Enclosure 3

(Ref. Technical Letter F500-L16-013)

MITRE

Center for Advanced
Aviation System Development

Nuevo Aeropuerto Internacional de la Ciudad de México

Feasibility of Independent Approach and Departure Procedures

Prepared for

Aeropuertos y Servicios Auxiliares

January 2016

REVISIONS

This document was originally provided by MITRE in late June 2015 (see enclosure No. 1 to MITRE Technical Letter F500-L15-021). MITRE frequently reviews its reports several times (both before and after they are submitted) due to its commitment to provide accurate and correct information. During this process, a few minor mistakes and a need to clarify an item in this report was discovered, which are described below. It is important to note that these items do not affect the overall results of MITRE's procedure design work.

- Page 18, Table 1
  - Changed the Intermediate terrain controlling obstacle elevation **from** 12,041 **to** 12,123
  - Changed the Missed Approach antenna* controlling obstacle elevation **from** 9413 **to** 9423
  - Changed the Missed Approach antenna** controlling obstacle elevation **from** 11,506 **to** 11,605
- Page 19, Table 2
  - Changed the Intermediate terrain controlling obstacle elevation **from** 12,041 **to** 12,123
  - Changed the Missed Approach antenna* controlling obstacle elevation **from** 9413 **to** 9423
  - Changed the Missed Approach antenna** controlling obstacle elevation **from** 11,506 **to** 11,605
- Page 20, Table 3
  - Changed the Intermediate terrain controlling obstacle elevation **from** 12,041 **to** 12,123
- Page 21, Figure 10
  - Replaced with corrected Missed Approach instructions
- Page 21, Table 4
  - Changed the Intermediate terrain controlling obstacle elevation **from** 12,041 **to** 12,123
  - Changed the Missed Approach terrain controlling obstacle elevation **from** 8990 **to** 9072

- Page 22, Figure 11
  - Replaced with corrected Missed Approach instructions
- Page 22, Table 5
  - Changed the Intermediate terrain controlling obstacle elevation **from** 9810 **to** 9892
  - Changed the Missed Approach terrain controlling obstacle
    - Description **from** "Terrain" **to** "Antenna"
    - Latitude **from** 19 26 29.20N **to** 19 26 27.48N
    - Longitude **from** 99 22 18.85W **to** 99 22 19.28W
    - Elevation **from** 11,254 **to** 11,605
- Page 23, Figure 12
  - Replaced with corrected Missed Approach instructions
- Page 23, Table 6
  - Changed the Intermediate terrain controlling obstacle elevation **from** 9810 **to** 9892
  - Changed the Missed Approach terrain controlling obstacle **from** 11,254 **to** 11,605
- Page 24, 5.1.7 Runway 18R
  - For the "***Intermediate Segment***" description, changed the IF distance **from** 30.2 **to** 30.3
- Page 24, Table 7
  - Changed the Intermediate terrain controlling obstacle elevation **from** 9544 **to** 9597
  - Changed the Missed Approach terrain controlling obstacle
    - Latitude **from** 19 06 35.95N **to** 19 06 35.53N
    - Longitude **from** 99 01 48.92W **to** 99 01 54.16W
    - Elevation **from** 11,873 **to** 12,123

- Page 25, 5.1.8 Runway 19L
  - Clarification of greatest amount of penetration (19.1 m / 62.66 ft) by Chiconautla (see re-worded paragraph)
- Page 26, Table 8
  - Changed the Intermediate terrain controlling obstacle elevation **from** 9515 **to** 9597
  - Changed the Missed Approach terrain controlling obstacle elevation **from** 8990 **to** 9072
- Page 33, Table 12
  - Changed ALKOM INT terrain controlling obstacle elevation **from** 9071 **to** 9072
- Page 36, Table 16
  - Changed ALKOM INT terrain controlling obstacle latitude **from** 19 38 02.03 **to** 19 38 02.02
  - Changed ALKOM INT terrain controlling obstacle elevation **from** 9071 **to** 9072

Principal Acronyms and Abbreviations

AICM	Mexico City International Airport
AR	Authorization Required
ATC	Air Traffic Control
CAT	Category
CG	Climb Gradient
DA	Decision Altitude
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
ft	Feet
GIS	Geographic Information System
HAT	Height Above Touchdown
ICAO	International Civil Aviation Organization
IF	Intermediate Fix
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INT	Intersection
MAP	Missed Approach Point
MITRE	The MITRE Corporation
MMP	Mexico Prohibited Area
MMR	Mexico Restricted Area
MSL	Mean Sea Level
MVAC	Minimum Vectoring Altitude Chart
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México
NAVAID	Navigational Aid
NM	Nautical Mile
OCS	Obstacle Clearance Surface
OEA	Obstacle Evaluation Area
OLS	Obstacle Limitation Surface

PAOA	Parallel Approach Obstruction Assessment
PAOAS	Parallel Approach Obstruction Assessment Surface
PFAF	Precise Final Approach Fix
RNP	Required Navigation Performance
ROC	Required Obstacle Clearance
SDF	Step Down Fix
SENEAM	Servicios a la Navegación en el Espacio Aéreo Mexicano
sm	Statute Mile
SOPs	Standard Operating Procedures
SRTM	Shuttle Radar Topography Mission
SUA	Special Use Airspace
TARGETS	Terminal Area Route Generation, Evaluation, and Traffic Simulation
TERPS	Standards for Terminal Instrument Procedures
U.S.	United States
UTM	Universal Transverse Mercator
VOR	Very High Frequency Omni Directional Range
WGS84	World Geodetic System 1984

1. Introduction

The MITRE Corporation (MITRE) is assisting Aeropuertos y Servicios Auxiliares and the aviation authorities 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). In support of this effort, as part of a previous study, MITRE assessed the feasibility of instrument approach and departure procedures at the NAICM site. As part of that feasibility assessment, a satellite-based photogrammetric survey of the NAICM site and its surroundings, consisting of detailed terrain and obstruction information, was provided to MITRE in 2010 for use in examining instrument approach and departure procedures and conducting other obstacle assessment work. As a result of that work, a feasible runway configuration, referred to as the MITRE-Recommended Runway Configuration (July 2012) was established.

More than four years have passed since the original above-mentioned 2010 survey was conducted, and MITRE felt it prudent that a new survey be performed to account for any recent construction that could affect the development of instrument approach and departure procedures. Therefore, a new satellite-based photogrammetric survey of the NAICM site and its surroundings was conducted and completed in late 2014. Upon receipt of the new survey data, MITRE reassessed the instrument approach and departure procedures for the opening-day runway configuration at NAICM (described below in the "Background" section). The purpose of this document is to provide the results of that reassessment work.

This document is organized into several sections. Section 2 provides general background information. Section 3 discusses MITRE's overall procedure development methodology. Section 4 provides an overview of the triple independent operational concept being considered for use at NAICM. Section 5 describes MITRE's reassessed triple independent Category (CAT) I Instrument Landing System (ILS) approach procedures. Section 6 describes MITRE's reassessed triple independent parallel departure procedures, and Section 7 describes MITRE's reassessed triple independent Required Navigation Performance (RNP) Authorization Required (AR) approach procedures. Finally, Section 8 provides a summary of key results. References are then provided, followed by Appendix A which provides runway coordinate information for the MITRE-Recommended Runway Configuration (July 2012).

2. Background

As previously mentioned, MITRE has been examining the feasibility of instrument approach and departure procedures at the NAICM site. As a result of this work and other supporting analyses, MITRE determined the feasibility of a six-runway configuration (i.e., consisting of three sets of closely-spaced parallel runways) at the NAICM site, which is referred to as the MITRE-Recommended Runway Configuration (July 2012). While the airport's ultimate runway configuration is planned to include six parallel runways, the proposed opening-day configuration will consist of three parallel runways appropriately spaced to support triple independent operations. The remaining three runways will be phased in over a number of years. Figure 1 shows the planned

opening-day runway configuration currently being considered by Mexican authorities. This configuration consists of Runways 35R/17L, 36L/18R, and 01R/19L (shown in red).

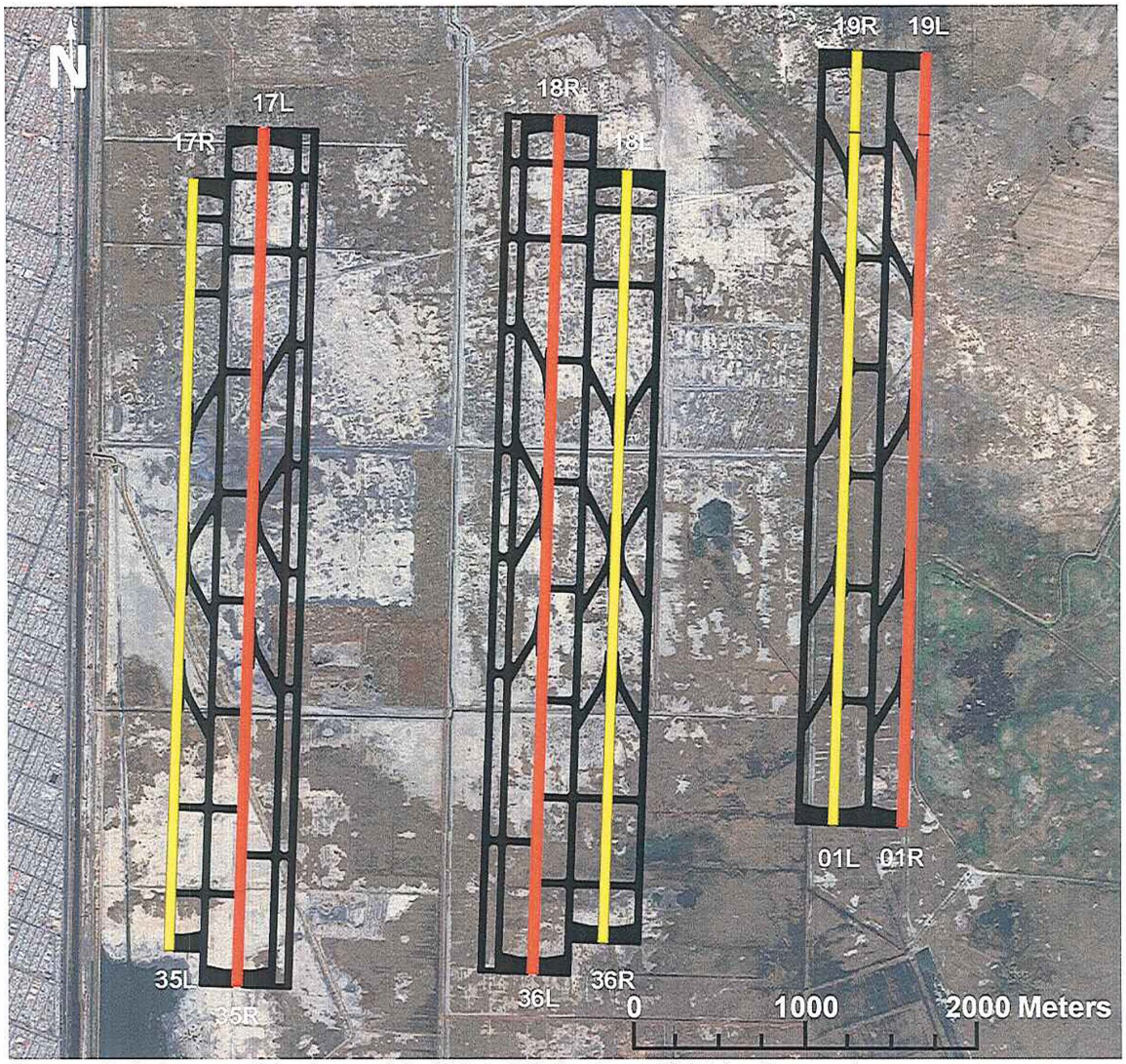

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Figure 1. Currently Planned Opening-Day Three-Runway Configuration at NAICM (Shown in Red)

The MITRE team, however, is concerned about plans to construct Runway 35R/17L before Runway 35L/17R, as that event will jeopardize in all likelihood subsequent construction of Runway 35L/17R due to social protests over noise concerns. Due to these concerns, MITRE recommends that the opening-day runway configuration consists of Runways 35L/17R, 36L/18R, and 01R/19L.

MITRE assembled a large team of engineers with diverse areas of expertise to prepare a document describing MITRE's concerns regarding NAICM's planned opening-day runway configuration. See MITRE letter F500-L15-009, *Special Technical*

Letter: NAICM Opening-Day Runway Configuration: Important Concerns and Considerations, dated 27 January 2014. In late February 2015, a team of MITRE engineers led by Dr. Bernard Lisker visited Mexico City to meet with the Secretary of Communications and Transportation, Lic. Gerardo Ruiz Esparza, along with his Undersecretary of Transportation, Lic. Yuriria Mascott Pérez and other top aviation officials to present a briefing on its concerns. MITRE was informed by the Secretary that the decision to construct Runway 35R/17L or Runway 35L/17R first will be reassessed and that MITRE will be kept informed.

Therefore, MITRE decided to also reassess the feasibility of instrument approach and departure procedures for Runway 35L/17R in the event aviation authorities decide to construct that runway first as part of the opening-day runway configuration. The results for Runway 35L/17R are also included in this document. Figure 2 shows MITRE's recommended opening-day runway configuration (shown as red lines).

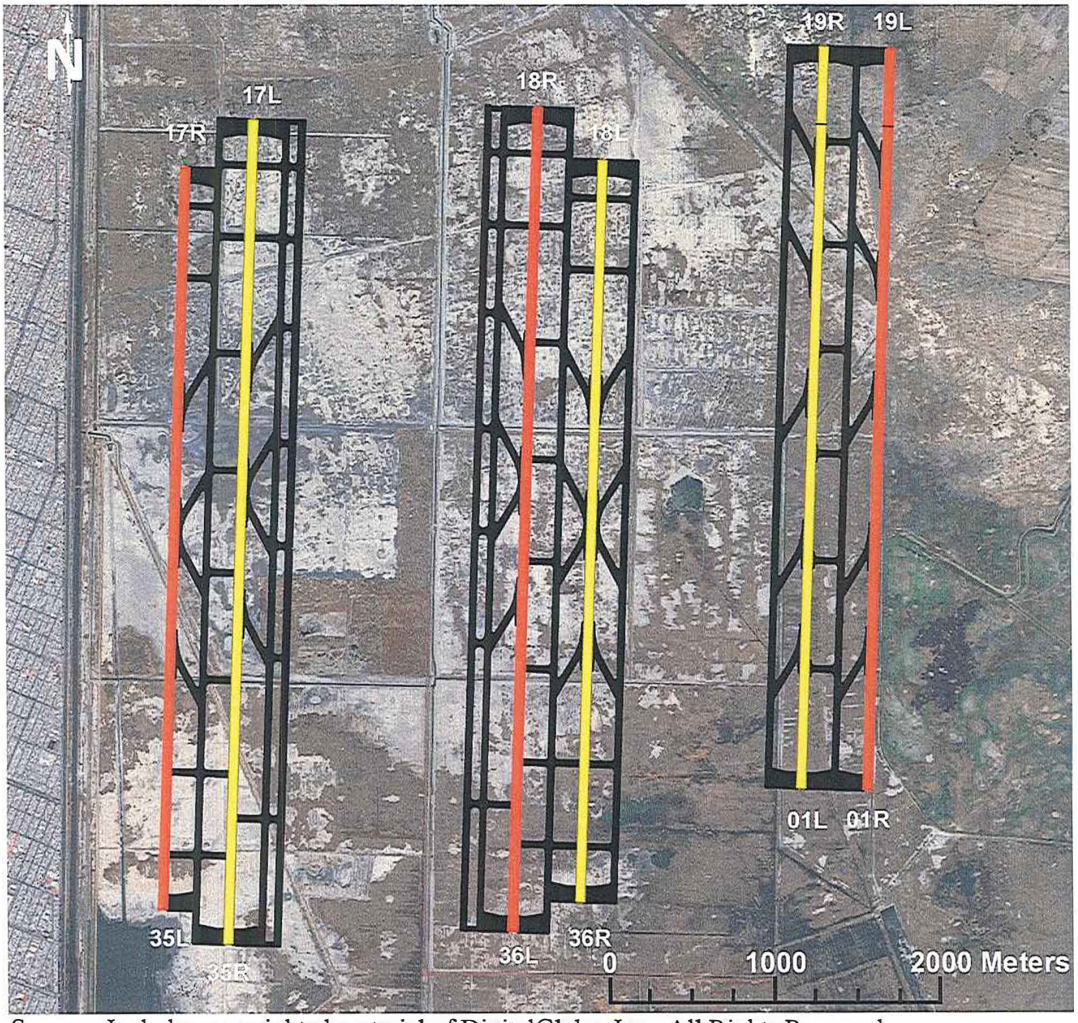

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Figure 2. MITRE-Recommended Opening-Day Three-Runway Configuration at NAICM (Shown in Red)

MITRE analyzed both conventional CAT I ILS and satellite-based RNP AR instrument approach procedures, as well as conventional departure procedures for the opening-day runway configuration at NAICM, including the option of constructing Runway 35L/17R instead of Runway 35R/17L. Several of the CAT I ILS procedures require missed approach Climb Gradients (CGs) above standard (i.e., above 200 feet [ft]/Nautical Mile [NM]), in order to achieve the lowest possible approach minimums. RNP AR procedures allow for greater design flexibility. Therefore, MITRE also examined RNP AR procedures as an alternative approach procedure option to try and avoid or reduce the missed approach CG requirements associated with the ILS procedures.

It is important to mention that other obstacle-related issues still need to be resolved. For example, the hills at Chiconautla and Chimalhuacán penetrate some International Civil Aviation Organization (ICAO) Annex 14 Obstacle Limitation Surfaces (OLS). Chiconautla penetrates ICAO Annex 14 Approach and Takeoff Climb Surfaces, as well as United States (U.S.) Federal Aviation Administration (FAA) Standard for Terminal Instrument Procedures (TERPS) final approach Obstacle Clearance Surface (OCS).[1] Chimalhuacán, on the other hand, only penetrates the ICAO Annex 14 Approach Surface. Therefore, the aviation authorities of Mexico and other stakeholders need to make a decision regarding the grading (including to what extent) of the hills at Chiconautla and Chimalhuacán.

