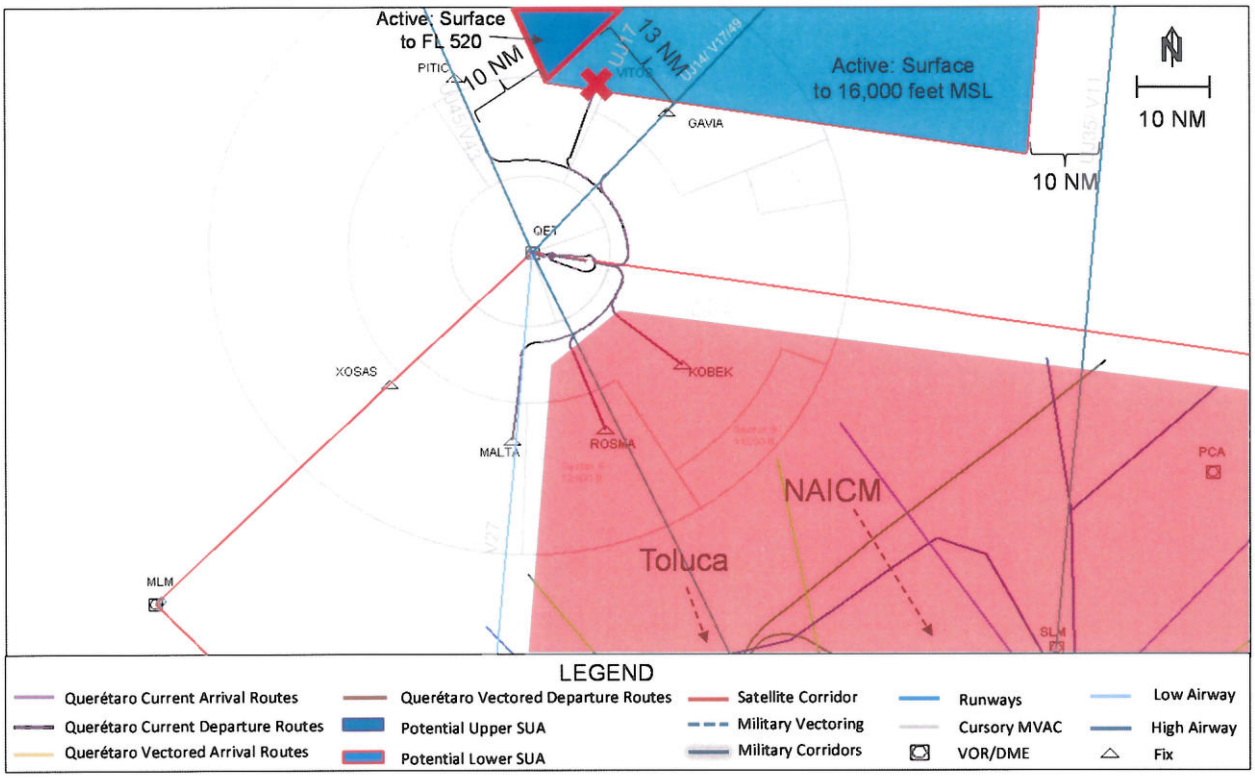

Figure 17. Querétaro VITOS Runway 09 Departure Procedure and the North Upper SUA

The restrictions on the Querétaro transitions and procedures caused by the activation of the North Upper SUA should not have any capacity impacts on Querétaro since there are other arrival transitions and departure procedures that can be used in place of those that go over VITOS. The vectoring of aircraft around active SUAs is a practice that SENEAM is currently performing and is expected to continue to perform in the future operational concept. As with today's existing vectoring practice, this may require aircraft to fly additional miles.

6.2 Potential Future Radar Control Services at Querétaro

As demand at Querétaro grows, the airspace and procedures will need to be adjusted to accommodate increased volumes of traffic. These adjustments would affect the airport, the users of the airport, and the surrounding airspace. A likely adjustment at Querétaro is the introduction of radar-based procedures. Therefore, MITRE examined a scenario that would use radar-based procedures in a radar environment. This was done to ensure that Querétaro can grow and still be able to accommodate FAM fixed-wing aircraft.