To support authorities in making these decisions, MITRE prepared a parametric analysis of runway threshold elevations that consider terrain at the hills Chiconautla and Chimalhuacán. The objective of the parametric analysis was to provide information to assist authorities in making key decisions regarding potential runway threshold elevations, grading (and its extent) of Chiconautla and Chimalhuacán, and the preparation of cost/benefit analyses. See MITRE letter F500-L15-018, *Technical Letter—Parametric Analysis of Runway Threshold Elevations (REVISION)*, dated 26 March 2015 for additional information.

3. Methodology and Other Key Considerations

The following section provides background information on MITRE's procedure development practices, obstacle databases, assumptions and other important considerations pertaining to the development of the instrument approach and departure procedures described in this document.

3.1. Methodology

The first step in the examination of instrument approach and departure procedures is the collection of relevant data used in the development of the procedures. The second step is the creation of a Master Basemap drawing, generally within a computer aided

[1] Note that several tall antennas and structures are located on top of Chiconautla. MITRE assumed that these items would be removed. MITRE also assumed that the hill itself would be graded so as not to penetrate the U.S. TERPS final approach OCS.

design program (MITRE uses AutoCAD). Subsequent steps involve using the Master Basemap drawing to formulate, test, and analyze various procedure design options in order to determine feasibility. Additional drawings containing data can be referenced to the Master Basemap as appropriate.

It is important to establish a well-structured drawing layer management system and naming convention for the drawing(s). This helps ensure that once procedures are completed and ready for peer review, all procedure design specialists are consistently using the same information. A comprehensive peer review of the Master Basemap and other associated drawings is accomplished once all the data have been incorporated. Once the procedures have been developed, a thorough and careful peer review is conducted for accuracy and completeness.

ICAO does not publish standards for independent approaches to three runways. Therefore, all procedures were developed in accordance with U.S. TERPS. It is important to mention that Mexico has also used U.S. TERPS for procedure design for many years. Additionally, U.S. Air Traffic Control (ATC) criteria and standards (e.g., turn-on-to-final altitude and communications transfer requirements) were also applied. For aircraft departing the same runway, MITRE followed the ICAO requirement of 1 minute separation between successive departures whose courses diverge by at least 45° since these criteria are used in Mexico today.

Unless noted otherwise, all radials, bearings, and headings are shown in true north, altitudes are shown in ft relative to Mean Sea Level (MSL), coordinates are in World Geodetic System 1984 (WGS84) and distances are in NM. All approach procedures utilized a glideslope (for ILSs)/glidepath (for RNP ARs) angle of 3°.

3.2. Software Tools

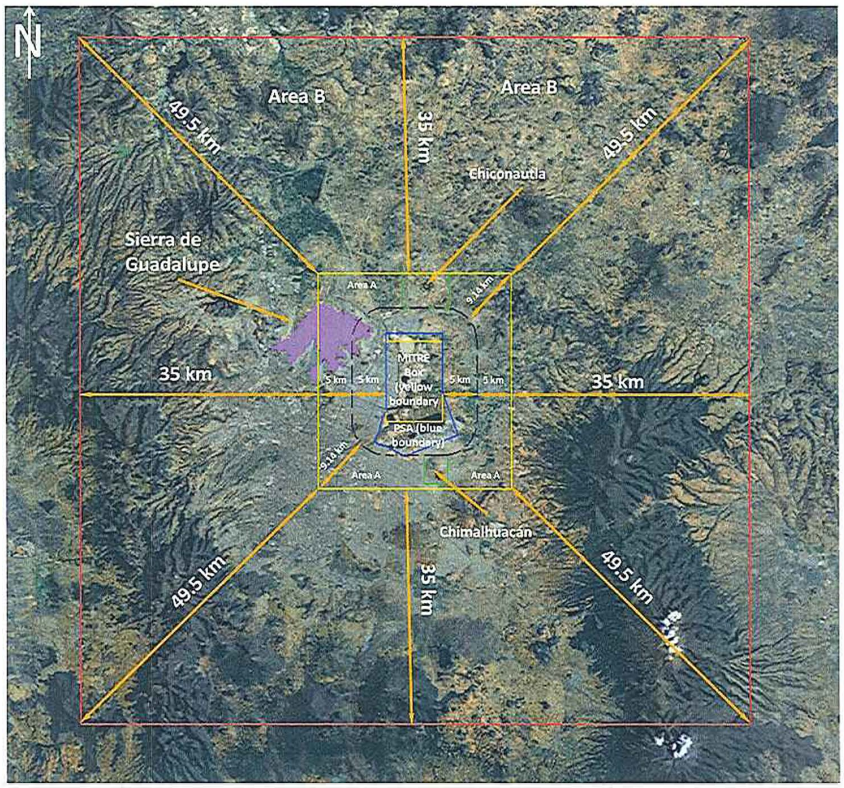
MITRE uses a variety of software applications and other tools when designing procedures, such as AutoCAD, PDToolKit and the MITRE-developed Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS) software.

PDToolKit is MITRE's primary software used to develop and evaluate conventional instrument procedures and conduct obstacle assessments. It makes use of AutoCAD's three-dimensional drawing capabilities and other functionality. TARGETS was developed by MITRE on behalf of the U.S. FAA and was used to develop and evaluate all RNP AR procedures described in this document. Other tools include:

- The U.S. National Geospatial-Intelligence Agency's Geographic Translator, which is used to convert geographic coordinates among a wide variety of coordinate systems, map projections, and datums
- Global Mapper, a Geographical Information System (GIS) program that makes use of vector, raster, and elevation data, and provides viewing, conversion, and other general GIS features
-

3.3. Data

The results of any procedure design are dependent on the currency, accuracy, and completeness of data used to develop the procedure. As mentioned earlier, to ensure that the data used were current, a new satellite-based photogrammetric survey of NAICM and its surroundings was conducted. The survey was completed in late 2014, and includes areas considered by MITRE to be critical in the design of instrument approach and departure procedures and other related activities. Figure 3 shows the areas considered in the survey. It is also important to note that while there are limitations to satellite-based surveys (e.g., difficulty, in some cases, in detecting narrow and/or latticed antennas and towers), there are also significant benefits, such as speed, cost, and the ability to cover very large areas.



Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Figure 3. NAICM 2014 Survey Areas

Where appropriate, MITRE used post-processed 3-arc second (~ 90 m postings) Shuttle Radar Topography Mission (SRTM) data from the Consortium for Spatial Information of the Consultative Group for International Agricultural Research. This post-processed SRTM data have been subjected to a number of steps to provide a seamless and complete digital elevation model for the world. MITRE applied a 16 m vertical accuracy adjustment to SRTM terrain identified as a segment controlling obstacle.

In addition to the survey, the Aeronautical Information Publication of Mexico provided key aeronautical information used in the development of the approach and departure procedures.

3.4. Assumptions

To determine the feasibility of instrument procedures at NAICM, certain assumptions regarding important aeronautical factors were made:

- The existing Mexico City International Airport (AICM) will close once NAICM opens
- The runway at Santa Lucía Military Base will be closed and its fixed-wing aircraft will be relocated. Additionally, all Special Use Airspace (SUA) associated with Santa Lucía, including SUAs located farther away from the base (Mexico Restricted Area [MMR] 101, MMR 102, and MMR 103) need to be eliminated.
- Several prohibited areas are located over and around Mexico City. Many procedures that are required to support operations at NAICM fly in the vicinity of the prohibited areas. These prohibited areas, with the exception of Mexico Prohibited Area (MMP) 11 "Primer Cuadro" and MMP 12 "San Lazaro" only affect Visual Flight Rules operations and, therefore, are not an issue for commercial Instrument Flight Rules (IFR) operations. MITRE was informed by Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) that MMP 11 and MMP 12 are rarely activated (once or twice per year) and, therefore, should not significantly affect future operations. MITRE assumed that the above mentioned situation will remain unchanged.
- The existing Very High Frequency Omnidirectional Range (VOR)/Distance Measuring Equipment (DME) located at existing AICM and at Santa Lucía Military Base will remain in their current locations and continue to operate (even after existing AICM closes and Santa Lucía Military Base is relocated). MITRE must be informed as soon as possible if this assumption is not correct as the absence of these VOR/DMEs will affect MITRE's procedure design work
- An on-airport VOR/DME (denoted as TEX VOR/DME) will be installed. Note that MITRE assumed a VOR/DME between the middle and eastern sets of runways at the southern end. This is a pseudo location and should not be construed to mean that this location meets siting requirements or can provide a full operational service volume. Since the location of the VOR/DME affects procedure design work, the location of the VOR/DME being proposed by aviation officials, Master Planners, or other stakeholders should be coordinated with MITRE.
- Radio, radar, and Navigational Aid (NAVAID) coverage was assumed to be adequate for the proposed use of arrival and departure routes
- Air traffic controllers will use radar vectors as the primary means of navigation to the final approach courses

- All appropriate equipment for a CAT I ILS (e.g., localizer, glideslope, approach lighting system) will be installed as necessary and meet operational requirements. Where appropriate, equipment will be flight-inspected and certified for use beyond normal operating distances (i.e., Expanded Service Volume) to accommodate procedure design.
  - The final approaches for NAICM are very long and exceed normal operating distances of localizer and glideslope equipment by significant amounts. Therefore, MITRE recommends that aviation authorities obtain and install ILS equipment as soon as possible at the NAICM site and conduct pre-commissioning flight inspection activities and other testing of the ILS equipment before runways are constructed to determine with great confidence that the ILS equipment can meet operational signal reception requirements and to examine other technical matters. Other flight inspection activities to identify unknown obstacles or other aircraft operational issues should be investigated at this time as well. See MITRE letter F500-L15-010, *NAICM Category III Instrument Landing System Acquisition Proposal*, dated 31 January 2015.
- Obstacle and terrain data from the 2014 survey took precedence over all other data sources. An Adverse Assumption Obstacle 200 ft Above Ground Level was assumed beyond Area B (see Figure 3).
- Obstacles within the site or under the control of airport authority (e.g., in the vicinity of the proposed runways) that affect instrument procedures will be removed and or modified so as to no longer pose an issue. For example, utility poles in the vicinity of the proposed runways that penetrate certain surfaces associated with the ILS would be removed appropriately. Other examples include trees or other man-made obstructions that are located on or near the planned runways.
- MITRE was informed by Comisión Nacional del Agua that the crane located at the coordinates shown below would be lowered to less than 10 m Above Ground Level:
  - 99 00 45.2W, 19 29 17.7N (based on WGS84)
  - X: 498682.2500, Y: 2154853.1600 (based on Universal Transverse Mercator [UTM], Zone 14 North)
- Several tall antennas and structures are located on top of the Chiconautla hill. MITRE assumed that any antennas and other structures/items (e.g., buildings, utility poles, etc.) on the Chiconautla hill would be removed. Additionally, as previously mentioned, the Chiconautla hill itself penetrates the U.S. TERPS final approach OCS, which is not permitted. Therefore, MITRE assumed that the hill itself would be graded appropriately.
- Future airport facilities (e.g., terminal buildings, aircraft parking stands, aprons, and other airfield components) were not considered. MITRE assumed that future

airport facilities would not impact any airport ICAO OLS, ILS OCS, departure OCS, or impede ILS equipment signals.

- The new combined NAICM/Toluca Minimum Vectoring Altitude Chart (MVAC), (jointly developed by SENEAM and MITRE during a previous project) will be implemented
- The U.S. FAA allows the use of a missed approach CG when the standard missed approach segment surface is penetrated and there is a desire to achieve lower landing minima, meet an air traffic requirement, or accommodate a specific airspace issue. At NAICM, with the exception of approaches to Runway 36L and Runway 36R, all ILS procedures require CGs. Therefore, MITRE assumed that missed approach CGs above standard on ILS procedures will be authorized by the Mexican aeronautical authorities.
- RNP AR procedures will be authorized by the Mexican aeronautical authorities
- Instrument approach and departure procedures to all runway ends were developed based on an assumed runway threshold elevation of 2223 m (7293 ft). This assumed elevation is based on information derived from the original survey completed in 2010, and is a conservative estimate for planning purposes. Raising the runway threshold elevation will have a positive effect on any results. However, if the location of any runways and/or thresholds change in any way MITRE will have to reassess the feasibility of the procedures.

3.5. Precipitous Terrain

Precipitous terrain is generally described as an area of steep or abrupt slopes, which can affect aircraft in flight, especially at lower altitudes. The FAA and ICAO offer different methodologies to determine the existence of precipitous terrain, how to address it when it does exist, and related implications.

In 2004, the FAA provided guidance on how to evaluate an area to determine the existence of precipitous terrain and the actions that must be taken should these conditions exist. This guidance is applicable for all types of procedures to include RNP AR. A key difference between the ILS and RNP AR procedure is that precipitous terrain conditions are not allowed in the final segment of an RNP AR procedure, whereas in the case of the ILS it is allowed but with an adjustment to the Height Above Touchdown (HAT).

This is a key reason why the ILS and RNP AR Precise Final Approach Fix (PFAF) altitudes are different (i.e., the RNP AR final segments were shortened to avoid precipitous terrain conditions). There were other considerations on why the ILS finals could not be shortened. However, for other segments of the ILS and RNP AR approach procedures, precipitous terrain adjustments to the amount of Required Obstacle Clearance (ROC) were made where appropriate.

3.6. Other Key Considerations

In general, instrument approach and departure procedures are not only developed for a specific runway configuration, but also for specific modes of operation. In the case of NAICM, MITRE examined the feasibility of triple independent instrument approach procedures, which will maximize ultimate runway capacity.

Runway configurations intended to support triple independent instrument approach procedures have a number of key procedure design requirements that must be considered. Although not all inclusive, the following requirements figured prominently in the design of instrument approach and departure procedures at NAICM.

- A key U.S. ATC requirement for triple independent instrument approach procedures is that no two aircraft will be assigned the same altitude during turn-on. All three aircraft will be assigned altitudes which differ by a minimum of 1000 ft (e.g., 4000 ft, 5000 ft and 6000 ft).
- Communications transfer to the control tower must be completed prior to losing vertical separation between aircraft
- The missed approach course of all approach procedures must diverge by at least 45°. Generally the left runway missed approach will turn to the left, the middle runway missed approach will be straight ahead and the right missed approach will turn to the right.
- Independent parallel departure courses must diverge by 15° or more immediately after departure. Like the missed approach course, the left runway departure course will turn to the left, the middle runway departure course will be straight ahead and the right departure course will turn to the right.

Wherever possible, MITRE attempted to work within the existing airspace structure by using existing NAVAIDs, airways, fixes, etc. However, as a part of the design, MITRE defined a future VOR/DME (i.e., TEX VOR/DME) at the NAICM site to assist in navigation.

RNP AR procedures are not subject to the limitations or availability of ground-based NAVAIDs or other navigational facilities. However, to provide an integrated and efficient operational terminal environment, all RNP AR procedures were designed to operate simultaneously with their ILS counterparts. Under the planned operational scenario, any combination of ILS and RNP AR approach procedures to the three opening-day runways can be used to conduct triple independent instrument approaches at NAICM.

During a previous study, MITRE discovered that the current MVAC, which depicts the lowest altitudes at which air traffic controllers can radar vector aircraft, would not adequately support the anticipated future instrument procedures at NAICM. Moreover, procedural and airspace changes for Toluca Airport could result in difficulties in the vectoring of traffic between the two airports. Therefore, during a previous project and in close coordination with SENEAM, MITRE developed a new MVAC for a combined

NAICM/Toluca Terminal Maneuvering Area to support future operations. The jointly-developed MVAC was considered in the development of all procedures described in this document.

4. Triple Independent Operations at NAICM

Triple independent operations require, at a minimum, well designed arrival, approach and departure procedures, extensive air traffic controller training, and well defined Standard Operating Procedures (SOPs). Denver International Airport outlines operating rules in their SOPs for conducting triple independent operations that MITRE feels is appropriate for NAICM. Of course other models exist, but Denver's mode of operation provides a straight forward, less complex environment for introducing independent operations in Mexico. Once the Mexican air traffic controllers gain experience handling triple independent operations, they may modify this concept or develop their own SOPs appropriate to their requirements.

At NAICM, all three aircraft will be at three different altitudes separated by at least 1000 ft. Markings and fixes will be displayed on the controller's video map to provide points of reference when conducting independent operations. For example, a hash mark across the extended final approach course of all three finals would indicate the Trips Bar. The Trips Bar marks the location where vertical separation is lost between the three arrival streams. Generally speaking, this is where the highest aircraft would begin descent (that point is established across all three approach courses). In MITRE's operational concept, all aircraft must be established on the final approach course 2 NM prior to the Trips Bar. The 2 NM point prior to the Trips Bar would be named fixes that would provide a reference point for controllers to vector aircraft to the final approach course. Transfer of communications must be accomplished prior to the Trips Bar (i.e., loss of vertical separation). Nominally, MITRE has identified this point as 1 NM prior to the Trips Bar. Figure 4 provides a high-level overview of the concept of northbound operations at NAICM.

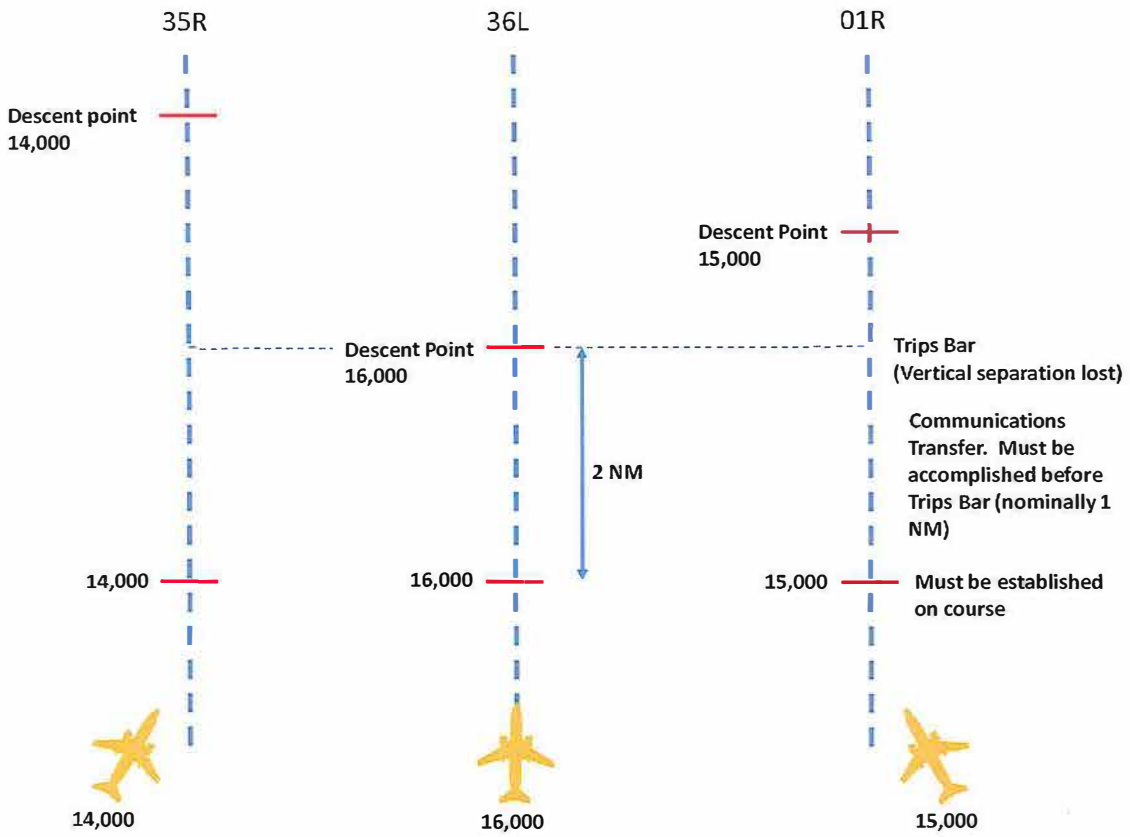


Figure 4. Northbound Triple Independent Approach Concept at NAICM

The operation of triple independent departures requires that their courses must diverge by at least 15° from each other. Furthermore, to take advantage of reduced inter-departure separation, a succeeding aircraft departing from the same runway must diverge at least 45° from the preceding aircraft. Additional information on independent departure procedures can be found in Section 6.

5. CAT I ILS Approach Procedures for NAICM

CAT I ILS approach procedures are a mainstay in the procedure design world. They offer precision capability to very low approach landing minimums. Even as the world transitions to Performance Based Navigation, the ILS approach will continue to be a viable approach option for the foreseeable future. However, there are limitations to these types of procedures, especially when considering triple independent operations, more so considering the terrain environment surrounding the NAICM site.

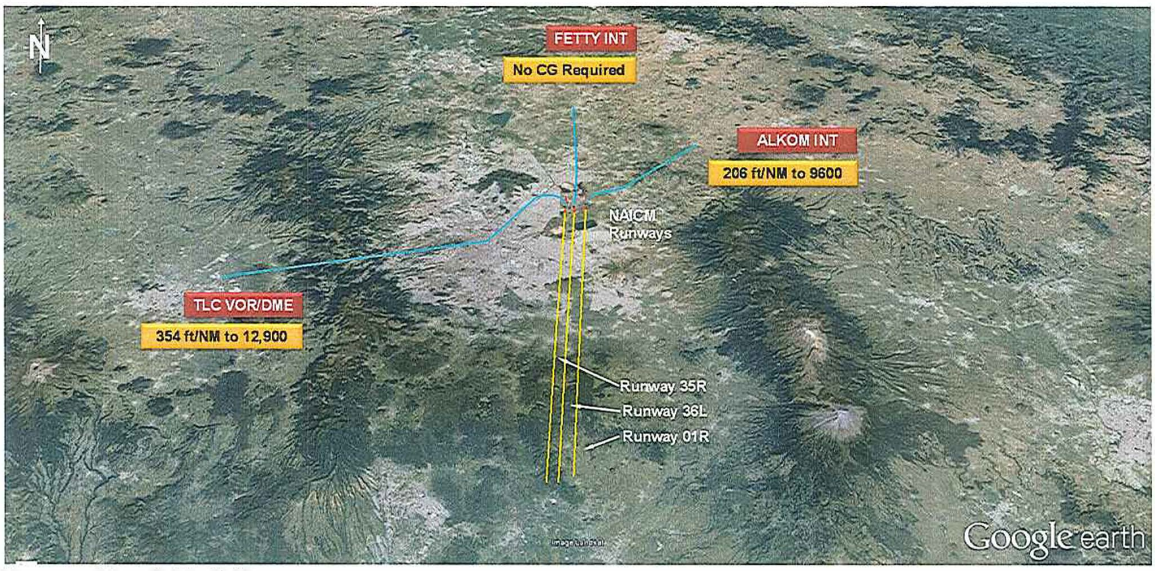
5.1. Updated Assessment of the CAT I ILS Approach Procedures

This section describes the results of MITRE's reassessment of CAT I ILS procedures for the NAICM opening-day runway configuration currently being considered by the aviation authorities of Mexico, which consists of Runways 35R/17L, 36L/18R, and 01R/19L. MITRE is also including an updated assessment of CAT I ILS procedures for

Runway 35L/17R in case authorities decide to include that runway in the opening-day runway configuration instead of Runway 35R/17L. All procedure descriptions are from the Intermediate Fix (IF) to the Missed Approach Point (MAP). Controlling obstacles are identified where appropriate and provided in the tables below. Note that the obstacle heights reflected in the tables include the obstacle raw height plus adjustments (e.g., for accuracy and rounding matters). The same applies for the tables in Sections 6 and 7.

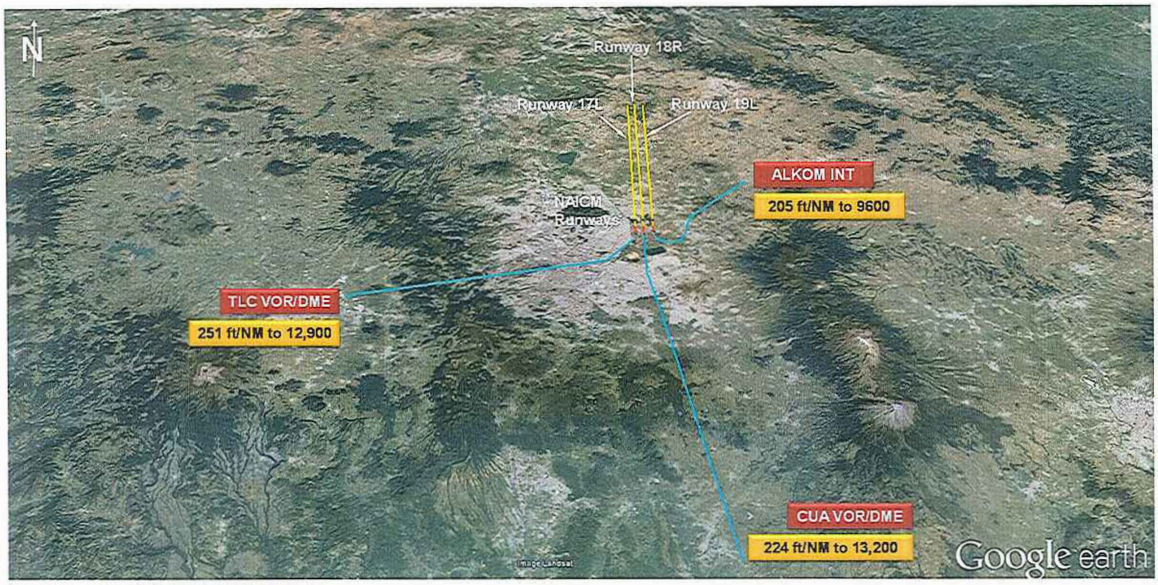
The final segment is a sloping surface and must be free of penetrations. The Glidepath Qualification Surface and visual surfaces are also sloping surfaces. They may be penetrated under certain circumstances, albeit not without some consequences. The missed approach segment is also a sloping surface and may be penetrated if a CG or some other type of mitigation is provided. The same is true for departure surfaces.

Figures 5 and 6 show an overhead view of the CAT I ILS final and missed approach flight tracks for north flow and south flow, respectively, for Runways 35R/17L, 36L/18R, and 01R/19L at NAICM.



Source: GoogleEarth Pro

Figure 5. CAT I ILS Final and Missed Approach Nominal Flight Tracks: <u>North Flow</u>



Source: GoogleEarth Pro

Figure 6. CAT I ILS Final and Missed Approach Nominal Flight Tracks: South Flow

5.1.1. Runway 35R

Intermediate Segment: The IF is located 35.4 DME[2] from the localizer. The IF altitude is at or above 14,000 ft. Precipitous terrain is present so an additional 313 ft adjustment has been applied to the ROC. The proposed vectoring altitude for approach to this runway is 14,000 ft. Crossing restrictions (14,000 ft) have been established 2 NM prior to the Trips Bar (32.7 DME) and at the Trips Bar (30.7 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 13,200 ft (i.e., the PFAF). Since the localizer portion is not included, there is no Final Approach Fix[3]. Precipitous terrain is present so an additional 12 ft adjustment has been applied to the HAT.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 7. A CG is required to achieve the lowest HAT and visibility of 212 ft and 2400 ft (1/2 Statute Mile [sm]), respectively, as shown below in Figure 7.

---

[2] DME are in NM

[3] The intent of MITRE's procedure design work is to demonstrate that CAT I ILS approach procedures are feasibility. Since the CAT I ILS has more critical requirements than the non-precision localizer MITRE used it to demonstrate feasibility.

Controlling obstacles for each segment of the Runway 35R CAT I ILS approach are shown in Table 1.

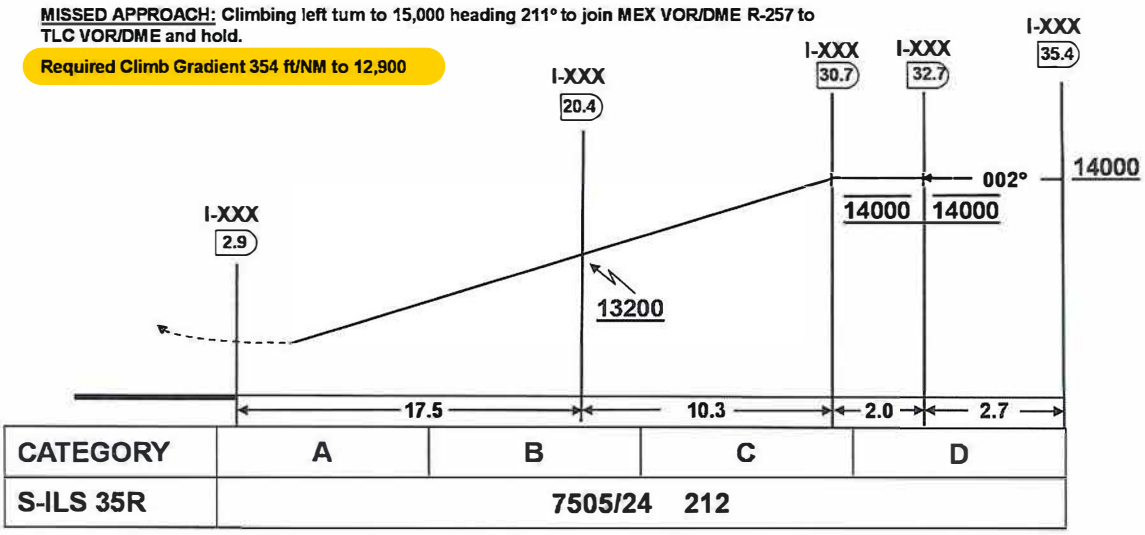


Figure 7. Runway 35R CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 1. Runway 35R CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	19 06 35.53N	99 01 54.16W	12,123
Final	Clear of Obstacles			
Missed Approach	Antenna*	19 32 08.35N	99 07 48.84W	9423
	Antenna**	19 26 27.48N	99 22 19.28W	11,605

Coordinates are based on WGS84
*Missed approach obstacle for CG
**Missed approach obstacle for climb to altitude

5.1.2. Runway 35L (Opening-Day Optional Runway in Lieu of Runway 35R)

Intermediate Segment: The IF is a DME fix located 35.1 DME from the localizer. The IF altitude is at or above 14,000 ft. Precipitous terrain is present so an additional 313 ft adjustment to the ROC has been applied. The proposed vectoring altitude for approach to this runway is 14,000 ft. Crossing restrictions (14,000 ft) have been established 2 NM prior to the Trips Bar (32.5 DME) and at the Trips Bar (30.5 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 13,200 ft (i.e., the PFAF). Precipitous terrain is present so an additional 12 ft adjustment to the HAT has been applied.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 8. A CG is required to achieve the lowest HAT and visibility of 212 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 8.

Segment controlling obstacles are shown in Table 2.

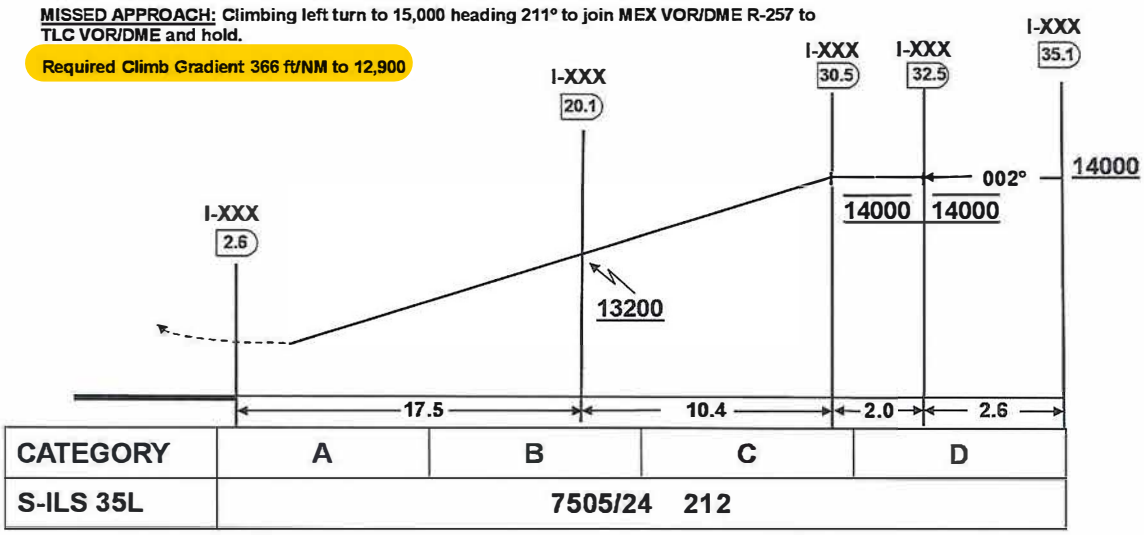


Figure 8. Runway 35L CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 2. Runway 35L CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	19 06 35.53N	99 01 54.16W	12,123
Final	Clear of Obstacles			
Missed Approach	Antenna*	19 32 08.35N	99 07 48.84W	9423
	Antenna**	19 26 27.48N	99 22 19.28W	11,605

Coordinates are based on WGS84
*Missed approach obstacle for CG
**Missed approach obstacle for climb to altitude

5.1.3. Runway 36L

Intermediate Segment: The IF is located 35.4 DME from the localizer. The IF altitude is at or above 16,000 ft. Precipitous terrain is present so an additional 313 ft

adjustment has been applied to the ROC. The proposed vectoring altitude for approach to this runway is 16,000 ft. Crossing restrictions (16,000 ft) have been established 2 NM prior to the Trips Bar (32.7 DME) and at the Trips Bar (30.7 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 13,200 ft (i.e., the PFAF). Precipitous terrain is present so an additional 12 ft adjustment has been applied to the HAT.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 9. No CG is required to achieve the lowest HAT and visibility of 212 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 9.

Segment controlling obstacles are shown in Table 3.

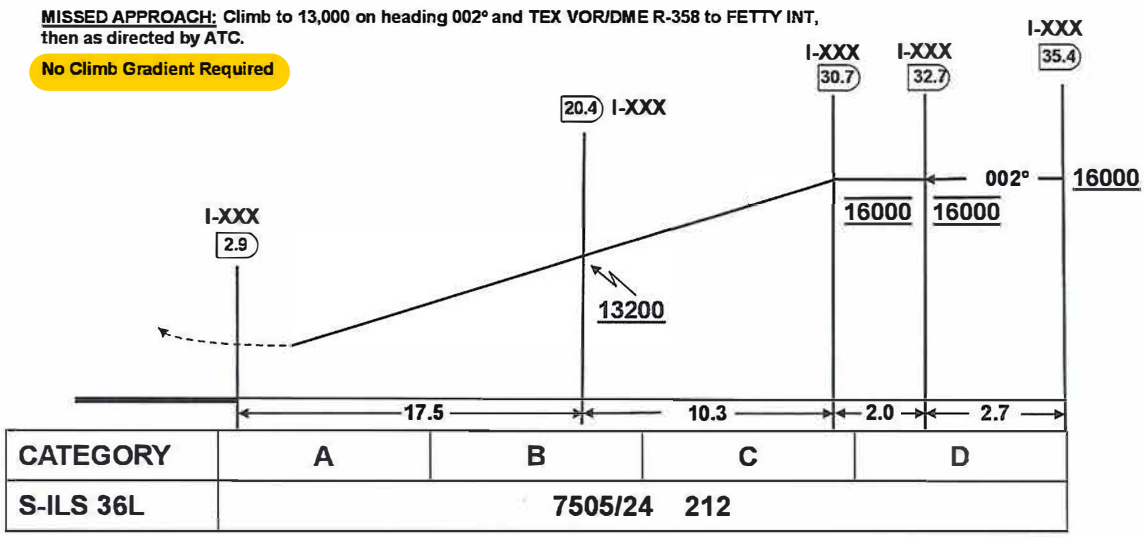


Figure 9. Runway 36L CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 3. Runway 36L CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	19 06 35.53N	99 01 54.16W	12,123
Final	Clear of Obstacles			
Missed Approach	Clear of Obstacles			

Coordinates are based on WGS84

5.1.4. Runway 01R

Intermediate Segment: The IF is located 35.1 DME from the localizer. The IF altitude is at or above 15,000 ft. Precipitous terrain is present so an additional 313 ft adjustment has been applied to the ROC. The proposed vectoring altitude for approaches to this runway is 15,000 ft. Crossing restrictions (15,000 ft) have been established 2 NM prior to the Trips Bar (32.9 DME) and at the Trips Bar (30.9 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 13,200 ft (i.e., the PFAF). Precipitous terrain is present so an additional 9 ft adjustment has been applied to the HAT.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 10. A CG is required to achieve the lowest HAT and visibility of 209 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 10.