Installing radar at Querétaro would not only increase safety by providing enhanced services, such as traffic information advisories, flight monitoring, and low altitude alerting, but also reduce delays and increase flexibility. The delay reduction would benefit both the civil and FAM aircraft, and would be accomplished through more direct routing, reduced separation between successive aircraft on the arrival and departure procedures, and a decrease in the need to use holding patterns by allowing more than one aircraft to be on the arrival and departure procedures at one time. The increase in flexibility benefits ATC by providing additional options

in routing aircraft and in handling aircraft with differing performance capabilities. For instance, radar would provide ATC personnel with the ability to observe the closure rate between a slow moving aircraft followed by a fast moving aircraft and provide ATC with time to make the necessary speed adjustments, or to manage safely the overtake of the slower aircraft by the faster one.

6.2.1 Potential Querétaro MVAC

MITRE determined that the SENEAM-MITRE MVAC, previously developed for a combined NAICM/Toluca TMA to support operations at those airports would not adequately support instrument procedures at Querétaro. Therefore, a cursory MVAC was developed for Querétaro to assist in the development of the radar vectoring portion of the arrival pattern. The MVAC was used in this analysis to determine the altitudes at which aircraft can be vectored onto final approach. Figure 18 shows the cursory MVAC developed for Querétaro and indicates the different sectors of airspace within 40 NM of the QET VOR/DME with the associated minimum altitudes (above MSL) in that airspace sector that aircraft may be safely vectored by ATC. As previously mentioned, the Querétaro MVAC used in this study is very preliminary at this stage of the project. The final MVAC will eventually need to be integrated into the above-mentioned NAICM/Toluca MVAC by SENEAM.