Segment controlling obstacles are shown in Table 4.

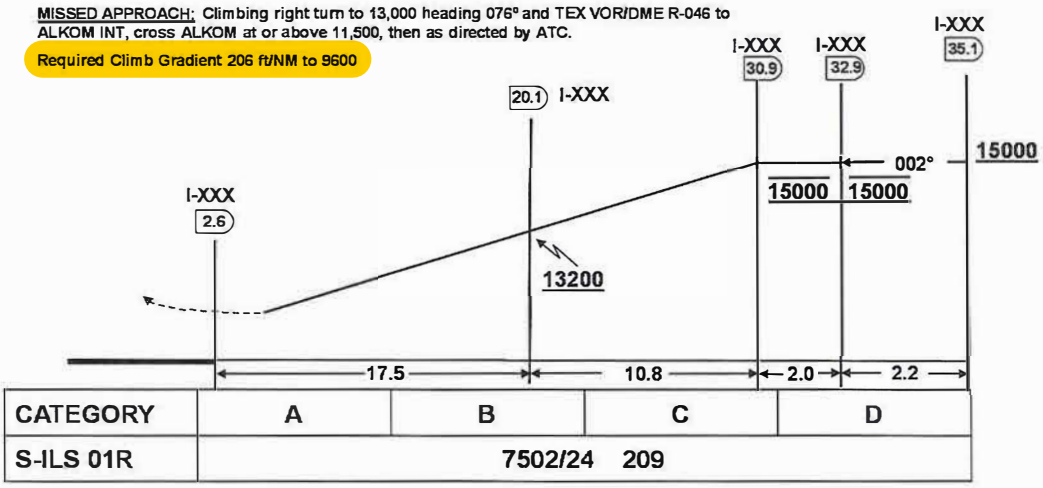


Figure 10. Runway 01R CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 4. Runway 01R CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	19 06 35.53N	99 01 54.16W	12,123
Final	Clear of Obstacles			
Missed Approach	Terrain	19 38 02.02N	98 50 29.23W	9072

Coordinates are based on WGS84

5.1.5. Runway 17L

Intermediate Segment: The IF is located 30.5 DME from the localizer. The IF altitude is 13,000 ft. Precipitous terrain is present so an additional 84 ft adjustment has been applied to the ROC. The proposed vectoring altitude for approaches to this runway is 12,500 ft. Crossing restrictions (12,500 ft) have been established 2 NM prior to the Trips Bar (24.5 DME) and at the Trips Bar (22.5 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 11,500 ft (i.e., the PFAF). Precipitous terrain is not present in the final segment.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 11. A CG is required to achieve the lowest HAT and visibility of 200 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 11.

Segment controlling obstacles are shown in Table 5.

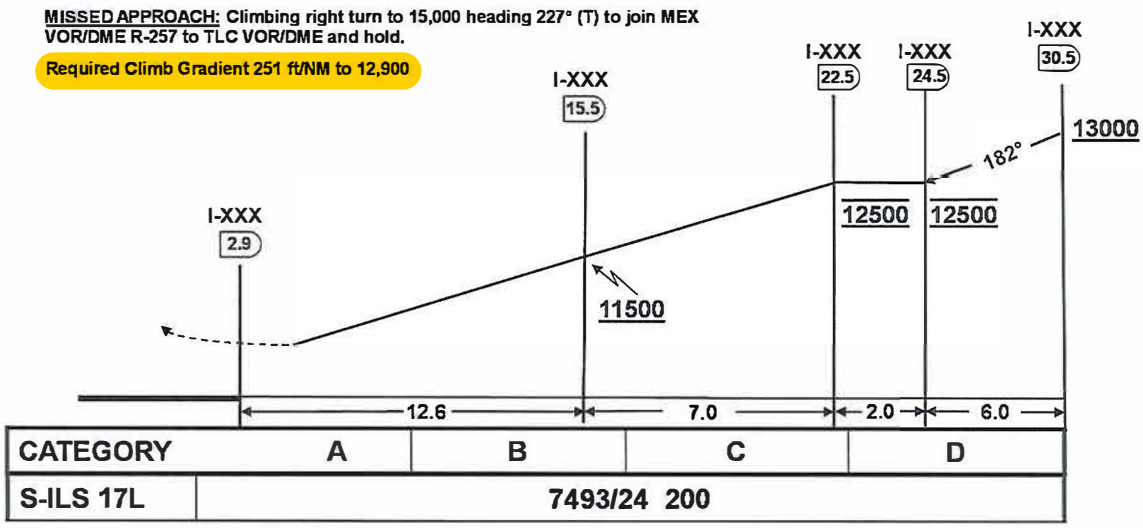


Figure 11. Runway 17L CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 5. Runway 17L CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	20 01 02.26N	99 03 58.85W	9892
Final	Clear of Obstacles			
Missed Approach	Antenna	19 26 27.48N	99 22 19.28W	11,605

Coordinates are based on WGS84

5.1.6. Runway 17R (Opening-Day Optional Runway in Lieu of Runway 17L)

Intermediate Segment: The IF is located 30.2 DME from the localizer. The IF altitude is 13,000 ft. Precipitous terrain is present so an additional 83 ft adjustment to the ROC has been applied. The proposed vectoring altitude for approaches to this runway is 12,500 ft. Crossing restrictions (12,500 ft) have been established 2 NM prior to the Trips Bar (24.0 DME) and at the Trips Bar (22.0 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 11,500 ft (i.e., the PFAF). Precipitous terrain is not present in the final segment.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 12. A CG is required to achieve the lowest HAT and visibility of 200 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 12.

Segment controlling obstacles are shown in Table 6.

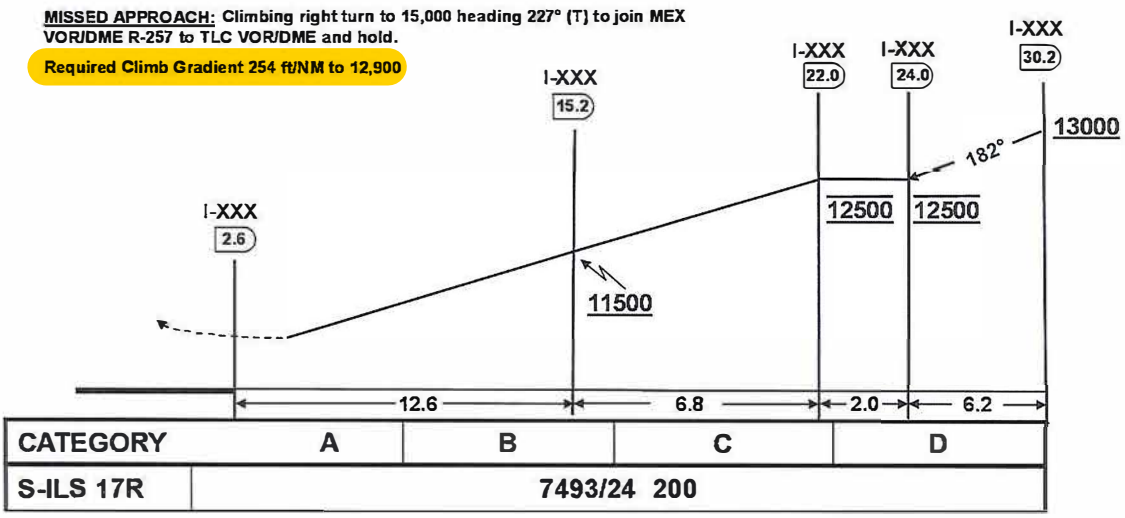


Figure 12. Runway 17R CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 6. Runway 17R CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	20 01 02.26N	99 03 58.85W	9892
Final	Clear of Obstacles			
Missed Approach	Antenna	19 26 27.48N	99 22 19.28W	11,605

Coordinates are based on WGS84

5.1.7. Runway 18R

Intermediate Segment: The IF is located 30.3 DME from the localizer. The IF altitude is 14,000 ft. Precipitous terrain is present so an additional 85 ft adjustment has been applied to the ROC. The proposed vectoring altitude for approaches to this runway is 13,500 ft. Crossing restrictions (13,500 ft) have been established 2 NM prior to the Trips Bar (24.3 DME) and at the Trips Bar (22.3 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 11,500 ft (i.e., the PFAF). Precipitous terrain is not present in the final segment.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 13. A CG is required to achieve the lowest HAT and visibility of 200 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 13.

Segment controlling obstacles are shown in Table 7.

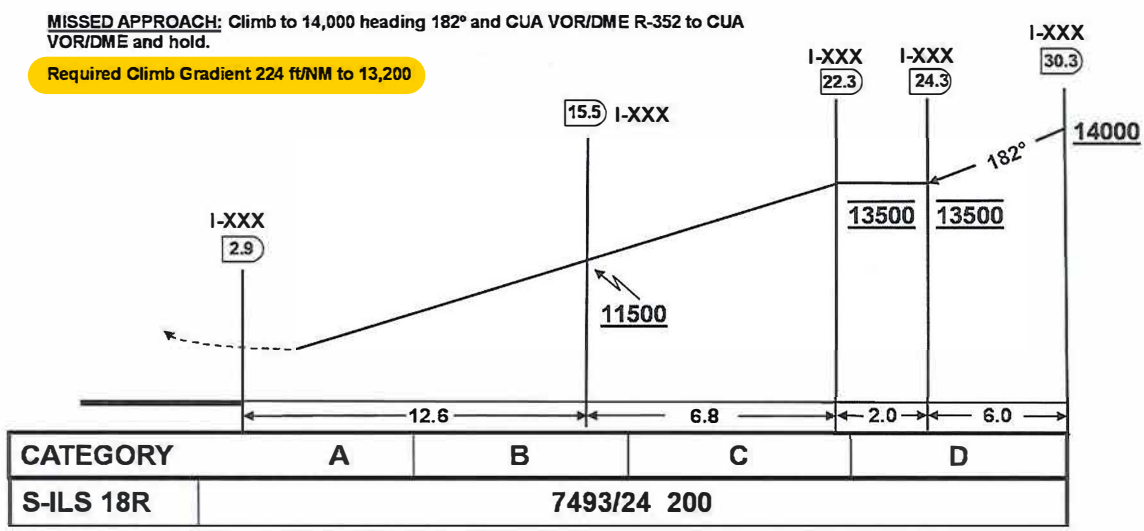


Figure 13. Runway 18R Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 7. Runway 18R Controlling Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	20 00 10.95N	98 55 55.84W	9597
Final	Clear of Obstacles			
Missed Approach	Terrain	19 06 35.53N	99 01 54.16W	12,123

Coordinates are based on WGS84

5.1.8. Runway 19L

The antennas located on top of Chiconautla penetrate the ILS final segment surfaces for both Runways 19L and 19R by approximately 62.78 m (205.98 ft)[4]. However, MITRE assumed that the antennas would be removed. Using terrain alone, MITRE determined that Chiconautla penetrates the ILS surface by 26.64 m (87.43 ft). Note that MITRE letter F500-L15-018, *Technical Letter—Parametric Analysis of Runway Threshold Elevations (REVISION)*, dated 26 March 2015 stated the greatest amount of penetration by Chiconautla (terrain only) was 19.1 m (62.66 ft). The reason for the difference is that in procedure design a single terrain point is identified as the segment controlling obstacle, in this case a terrain spot elevation of 2590 m (8497.37 ft). A vertical accuracy (3 m / 9.84 ft) was then applied to determine an overall elevation of 2593 m (8507.21 ft). The parametric analysis used a generalized contoured landform digital elevation model, which did not include spot elevations nor were any vertical accuracies applied. Again, MITRE assumed that the hill would be graded in such as a manner as to no longer be a penetration to the ILS final approach segments for either Runway 19L or 19R. These are important considerations and the appropriate authorities will have to make critical decisions on the grading of hill and to what extent.

It is important to note that the impact of terrain penetrations, may, in some cases, be mitigated and/or alleviated through measures such as modification of runway lengths, displacement of thresholds, and other means. However, these measures need to be carefully considered with the airlines and various other stakeholders to ensure a safe and efficient operational environment for arriving and departing aircraft.

Intermediate Segment: The IF is located 30.0 DME from the localizer. The IF altitude is 12,000 ft. Precipitous terrain is present so an additional 86 ft adjustment has been applied to the ROC. The proposed vectoring altitude for approaches to this runway is 11,500 ft. Crossing restrictions (11,500 ft) have been established 2 NM prior to the Trips Bar (23.8 DME) and at the Trips Bar (21.8 DME). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The glideslope intercept altitude is 11,500 ft (i.e., the PFAF). Precipitous terrain is not present in the final segment.

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 14. A CG is required to achieve the lowest HAT and visibility of 200 ft and 2400 ft (1/2 sm), respectively, as shown below in Figure 14.

Segment controlling obstacles are shown in Table 8.

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[4] MITRE assumed a runway elevation of 2223 m (7293 ft), a runway displacement of 427 m (1401 ft) and a 3° glidepath angle. Changes to any of these parameters will affect penetration values.

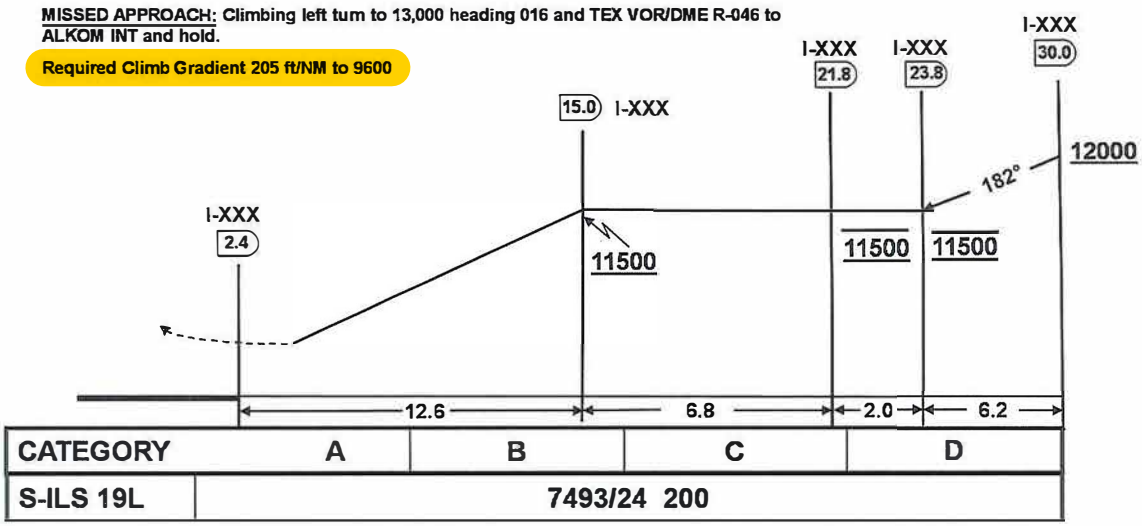


Figure 14. Runway 19L CAT I ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 8. Runway 19L CAT I ILS: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate	Terrain	20 00 10.95N	98 55 55.84W	9597
Final	Clear of Obstacles			
Missed Approach	Terrain	19 38 02.02N	98 50 29.23W	9072

Coordinates are based on WGS84

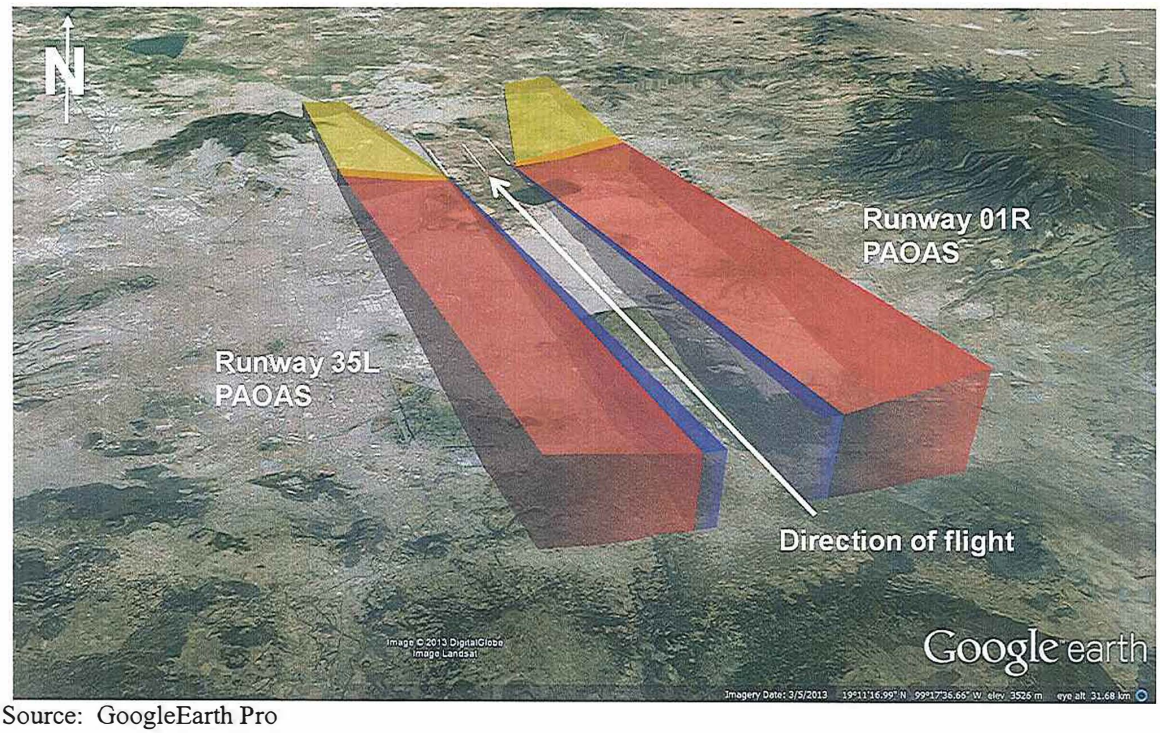
5.1.9. Parallel Approach Obstruction Assessment Surfaces

A Parallel Approach Obstruction Assessment (PAOA) must be accomplished before independent parallel operations can be conducted. The purpose of the PAOA is to ensure an obstacle-free path for an aircraft on final approach that needs to conduct an evasive maneuver (typically a command to turn and climb) to avoid another aircraft on final approach to an adjacent runway that blunders into its path. The Parallel Approach Obstruction Assessment Surfaces (PAOAS) were applied to all runways.