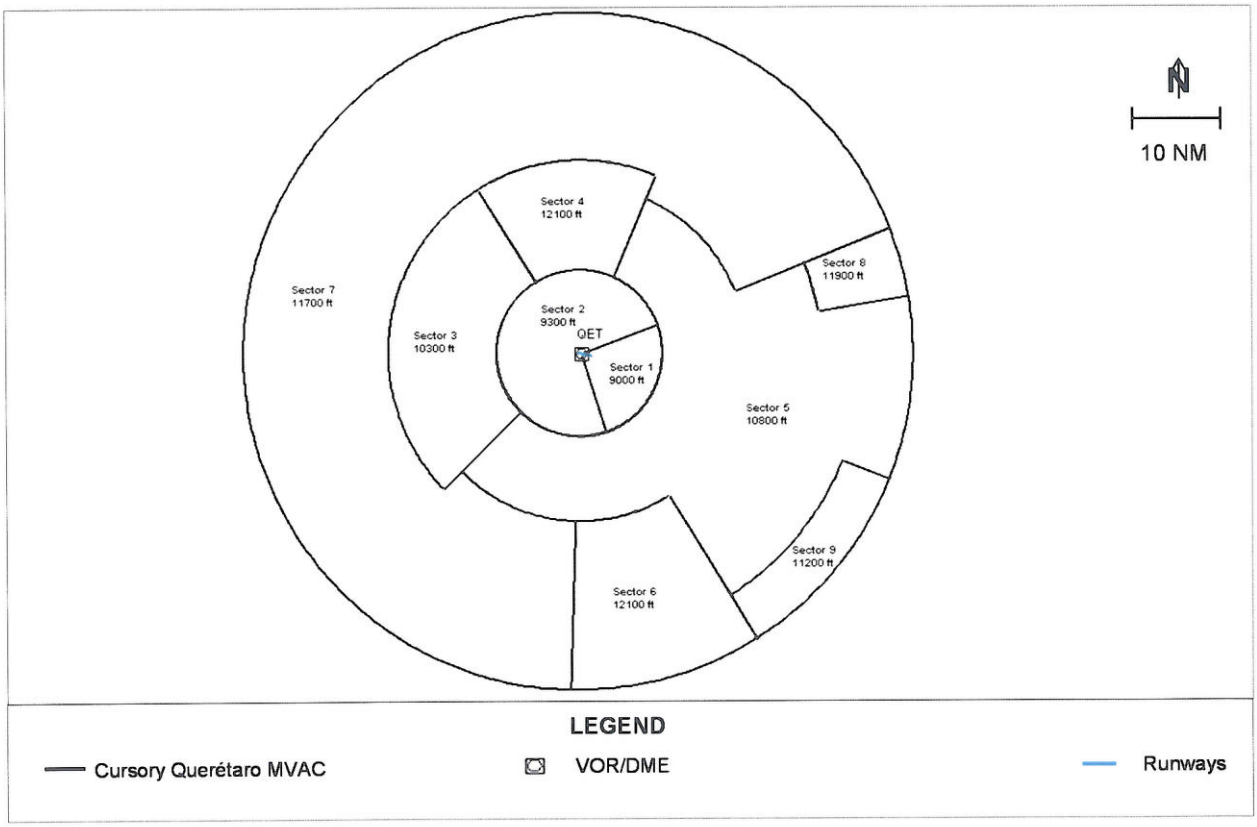

Figure 18. Cursory Querétaro MVAC (Not to be Considered as Final)

6.2.2 Potential Querétaro Radar Services Concept

The future radar operational concept for Querétaro arrivals would be to use the standard downwind-base leg-final arrival pattern used at many airports around the world. The aircraft would be vectored to enter the arrival pattern either on the downwind or the base leg from the satellite corridor or from an enroute airway. Once in the arrival pattern the aircraft would continue to be vectored by ATC to the final approach course. This arrival pattern allows for more than one aircraft to be in the arrival pattern at the same time. Any sequencing required would be accomplished by ATC through the use of delay vectors, extending the downwind leg, or speed control (or combinations thereof), either before entering the arrival pattern or once the aircraft is in the pattern. As a last resort, holding could also be used for longer delay measures.

The future radar operational concept for Querétaro departures would be for the departing aircraft to follow newly designed SIDs to join either the satellite corridor or an enroute airway, keeping the aircraft away from heavy traffic areas associated with NAICM and Toluca Airport. These newly designed SIDs would allow aircraft to turn away from the runway centerline towards the satellite corridor or enroute airway earlier than the non-radar departure procedures. MITRE developed cursory new SIDs for Querétaro, but did not go as far as developing new SIDs for all exit points. For the purposes of this report, for cases where the aircraft's destination is in the opposite direction to that of the departure runway, aircraft will need to be vectored from the departure procedure to join the satellite corridor. For instance, in the case of Querétaro operating in the Runway 27 direction and aircraft flying to destinations that are east of Querétaro, the aircraft would use the north departure and then be vectored off the SID once it has reached a safe vectoring altitude to join the satellite corridor and head east. This would also be the case when Querétaro is operating in the Runway 09 direction and the aircraft's destination is west of the airport. An alternative option will be for additional SIDs to be implemented.

Figure 19 show the potential civil arrival and departure routes for Querétaro radar-based operations in the Runway 27 direction. The arrival routes are shown in tan solid lines and the departure routes are shown in brown solid lines. The brown dashed lines represent the vectoring path that ATC could use to vector aircraft from the north departure route to the satellite corridor before heading east to the destination airport. Included in the figure is the cursory MITRE-developed MVAC for Querétaro which is shown in light grey lines.