The PAOAS extend laterally from the final approach course sloping upward at 11:1. Further application is not required when the 11:1 surface reaches a height of 303 m (1000 ft) below the minimum vectoring altitude, minimum safe altitude or minimum obstruction clearance altitude. This would have resulted in the surface terminating before

encompassing the highest areas of Sierra de Guadalupe. Figure 15 shows the PAOAS for Runways 35R[5] and 01R. Figure 16 shows the PAOAS for Runways 17L and 19L.

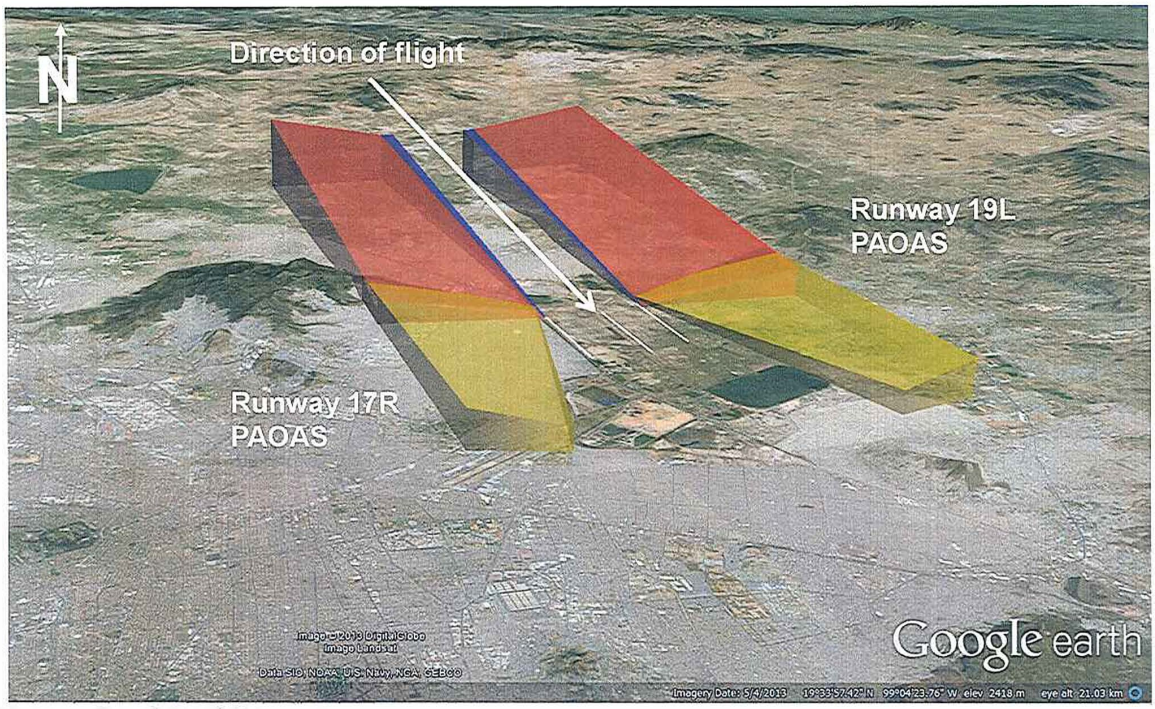
While not reflected in Figure 15 and Figure 16, MITRE extended the PAOAS for Runway 35R/17L and Runway 35L/17R to the western side of Sierra de Guadalupe to ensure that the mountain, including the antennas on its peaks, did not penetrate the surfaces.



Source: GoogleEarth Pro

Figure 15. PAOAS for Runways 35R and 01R

[5] MITRE also evaluated the PAOAS for Runways 35L/17R (as MITRE recommends that this runway be included in the opening-day configuration) and determined that these PAOAS were also clear of any obstacle penetrations, even after extending the surfaces to the west of Sierra de Guadalupe.



Source: GoogleEarth Pro

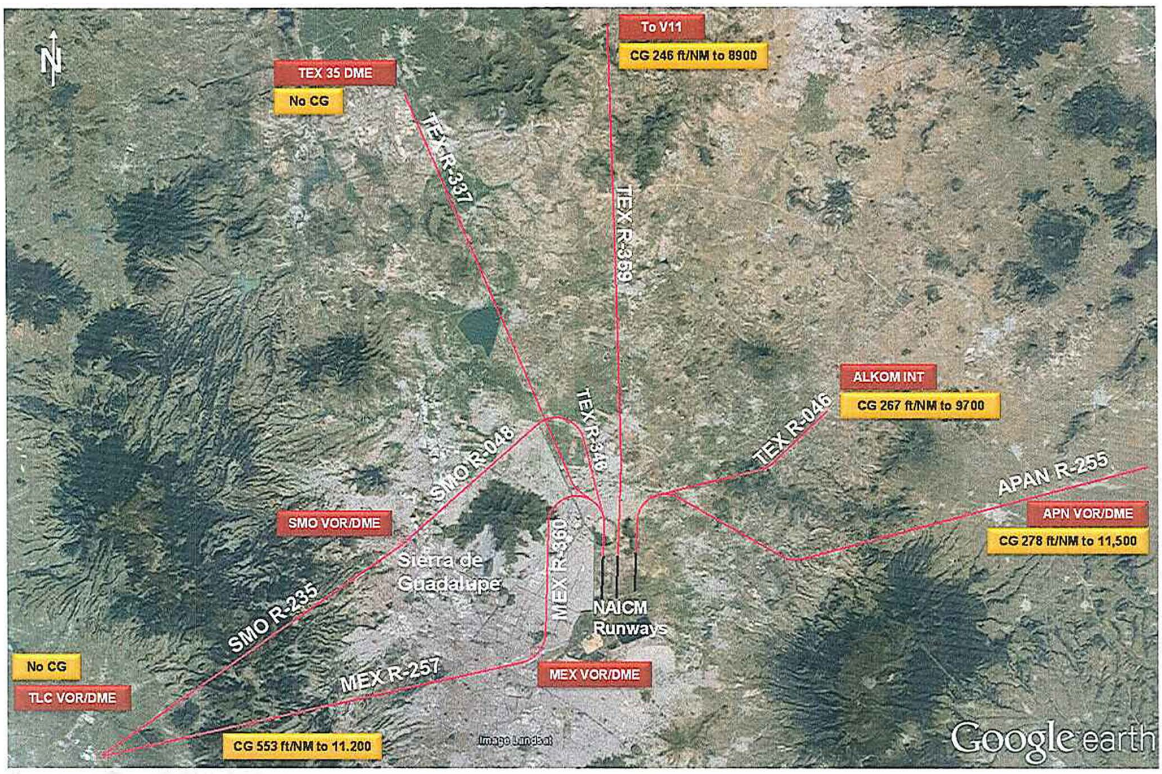
Figure 16. PAOAS for Runways 17L and 19L

6. Independent Parallel Departure Procedures

All conventional departure procedures were reassessed based on the 2014 survey data. Figures 17 and 18 show the nominal flight tracks for the NAICM opening-day runways: 35R/17L, 36L/18R, and 01R/19L. MITRE is also including an updated assessment of departure procedures for Runway 35L/17R in case authorities decide to include that runway in the opening-day runway configuration instead of Runway 35R/17L.

Runways 35L/R has three departure options each. All other runways, except Runways 36L/18R, have two departure options. Runways 36L/18R each have one straight departure route.

The following paragraphs provide information pertaining to each departure from each runway end to include takeoff minimums, departure instructions and CGs.



Source: GoogleEarth Pro

Figure 17. Departure Nominal Flight Tracks: North Flow

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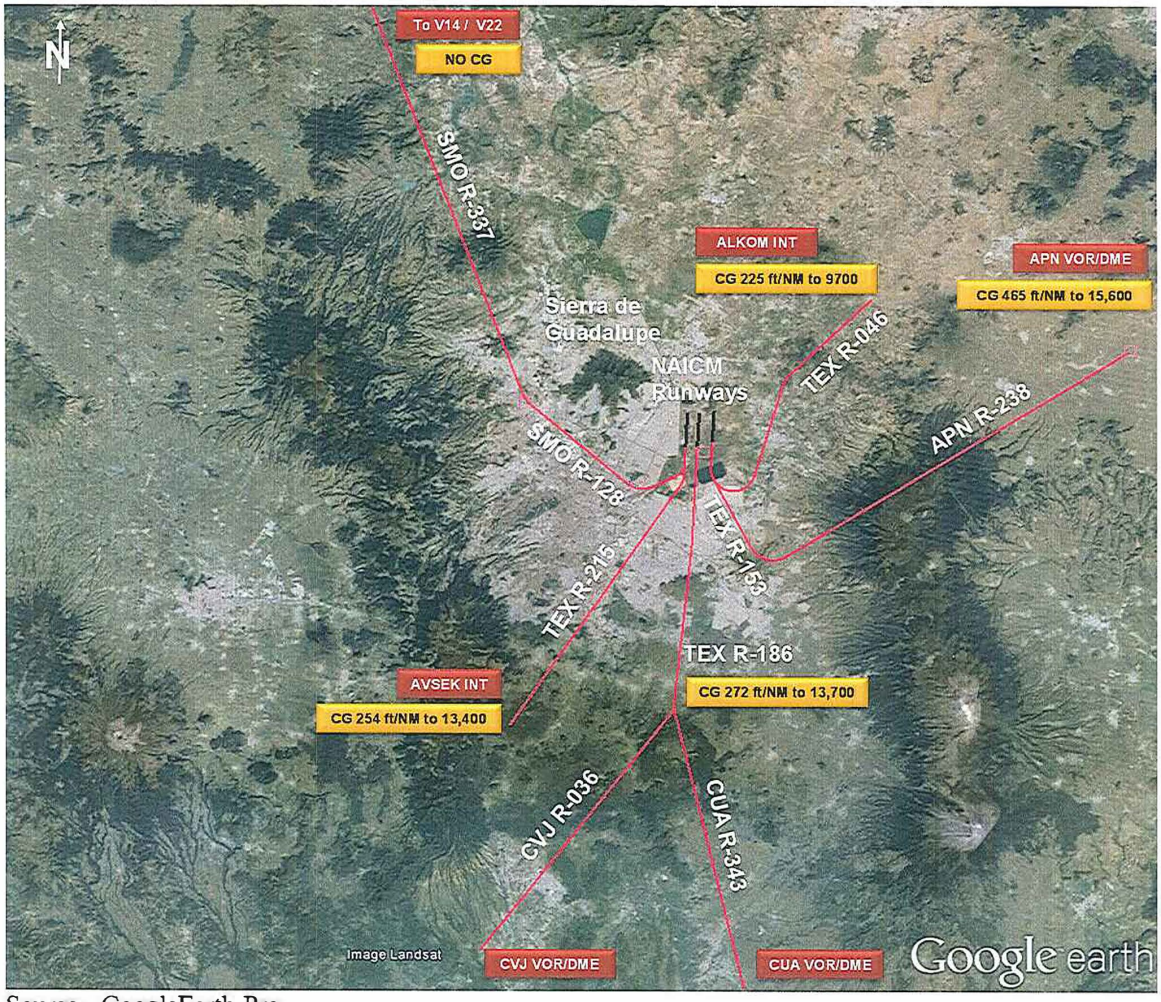


Source: GoogleEarth Pro

Figure 18. Departure Nominal Flight Tracks: South Flow

6.1. Runway 35R

There are three proposed departure procedures from Runway 35R:

1. A hard left turn to the TLC VOR/DME
2. A left turn around the north side of Sierra de Guadalupe then turning southwest to the TLC VOR/DME
3. A left turn to the northwest proceeding to TEX R-337/35 DME

Information for departures from Runway 35R is provided below. See Table 9 for CG obstacle information.

6.1.1. TLC Departure (Hard Left Turn)

Takeoff Minimums: Standard with a minimum CG of 553 ft/NM[6] to 11,200 ft.

Departure Instructions: Climbing left turn to intercept MEX VOR/DME R-360 to MEX VOR/DME to 13,000 ft, then direct TLC VOR/DME via MEX VOR/DME R-257, then on course.

6.1.2. TLC Departure (Left Turn to the North Side of Sierra de Guadalupe)

Takeoff Minimums: Standard

Departure Instructions: Climbing left turn to intercept TEX VOR/DME R-346 to 15,000 ft, intercept SMO VOR/DME R-048 to SMO VOR/DME, then direct TLC VOR/DME via SMO VOR/DME R-235, then on course.

6.1.3. Northwest Departure

Takeoff Minimums: Standard

Departure Instructions: Climbing left turn to intercept TEX VOR/DME R-337 to TEX VOR 35 DME to 13,000 ft, then as assigned by ATC.

Table 9. Runway 35R Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
TLC VOR/DME	553 ft/NM to 11,200	Antenna	19 35 28.87N	99 06 56.26W	10,203
TLC VOR/DME	Standard*	Clear of obstacles			
TEX VOR/DME R-337/35	Standard*	Clear of obstacles			

Coordinates are based on WGS84
*If takeoff weather minimums are not prescribed, FAA weather minimums for takeoffs under IFR are 1 sm (fixed-wing with two or fewer engines) or ½ sm (more than two engines).

6.2. Runway 35L (Opening-Day Optional Runway in Lieu of Runway 35R)

The departure procedures for Runway 35L are similar to the departures for Runway 35R described above. Information on each of the Runway 35L departure procedures is provided below. See Table 10 for CG obstacle information.

[6] In the U.S., climb gradients in excess of 500 ft/NM require approval from an approving authority.

6.2.1. TLC Departure (Hard Left Turn)

Takeoff Minimums: Standard with a minimum CG of 564 ft/NM[7] to 11,200 ft.

Departure Instructions: Climbing left turn to intercept the MEX VOR/DME R-360 to MEX VOR/DME to 13,000 ft, then direct TLC VOR/DME via MEX VOR/DME R-257, then on course.

6.2.2. TLC Departure (Left Turn to North Side of Sierra de Guadalupe)

Takeoff Minimums: Standard

Departure Instructions: Climbing left turn to intercept TEX VOR/DME R-343 to 15,000 ft, intercept SMO VOR/DME R-048 to SMO VOR/DME, then direct TLC VOR/DME via SMO VOR/DME R-235, then on course.

6.2.3. TLC Departure (Northwest)

Takeoff Minimums: Standard

Departure Instructions: Climbing left turn to intercept TEX VOR/DME R-337 to TEX VOR/DME 35 DME to 13,000 ft, then as assigned by ATC.

Table 10. Runway 35L Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
TLC VOR/DME	564 ft/NM to 11,200	Antenna	19 35 28.87N	99 06 56.26W	10,203
TLC VOR/DME	Standard*	Clear of obstacles			
TEX VOR/DME R-337/35	Standard*	Clear of obstacles			

Coordinates are based on WGS84
*If takeoff weather minimums are not prescribed, FAA weather minimums for takeoffs under IFR are 1 sm (fixed-wing with two or fewer engines) or ½ sm (more than two engines).

6.3. Runway 36L

There is one proposed departure procedure from Runway 36L that goes straight ahead. Information on the Runway 36L departure procedure is provided below. See Table 11 for CG obstacle information.

Takeoff Minimums: Standard with a minimum CG of 246 ft/NM to 8900 ft.

[7] In the U.S., climb gradients in excess of 500 ft/NM require approval from an approving authority.

Departure Instructions: Climb heading 002° to 13,000 ft, intercept TEX VOR/DME R-359 to join V11, then on course.

Table 11. Runway 36L Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
TEX VOR/DME R-359 to V11	246 ft/NM to 8900	Terrain (Spot Elevation)	19 39 08.91N	98 58 03.68W	8510

Coordinates are based on WGS84

6.4. Runway 01R

There are two proposed departure procedures from Runway 01R:

1. A right turn to the ALKOM Intersection (INT)
2. A right turn to the APN VOR/DME

Information on the Runway 01R departure procedures is provided below. See Table 12 for CG obstacle information.

6.4.1. ALKOM

Takeoff Minimums: Standard with a minimum CG of 267 ft/NM to 9700 ft.

Departure Instructions: Climbing right turn to intercept TEX VOR/DME R-046 to ALKOM INT to 13,000 ft, then on course.

6.4.2. APN VOR/DME

Takeoff Minimums: Standard with a minimum CG of 278 ft/NM to 11,500 ft.

Departure Instructions: Climbing right turn to intercept APN VOR/DME R-255 to APN VOR/DME to 14,000 ft, then on course.

Table 12. Runway 01R Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
AKLOM INT	267 ft/NM to 9700	Terrain	19 38 02.02N	98 50 29.23W	9072
APN VOR/DME	278 ft/NM to 11,500	Terrain	19 32 46.31N	98 42 09.79W	10,449

Coordinates are based on WGS84

6.5. Runway 17L

There are two proposed departure procedures from Runway 17L:

1. A right turn to SMO VOR/DME, then V14/V22
2. A right turn proceeding to the AVSEK INT

Information on the Runway 17L departure procedures is provided below. See Table 13 for CG obstacle information.

6.5.1. SMO to V14/V22

Takeoff Minimums: Standard.

Departure Instructions: Climbing right turn direct MEX VOR/DME to 13,000 ft, then direct SMO VOR/DME via SMO VOR R-128, then SMO VOR R-337 to join V14/22, then on course.

6.5.2. AVSEK INT

Takeoff Minimums: Standard with a minimum CG of 254 ft/NM to 13,400 ft.

Departure Instructions: Climb heading 182° to intercept TEX VOR/DME R-215 to AVSEK INT, to 15,000 ft, then as assigned by ATC.

Table 13. Runway 17L Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
SMO (V14/V22)	Standard*	Clear of obstacles			
AVSEK	254 ft/NM to 13,400	Terrain	19 09 10.62N	99 13 01.22W	11,893

Coordinates are based on WGS84
*If takeoff weather minimums are not prescribed, weather minimums for takeoffs under IFR are 1 sm (fixed-wing with two or fewer engines) or ½ sm (more than two engines).

6.6. Runway 17R (Opening-Day Optional Runway in Lieu of Runway 17L)

The departure procedures for Runway 17R are similar to the departures for Runway 17L described above. Information on each of the Runway 17R departure procedures is provided below. See Table 14 for CG obstacle information.

6.6.1. SMO to V14/V22

Takeoff Minimums: Standard.

Departure Instructions: Climbing right turn direct MEX VOR/DME to 13,000 ft, then direct SMO VOR/DME via SMO VOR/DME R-128, then SMO VOR/DME R-337 to join V14/22, then on course.

6.6.2. AVSEK INT

Takeoff Minimums: Standard with a minimum CG of 254 ft/NM to 13,400 ft.

Departure Instructions: Climb heading 182° to intercept TEX VOR/DME R-215 to AVSEK INT, to 15,000 ft, then as assigned by ATC.

Table 14. Runway 17R Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
SMO (V14/V22)	Standard*	Clear of obstacles			
AVSEK	254 ft/NM to 13,400	Terrain	19 09 10.62N	99 13 01.22W	11,893

Coordinates are based on WGS84
*If takeoff weather minimums are not prescribed, FAA weather minimums for takeoffs under IFR are 1 sm (fixed-wing with two or fewer engines) or ½ sm (more than two engines).

6.7. Runway 18R

There is one proposed departure procedure from Runway 18R that goes straight ahead. Information on the Runway 18R departure procedure is provided below. Note that the departure procedure has two transitions. See Table 15 for CG obstacle information.

Takeoff Minimums: Standard with a minimum CG of 272 ft/NM to 13,700 ft.

Departure Instructions: Climb heading 182° to 15,000 ft and intercept the TEX VOR/DME R-186 to 20 DME, thence… (i.e., to one of the two transitions described below).

CVJ TRANSITION: Intercept the CVJ VOR/DME R-036 to the CVJ VOR/DME, then on course.

CUA TRANSITION: Intercept the CUA VOR/DME R-343 to the CUA VOR/DME, then on course.

Table 15. Runway 18R Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
CVJ VOR/DME	272 ft/NM to 13,700	Terrain	19 06 38.19N	99 01 52.68W	12,122
CUA VOR/DME	272 ft/NM to 13,700	Terrain	19 06 38.19N	99 01 52.68W	12,122

Coordinates are based on WGS84

6.8. Runway 19L

There are two proposed departure procedures from Runway 19L:

1. A left turn to the ALKOM INT
2. A left turn to the APN VOR/DME

Information on the Runway 19L departure procedures is provided below. See Table 16 for CG obstacle information.

6.8.1. ALKOM

Takeoff Minimums: Standard with a minimum CG of 225 ft/NM to 9700 ft.

Departure Instructions: Climbing left turn to intercept TEX VOR/DME R-046 to ALKOM INT to 13,000 ft, then on course.

6.8.2. APAN

Takeoff Minimums: Standard with a minimum CG of 465 ft/NM to 15,600 ft.

Departure Instructions: Climbing left turn to intercept the TEX VOR/DME R-153 to 15,600 ft, intercept the APN VOR/DME R-238 to APN, then on course.

Table 16. Runway 19L Climb Gradient Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
AKLOM INT	225 ft/NM to 9700	Terrain	19 38 02.02N	98 50 29.23W	9072
APN VOR/DME	465 ft/NM to 15,600	Terrain	19 24 45.52N	98 42 43.67W	13,599

Coordinates are based on WGS84

7. RNP AR Procedures for NAICM

This section describes the results of MITRE's reassessment of RNP AR procedures for the NAICM opening-day runway configuration currently being considered by the aviation authorities of Mexico, which consists of Runways 35R/17L, 36L/18R, and 01R/19L. MITRE is also including an updated assessment of RNP AR procedures for Runway 35L/17R in case authorities decide to include that runway in the opening-day runway configuration instead of Runway 35R/17L.

RNP AR procedures can offer many advantages over conventional procedures, such as curved segments, narrower Obstacle Evaluation Areas (OEAs), and the ability to better optimize and de-conflict arrival and departure flows. It is important to note that RNP AR OEAs run parallel to the flight track and are narrower than the OEAs of the conventional ILS initial and intermediate segments and portions of the final segment. This can be very beneficial far away from the airport. However, the RNP AR OEAs do not taper inward as they approach the runway like the areas of a conventional ILS procedure. This means that it is more likely that RNP AR OEAs fall outside the bounds of the airport close in and, more importantly, potentially lie outside the control of the airport authority, making the control of obstacles more difficult. The satellite-based photogrammetric survey identified some obstacles close to the airport that affected some RNP AR landing minimums.

Other issues specific to RNP AR procedures are that aircraft must be appropriately equipped, pilots must be properly trained and certified, and policies and procedures (e.g., government, airline, ATC) must be established and implemented. RNP procedures denote the level of performance in the name. For instance, RNP 0.3 means that the aircraft's navigation system is able to calculate its position within 3 tenths of a NM with a 95% probability.

Standard RNP AR criteria require less equipage and fewer training requirements than for procedures developed using non-standard criteria. In the design of the missed approach procedures, criteria for triple independent procedures dictate that aircraft diverge by 45° from missed approach tracks from an adjacent parallel runway. The divergence should occur as soon as possible after reaching at least 400 ft above the touchdown elevation. However, this is not feasible with the standard RNP missed approach criteria (i.e., RNP value of 1), which requires the aircraft to fly straight ahead for 5.22 NM before commencing a turn. Therefore, all outer runways (35R/17L or 35L/17R, and 01R/19L) were developed using a less than standard RNP value for the missed approach. This requirement makes it necessary to have additional on-board equipment. See Table 17.

Table 17. RNP AR Missed Approach Equipment Values

Key Equipment Differences Between RNP AR Missed Approaches		
Equipment	**Missed Approach Value**	
	RNP 1	**RNP < 1**
Global Navigation Satellite System	Single	Dual
Flight Management System	Single	Dual
Air Data System	Single	Dual
Autopilot	Single	Dual
Internal Reference Unit	Single	Dual (Tightly Coupled)

Source: FAA Advisory Circular 90-101A, 23 February 2011

Since the middle runway's missed approach must be straight ahead, they were designed with a standard RNP value of 1. This allows for those aircraft not meeting the additional equipage requirements to utilize the center runway.

It is important to mention that lower RNP values could be applied at NAICM that may allow for lower minima. However, the use of procedures with lower RNP values could reduce the percentage of aircraft that could utilize those procedures due to equipage and training requirements.

Note that distances in the profile view figures shown below are from the threshold and not the localizer. MAP distances for 17L and 17R are for RNP 0.3. The following sections provide additional information on the NAICM RNP AR procedures and updated findings based on the 2014 survey data.

7.1. Runway 35R

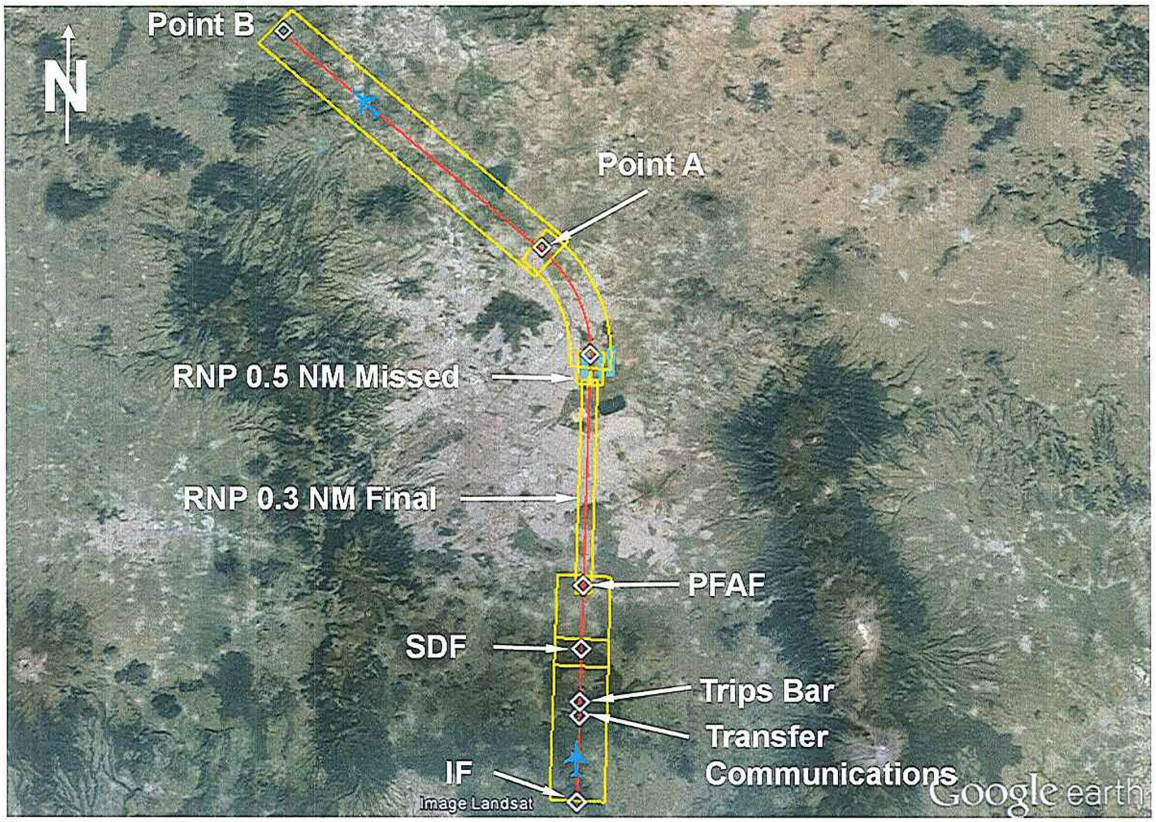
Figures 19 and 20 show an overhead and profile view, respectively, of the Runway 35R RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 18.

Intermediate Segment: The IF is located 32.5 NM from the threshold. The IF altitude is 14,000 ft. The proposed vectoring altitude for approaches to this runway is 14,000 ft. Crossing restrictions (14,000 ft) have been established 2 NM prior to the Trips Bar (29.8) and at the Trips Bar (27.8). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

A Stepdown Fix (SDF), located at 21.5 NM from the threshold has been established with a 14,000 ft crossing restriction. Once passing the SDF aircraft will begin descent to 12,700 ft.

Final Segment: The PFAF altitude is 12,700 ft (16.8 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.17 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 2.24 NM and then begin a 13° bank angle left turn for 9.77 NM to Point A (see Figure 19). From Point A, the aircraft would fly straight ahead (311°) for 28.13 NM to Point B (see Figure 19). No CG is required. The HAT and visibility for this procedure are 418 ft and 3/4 sm, respectively.

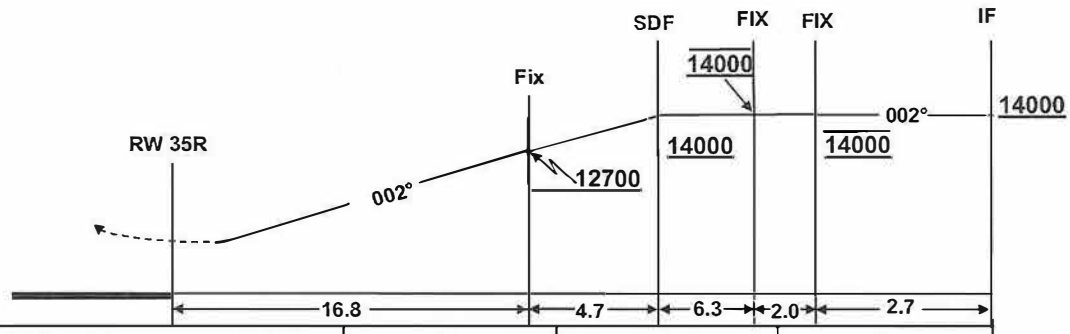


Source: GoogleEarth Pro

Figure 19. Runway 35R RNP AR Approach: Overhead View

MISSED APPROACH: Climbing left turn to 14,000 to Point A then heading 311° to Point B and hold.

No waivers required
No Climb Gradient Required



CATEGORY	A	B	C	D
RNP 0.3 DA*	7711 / 3/4 418			

*Decision Altitude (DA)

Figure 20. Runway 35R RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 18. Runway 35R RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - Stepdown	Terrain	19 06 36.00N	99 01 51.00W	12,131
Stepdown - PFAF	Terrain	19 07 24.00N	99 01 12.00W	11,353
Final	Clear			
Missed Approach	Light Pole	19 29 08.68N	99 00 55.65W	7432

Coordinates are based on WGS84

7.2 Runway 35L (Opening-Day Optional Runway in Lieu of Runway 35R)

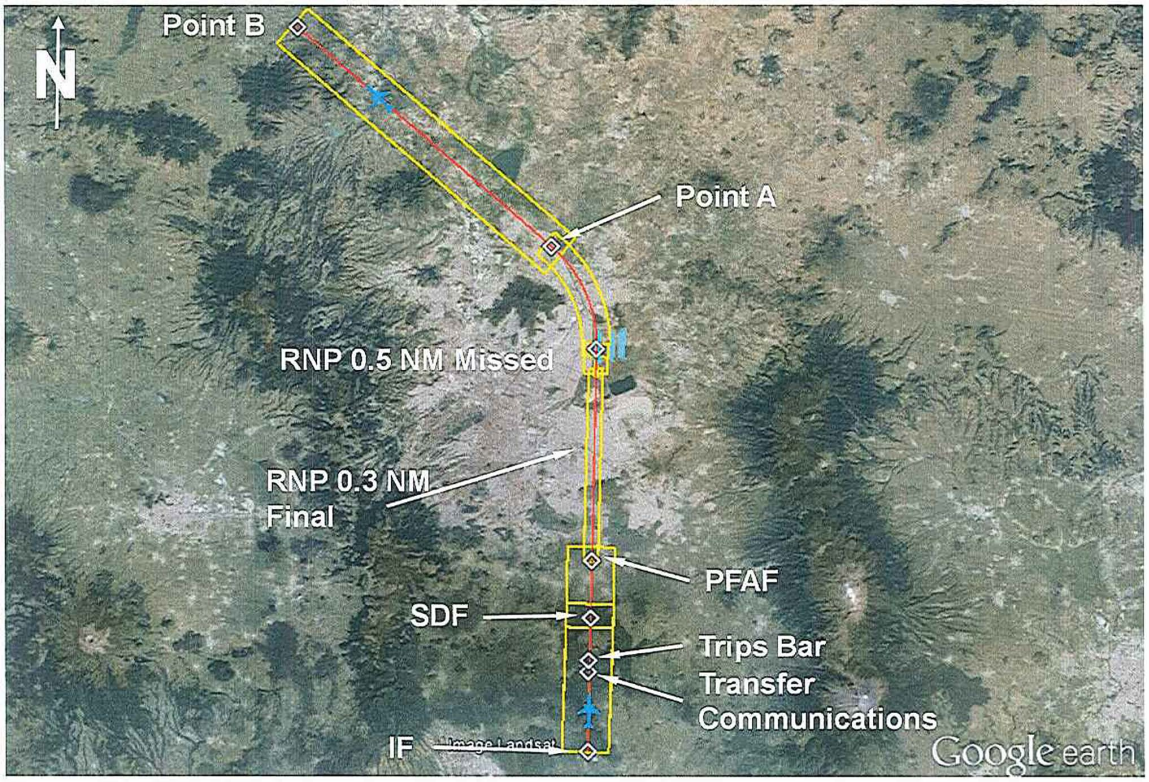
Figures 21 and 22 show an overhead and profile view, respectively, of the Runway 35L RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 19.

Intermediate Segment: The IF is located 32.6 NM from the threshold. The IF altitude is 14,000 ft. The proposed vectoring altitude for approaches to this runway is 14,000 ft. Crossing restrictions (14,000 ft) have been established 2 NM prior to the Trips Bar (29.9 NM) and at the Trips Bar (27.9 NM). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

A SDF, located at 21.6 NM from threshold has been established with a 14,000 ft crossing restriction. Once passing the SDF aircraft will begin descent to 12,700 ft.

Final Segment: The PFAF altitude is 12,700 ft (16.8 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.17 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 2.24 NM and then begin a 13° bank angle left turn for 9.77 NM to Point A (see Figure 20). From Point A, the aircraft would fly straight ahead (311°) for 28.13 NM to Point B (see Figure 20). No CG is required. The HAT and visibility for this procedure are 429 ft and 3/4 sm, respectively.