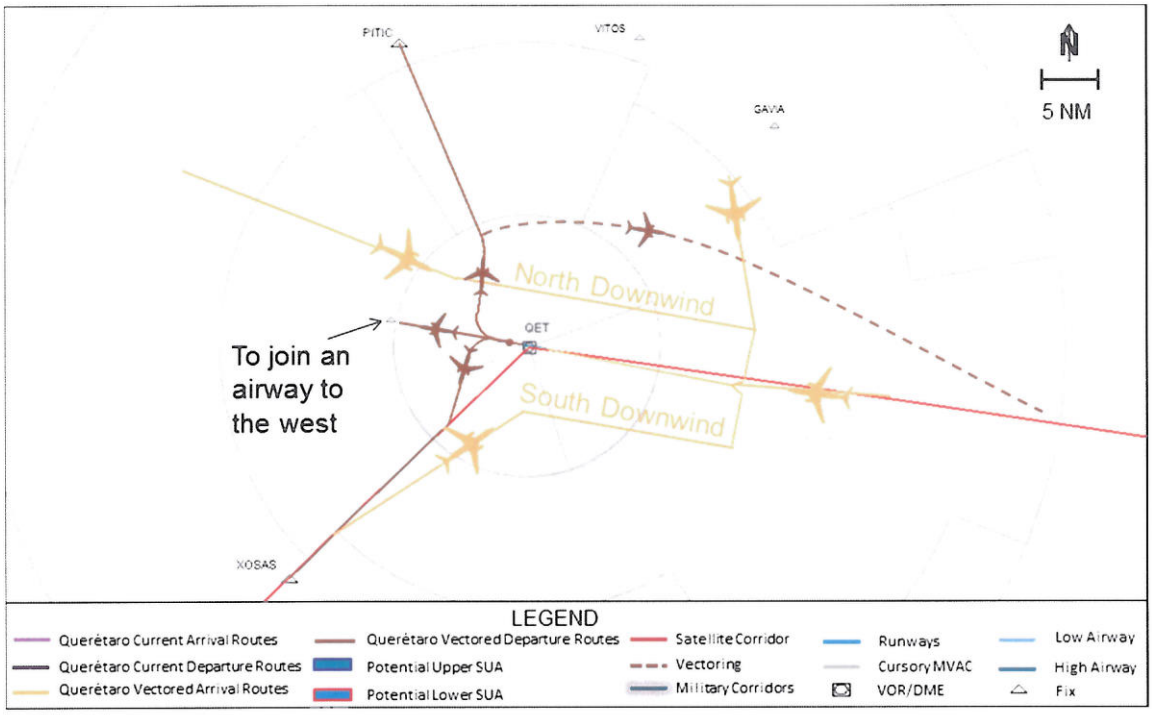

Figure 19. Querétaro Runway 27 Potential Civil Arrival and Departure Radar-Based Routes

As shown in Figure 19, aircraft arriving from the east would be vectored for a straight-in approach from the satellite corridor. Aircraft arriving from the northeast, northwest, and west would be vectored to the downwind or base leg of the arrival pattern and then be vectored onto the final approach course. Aircraft from the southwest would join the arrival pattern from the satellite corridor on the downwind. The departing aircraft would execute one of the new SIDs and then either join an enroute airway to the west, northwest and north, the satellite corridor to the southwest, or be vectored to join the satellite corridor to the east.

Figure 20 shows the potential radar-based arrival and departure route design for the Runway 09 direction at Querétaro. The arrival routes are shown in a solid tan line and the departures are in a brown solid line.