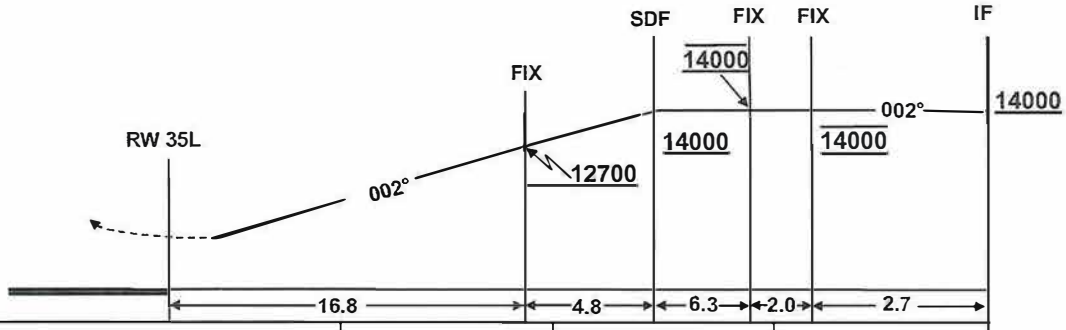


Source: GoogleEarth Pro

Figure 20. Runway 35L RNP AR Approach: Overhead View

MISSED APPROACH: Climbing left turn to 14,000 to Point A then heading 311° to Point B and hold.

No waivers required
No Climb Gradient Required



CATEGORY	A	B	C	D
RNP 0.3 DA	7722 / 3/4 429			

Figure 21. Runway 35L RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 19. Runway 35L RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - Stepdown	Terrain	19 06 36.00N	99 01 51.00W	12,131
Stepdown - PFAF	Terrain	19 07 27.00N	99 01 15.00W	11,327
Final	Clear			
Missed Approach	Light Pole	19 29 08.68N	99 00 55.65W	7432

Coordinates are based on WGS84

7.3. Runway 36L

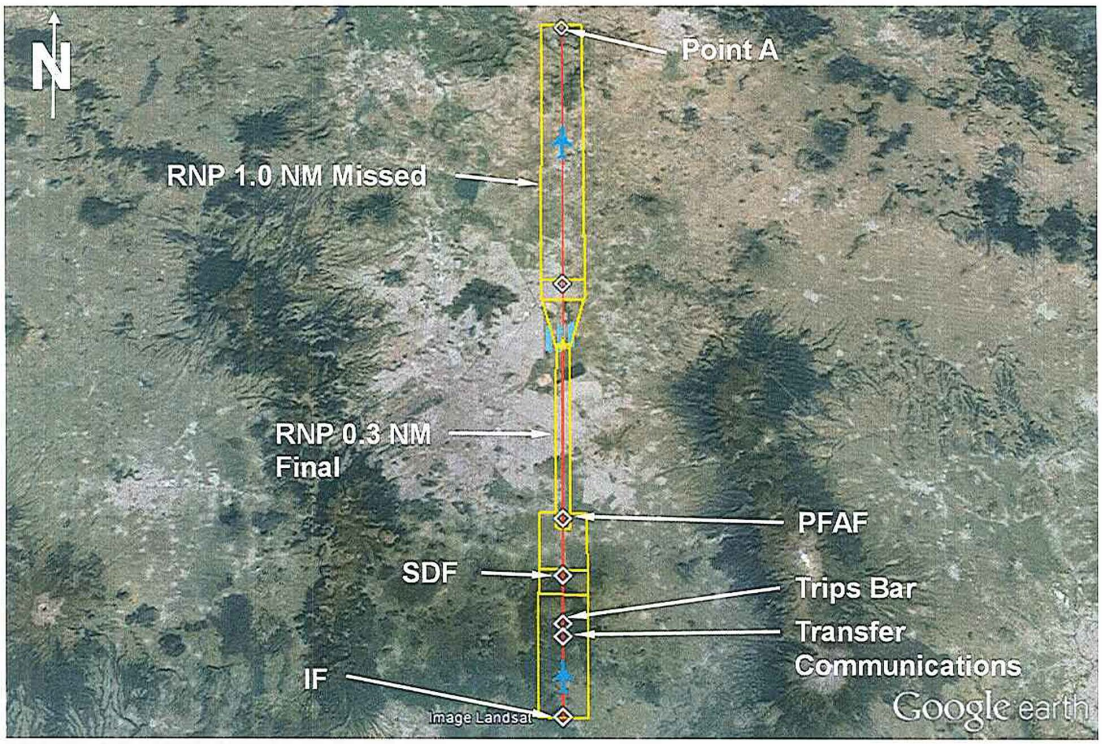
Figures 22 and 23 show an overhead and profile view, respectively, of the Runway 36L RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 20.

Intermediate Segment: The IF is located 32.5 NM from the threshold. The IF altitude is 16,000 ft. The proposed vectoring altitude for approaches to this runway is 16,000 ft. Crossing restrictions (16,000 ft) have been established 2 NM prior to the Trips Bar (i.e., 29.8) and at the Trips Bar (27.8). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

A SDF, located at 21.5 NM from the threshold has been established with a 14,000 ft crossing restriction. Once passing the SDF aircraft will begin descent to 12,700 ft.

Final Segment: The PFAF altitude is 12,700 ft (16.8 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.08 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 34 NM to Point A (see Figure 22). No CG is required. The HAT and visibility for this procedure are 400 ft and 5/8 sm, respectively.



Source: GoogleEarth Pro

Figure 22. Runway 36L RNP AR Approach: Overhead View

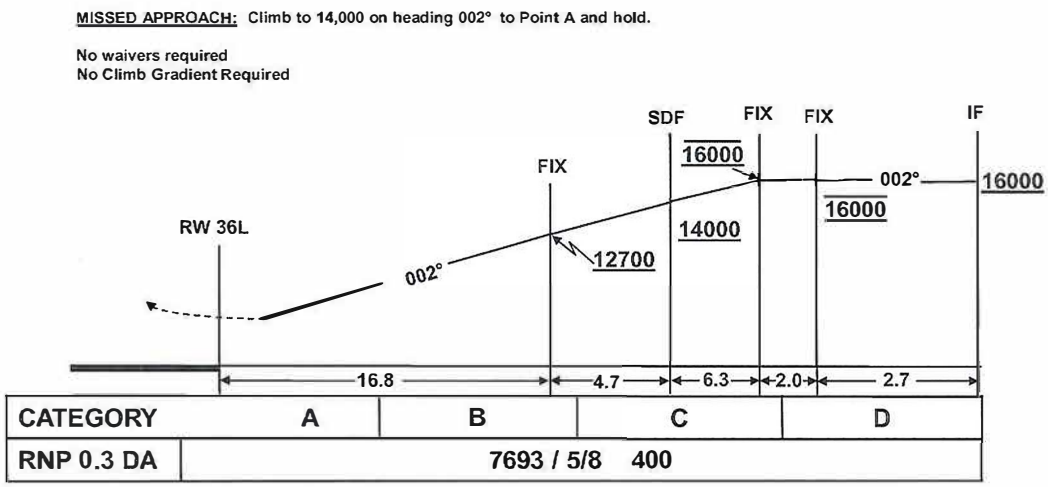


Figure 23. Runway 36L RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 20. Runway 36L RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - Stepdown	Terrain	19 06 36.00N	99 01 51.00W	12,131
Stepdown - PFAF	Terrain	19 07 27.00N	99 01 15.00W	11,327
Final	Clear			
Missed Approach	Terrain	19 29 06.00N	98 59 00.00W	7393

Coordinates are based on WGS84

7.4. Runway 01R

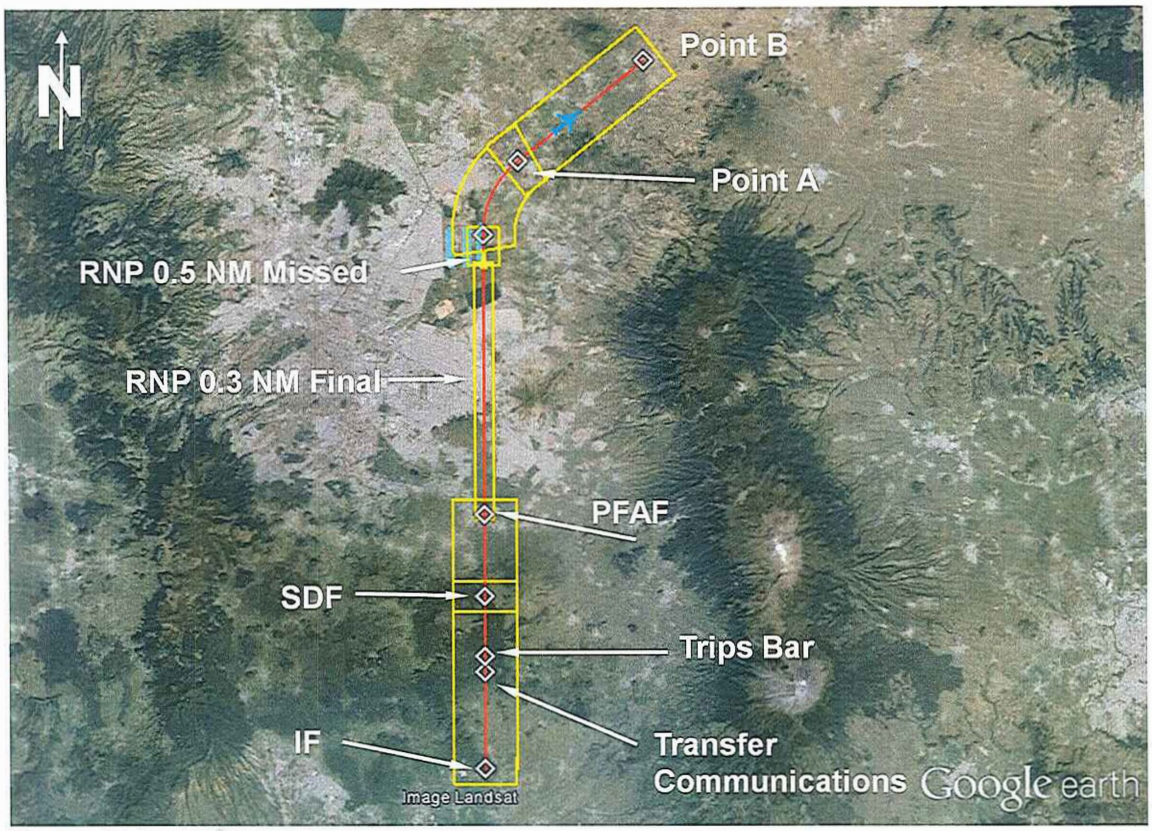
Figures 24 and 25 show an overhead and profile view, respectively, of the Runway 01R RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 21.

Intermediate Segment: The IF is located 33.0 NM from the threshold. The IF altitude is 15,000 ft. The proposed vectoring altitude for approaches to this runway is 15,000 ft. Crossing restrictions (15,000 ft) have been established 2 NM prior to the Trips Bar (i.e., 30.3) and at the Trips Bar (28.3). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

A SDF, located at 22.0 NM from threshold has been established with a 15,000 ft crossing restriction. Once passing the SDF aircraft will begin descent to 12,700 ft.

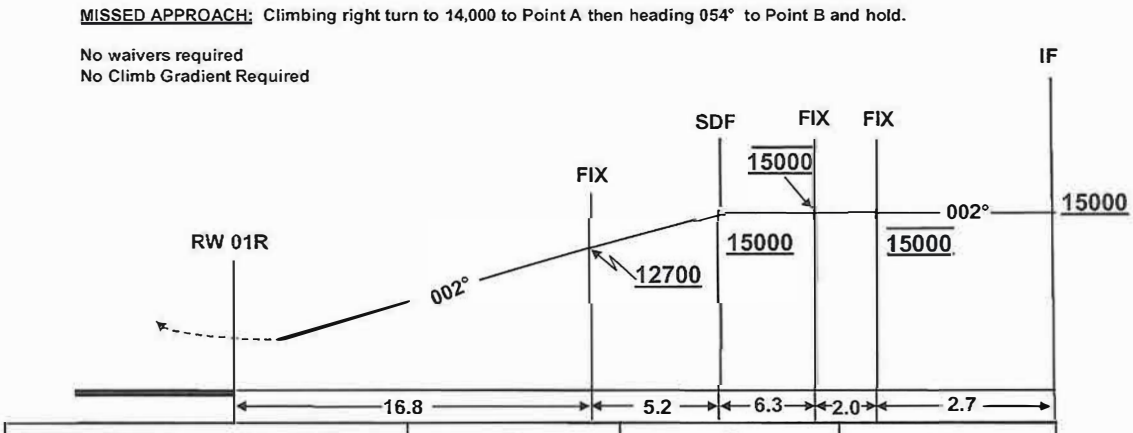
Final Segment: The PFAF altitude is 12,700 ft (16.8 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.0 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 2.12 NM and then begin a 20° bank angle right turn for 5.4 NM to Point A (see Figure 24). From Point A, the aircraft would fly straight ahead (054°) for 10.37 NM to Point B (see Figure 24). No CG is required. The HAT and visibility for this procedure are 410 ft and 3/4 sm, respectively.



Source: GoogleEarth Pro

Figure 24. Runway 01R RNP AR Approach: Overhead View



CATEGORY	A	B	C	D
RNP 0.3 DA	7703 / 3/4 410			

Figure 25. Runway 01R RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 21. Runway 01R RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - Stepdown	Terrain	19 06 12.00N	98 59 18.00W	11,809
Stepdown - PFAF	Terrain	19 07 24.00N	99 01 00.00W	11,290
Final	Clear			
Missed Approach	Terrain	19 29 27.00N	98 57 06.00W	7400

Coordinates are based on WGS84

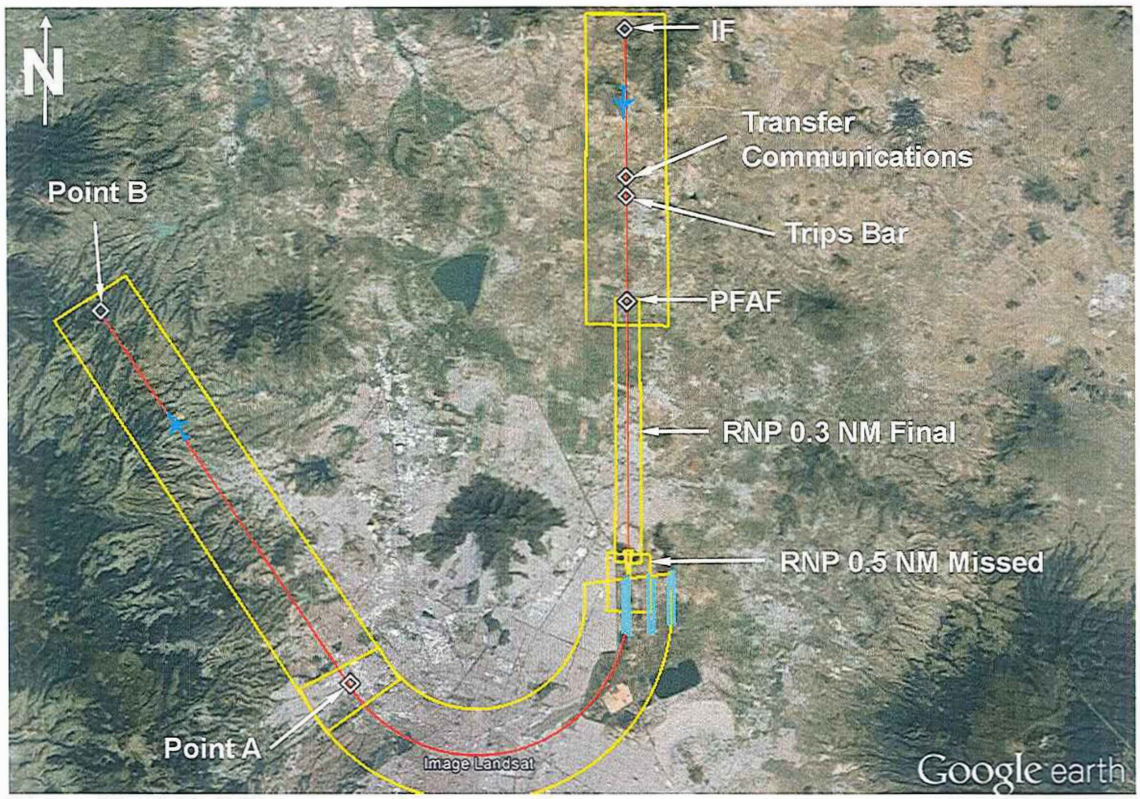
7.5. Runway 17L

Figures 26 and 27 show an overhead and profile view, respectively, of the Runway 17L RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 22.

Intermediate Segment: The IF is located 27.6 NM from the threshold. The IF altitude is 13,000 ft. The proposed vectoring altitude for approaches to this runway is 12,500 ft. Crossing restrictions (12,500 ft) have been established 2 NM prior to the Trips Bar (21.6 NM) and at the Trips Bar (19.6 NM). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

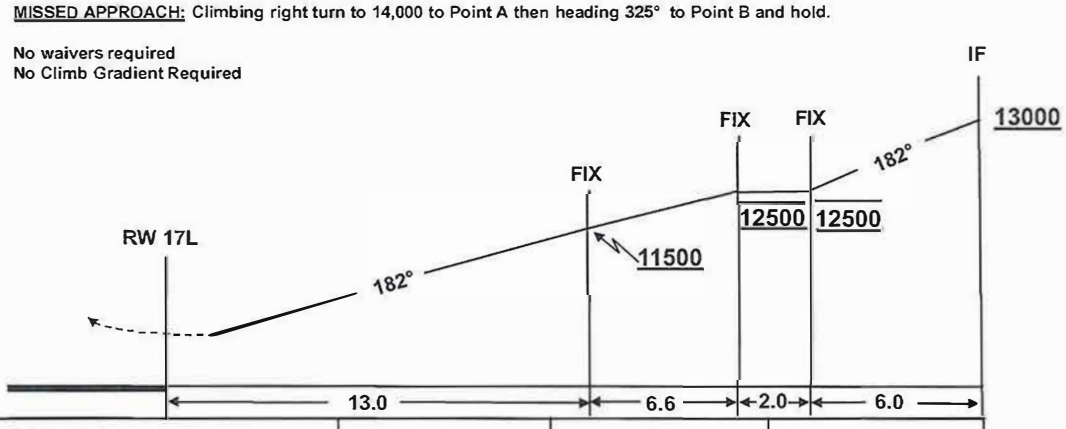
Final Segment: The PFAF altitude is 11,500 ft (13.0 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.17 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 2.12 NM and then begin a 20° bank angle right turn for 18.00 NM to Point A (see Figure 26). From Point A, the aircraft would fly straight ahead heading 325° for 22.00 NM to Point B (see Figure 26). No CG is required. The HAT and visibility for this procedure are 427 ft and 3/4 sm, respectively.