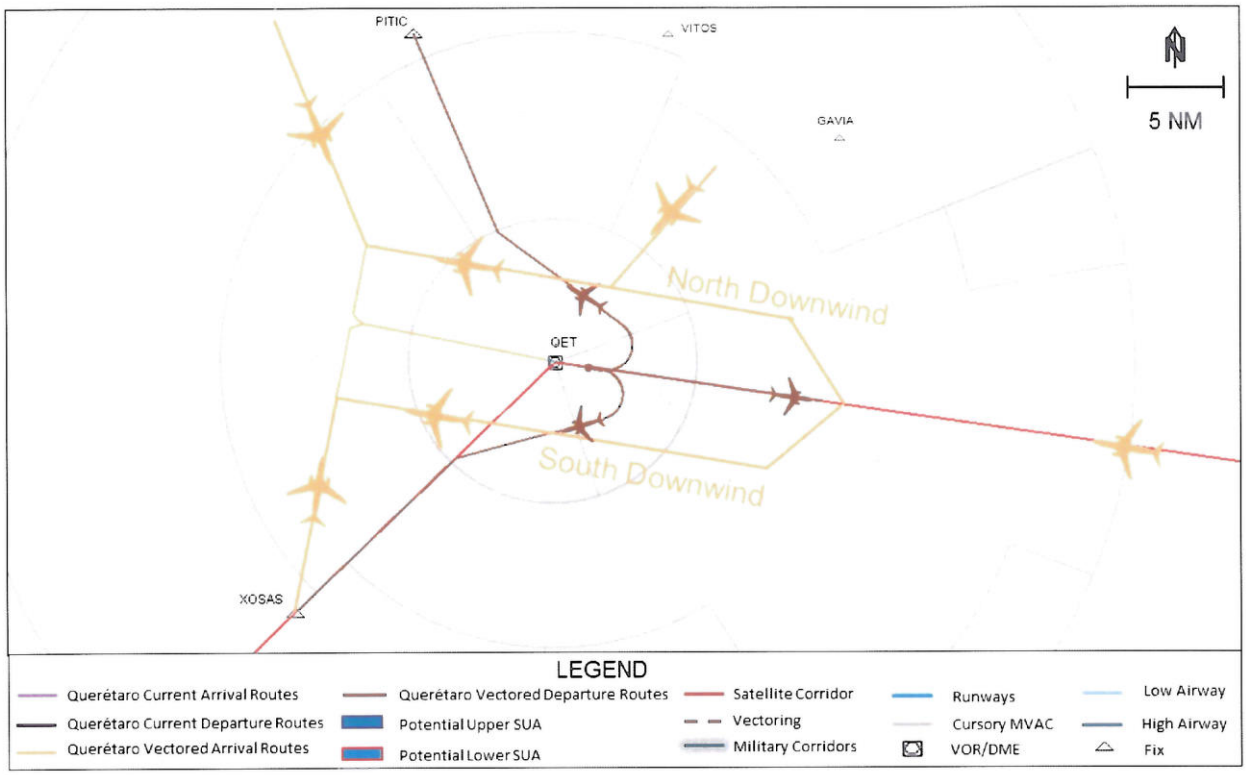

Figure 20. Querétaro Runway 09 Potential Civil Arrival and Departure Radar-Based Routes

Arrival aircraft from the east would be vectored from the satellite corridor to join the downwind. The downwind could be on either side of the final approach course of the arrival pattern, and would be the choice of the controller, in order to minimize conflicts with other traffic. From the northeast, aircraft would be vectored to the north downwind of the arrival pattern without ever joining the satellite corridor. Arrivals from the northwest and southwest would be vectored to join directly on to the left and right base legs, respectively, before joining the final approach course. The departing aircraft would execute one of the new SIDs that would either take the aircraft straight-out to the east to join the satellite corridor or make a right or left turn, staying within 15 NM of the airport, to join an enroute airway or the satellite corridor to the southwest.

FAM aircraft would be expected to fly the civil radar procedures and be integrated and sequenced with the civil aircraft in the radar environment. FAM aircraft arriving from the potential East and West SUAs would exit the SUAs on the military corridors and then either be vectored to join the radar arrival pattern or join the satellite corridor and then the radar arrival pattern. The arrivals from the North SUA would be vectored out of the SUA to join the radar arrival pattern. FAM aircraft departing Querétaro would also follow the civil procedures to join the military corridors or be radar vectored to the North SUA once they had reached an appropriate minimum vectoring altitude.

FAM arrival and departure routes and military corridors are shown in Figures 21 and 22 for Runway 27 and Runway 09, respectively. In each of these figures, the military corridors are

shown in a grey-shaded teal line with teal aircraft representing how FAM aircraft would use the potential radar-based arrival and departure procedures and the military corridors. The teal dashed lines represent the vectoring of aircraft arriving to and departing from the North SUA, or being vectored to the East SUA military corridor.

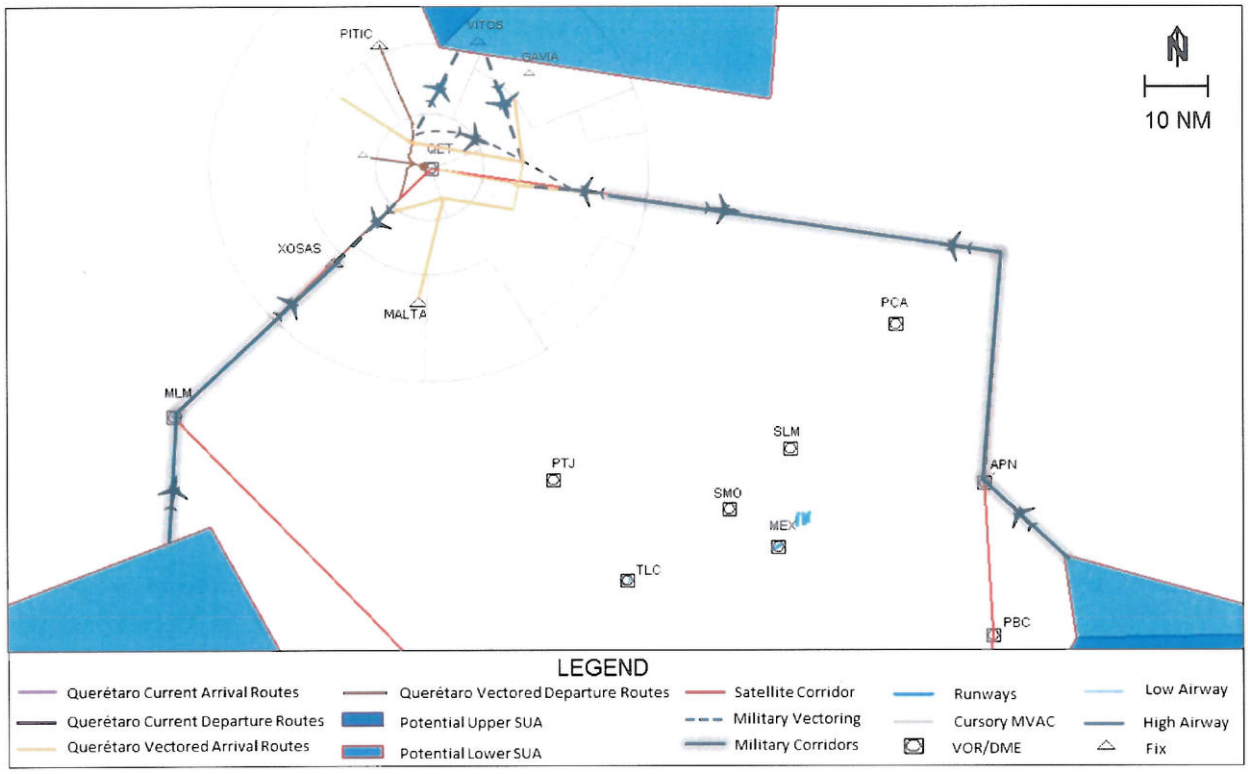

Figure 21. Military Corridors and Runway 27 Operations in a Radar-Based Environment

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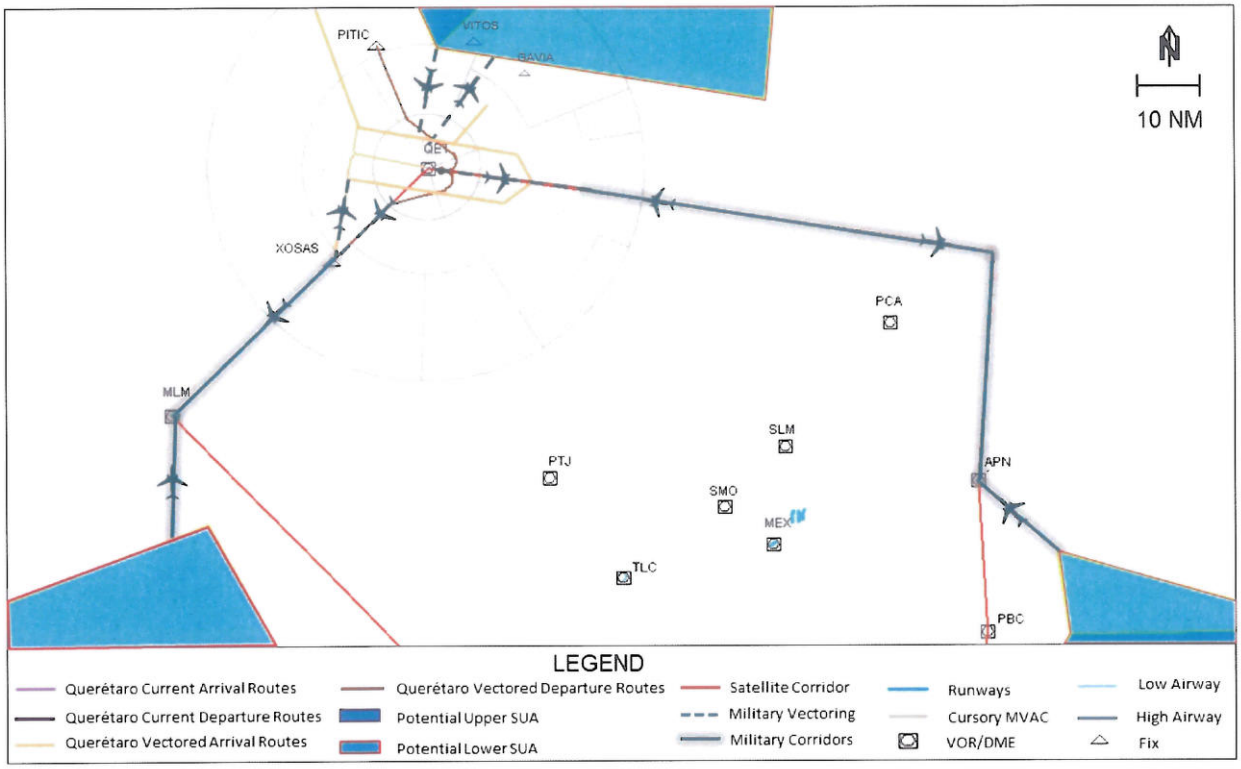

Figure 22. Military Corridors and Runway 09 Operations in a Radar-Based Environment

7. Summary

Based on its analysis of airspace, published arrival and departure procedures, and ATC procedures, MITRE has determined that it appears feasible for FAM fixed-wing military aircraft (such as fighter jets) to operate at Querétaro and that potential SUAs can be designed to support FAM aircraft with the following restrictions:

- FAM aircraft would use either the remaining civil non-radar procedures or the potential civil radar routes when arriving to or departing from Querétaro
- FAM aircraft would use the military corridors to transition between Querétaro and the East and West SUAs, thus avoiding the heavy traffic areas associated with NAICM and Toluca Airport. FAM aircraft going to the North SUA would use VITOS and/or GAVIA civil non-radar procedures, the potential civil radar routes, or be radar vectored.

MITRE recommends that radar-based procedures be introduced at some point in the future. The radar control services would provide benefits for both civil and military users of the airport through reduced track mileage and delays and would enhance ATC procedures through increased flexibility. Overall safety of the operations would also increase through the ability of ATC to monitor flights and provide traffic advisories.

As previously mentioned, MITRE met with experts from SENEAM in June 2014 to discuss FAM fixed-wing military operations at Querétaro. During this meeting, the SENEAM experts were of the opinion that FAM operations could use the non-radar procedures that exist today.

SENEAM also informed MITRE that they were aware that ATC at Querétaro would at some point in the future need to provide radar control services, but that the time frame for this is unclear.

Another aspect of relocating FAM fixed-wing military operations to Querétaro involves physically accommodating FAM facilities at the airport. As previously mentioned, MITRE noticed an area on the airport that could potentially accommodate FAM facilities and operations. However, the area in question is limited in size and more investigation by FAM officials and other stakeholders is required to determine its appropriateness to accommodate FAM support facilities.

Finally, it is very important that MITRE discusses and reviews the results of this report with FAM officials, SENEAM, and other stakeholders in a collaborative manner so that appropriate feedback can be obtained.