Source: GoogleEarth Pro

Figure 26. Runway 17L RNP AR Approach: Overhead View



CATEGORY	A	B	C	D
RNP 0.3 DA	7720 / 3/4 427			

Figure 27. Runway 17L RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 22. Runway 17L RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - PFAF	Terrain	19 57 24.00N	98 57 36.67W	9188
Final	Clear			
Missed Approach	Antenna	19 33 31.71N	99 01 02.47W	7442

Coordinates are based on WGS84

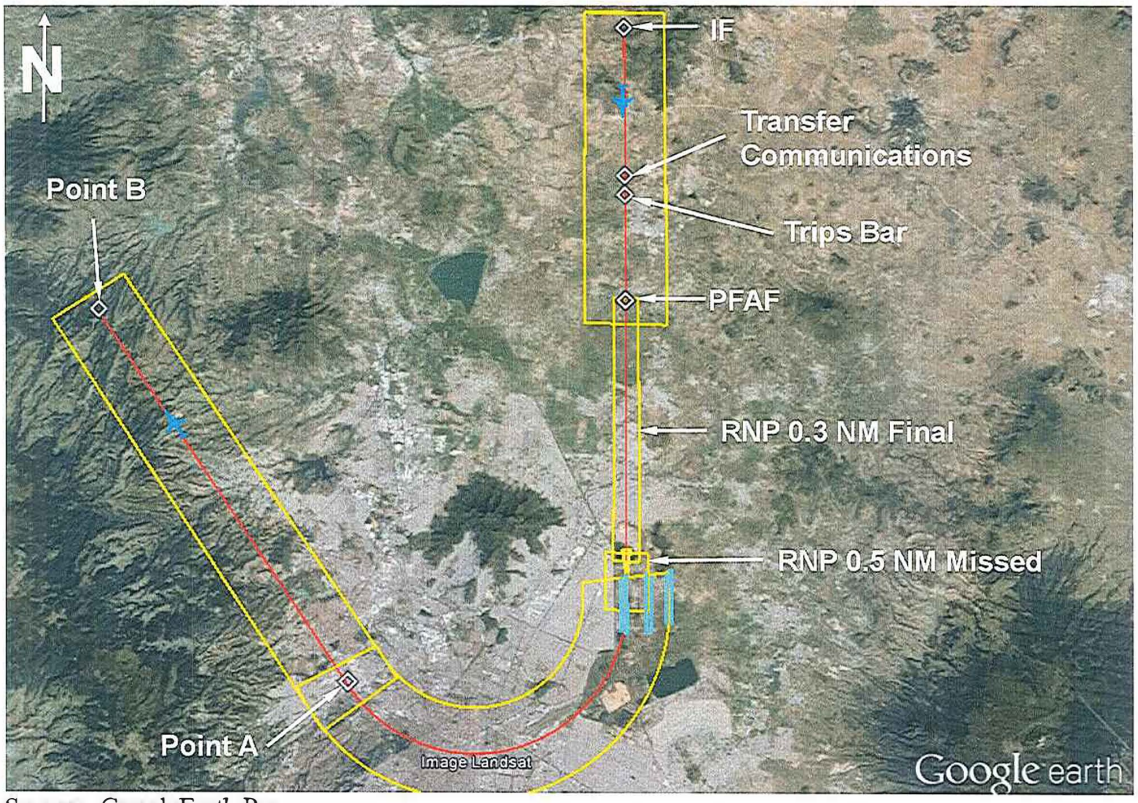
7.6. Runway 17R (Opening-Day Optional Runway in Lieu of Runway 17L)

Figures 28 and 29 show an overhead and profile view, respectively, of the Runway 17R RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 23.

Intermediate Segment: The IF is located 27.6 NM from the threshold. The IF altitude is 13,000 ft. The proposed vectoring altitude for approaches to this runway is 12,500 ft. Crossing restrictions (12,500 ft) have been established 2 NM prior to the Trips Bar (21.4 NM) and at the Trips Bar (19.4 NM). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

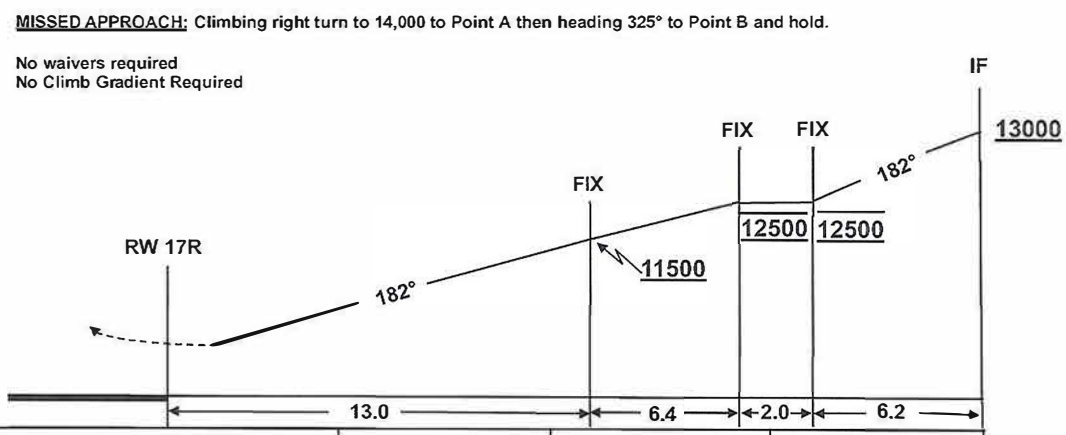
Final Segment: The PFAF altitude is 11,500 ft (13.0 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.35 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 2.47 NM and then begin a 20° bank angle right turn for 18.00 NM to Point A (see Figure 28). From Point A, the aircraft would fly straight ahead heading 325° for 22.00 NM to Point B (see Figure 28). No CG is required. The HAT and visibility for this procedure are 486 ft and 1 sm, respectively.



Source: GoogleEarth Pro

Figure 28. Runway 17R RNP AR Approach: Overhead View



CATEGORY	A	B	C	D
RNP 0.3 DA	7779 / 1 486			

Figure 29. Runway 17R RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 23. Runway 17R RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - PFAF	Terrain	19 57 24.00N	98 57 36.67W	9188
Final	Clear			
Missed Approach	Antenna	19 33 40.88N	99 01 19.67W	7481

Coordinates are based on WGS84

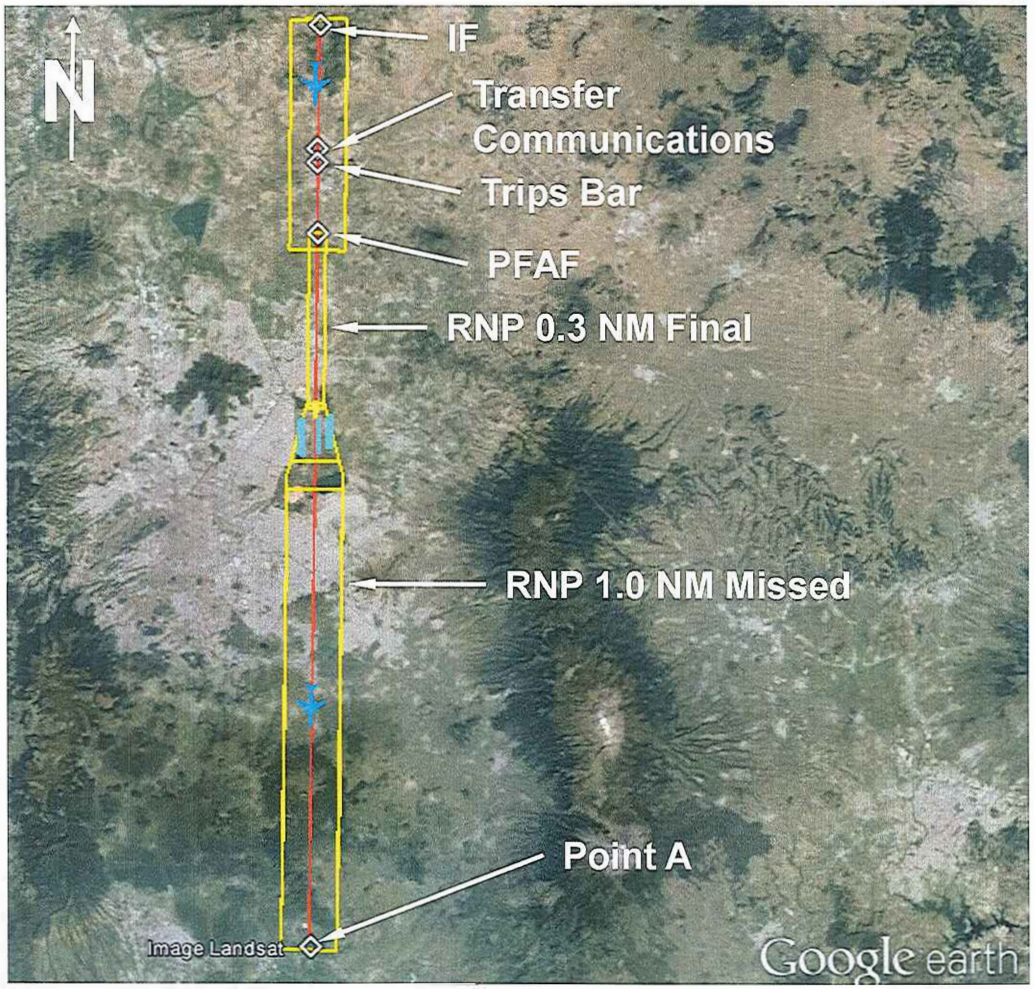
7.7. Runway 18R

Figures 30 and 31 show an overhead and profile view, respectively, of the Runway 18R RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 24.

Intermediate Segment: The IF is located 27.4 NM from the threshold. The IF altitude is 14,000 ft. The proposed vectoring altitude for approaches to this runway is 13,500 ft. Crossing restrictions (13,500 ft) have been established 2 NM prior to the Trips Bar (21.4 NM) and at the Trips Bar (19.4 NM). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The PFAF altitude is 11,500 ft (13.0 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.00 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 34 NM to Point A (see Figure 30). A CG of 250 ft/NM to 13,000 ft is required. The HAT and visibility for this procedure are 406 ft and 3/4 sm, respectively.



Source: GoogleEarth Pro

Figure 30. Runway 18R RNP AR Approach: Overhead View

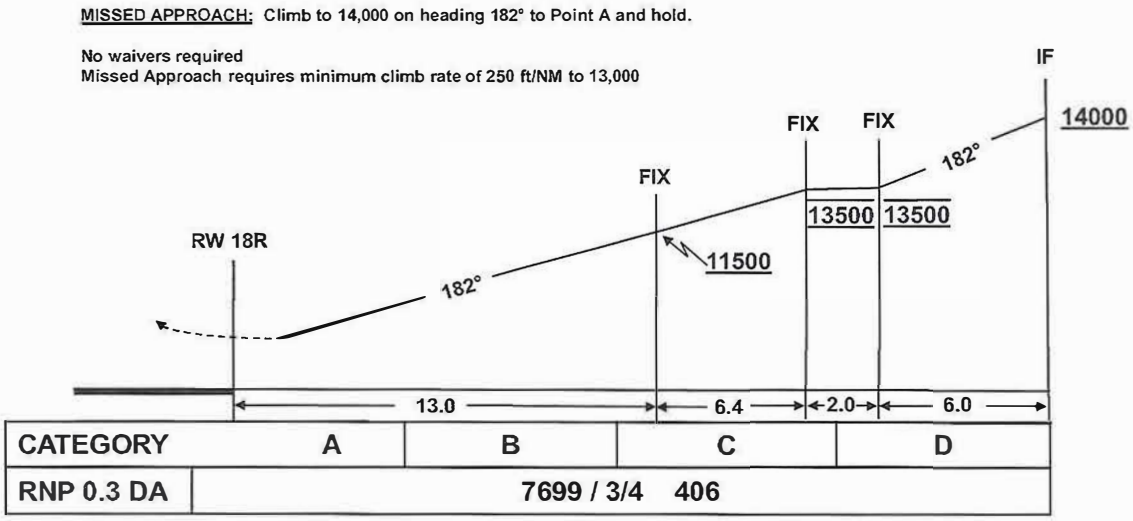


Figure 31. Runway 18R RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 24. Runway 18R RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - PFAF	Terrain	20 00 09.00N	98 56 06.00W	9598
Final	Clear			
Missed Approach*	Terrain	19 33 39.00N	98 59 24.00W	7356
Missed Approach Climb Gradient**	Terrain	19 06 36.00N	99 01 51.00W	12,131

Coordinates are based on WGS84
*The missed approach obstacle controls the HAT
**The missed approach climb gradient obstacle controls the CG

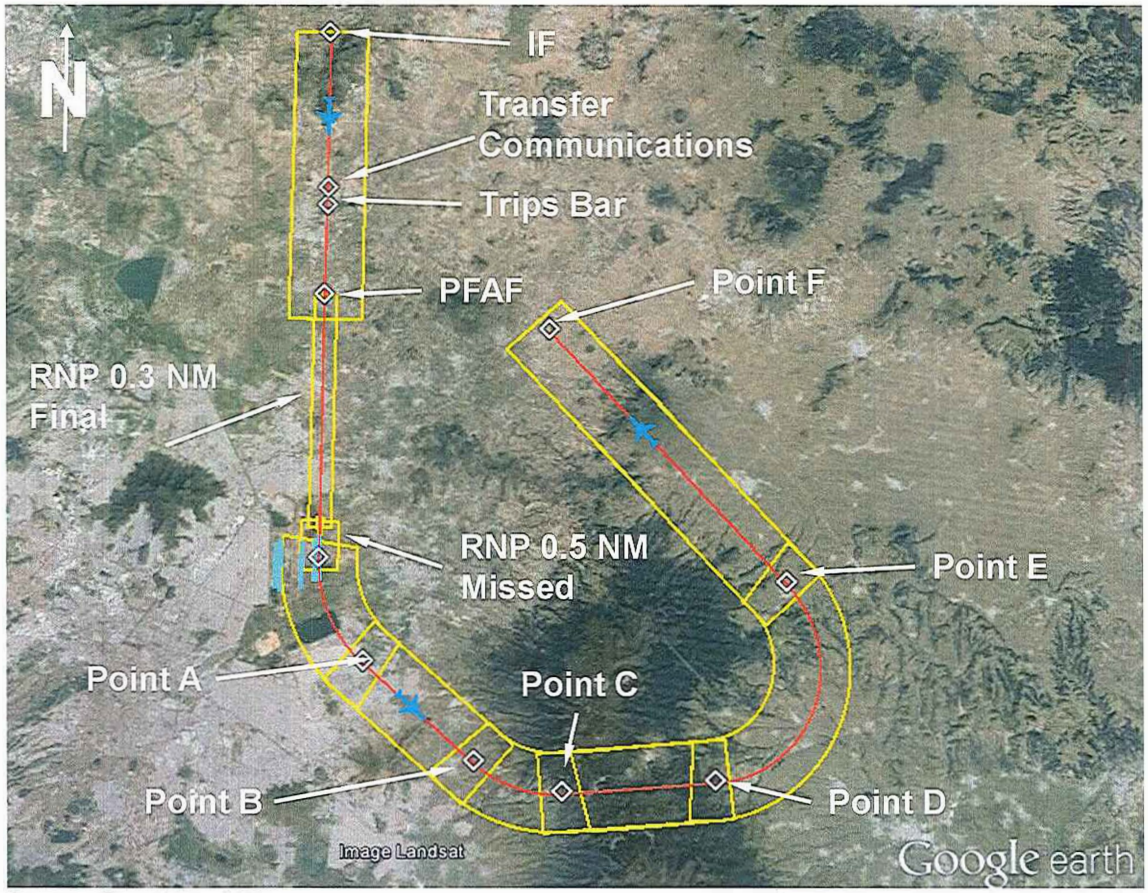
7.8. Runway 19L

Figures 32 and 33 show an overhead and profile view, respectively, of the Runway 19L RNP AR approach procedure. Controlling obstacles for each segment of the procedure are shown in Table 25.

Intermediate Segment: The IF is located 27.6 NM from the threshold. The IF altitude is 12,000 ft. The proposed vectoring altitude for approaches to this runway is 11,500 ft. Crossing restrictions (11,500 ft) have been established 2 NM prior to the Trips Bar (21.4 NM) and at the Trips Bar (19.4 NM). Aircraft are expected to be transferred to the Control Tower prior to the Trips Bar (i.e., nominally 1 NM prior).

Final Segment: The PFAF altitude is 11,500 ft (13.0 NM from the threshold).

Missed Approach Segment: The missed approach segment commences at the MAP, 1.00 NM prior to the threshold. If aircraft were to execute the missed approach they would fly straight ahead for 2.12 NM and then begin a 18° bank angle left turn for 6.07 NM to Point A (see Figure 32 for Point A and all successive points). From Point A, the aircraft would fly straight ahead (132°) for 7.53 NM to Point B. At Point B, the aircraft would execute a 23° bank angle left turn for 4.77 NM to Point C. At point C, the aircraft would fly straight ahead (083°) for 7.74 NM to Point D. At Point D, the aircraft would again execute a 23° bank angle left turn for 13.36 NM to Point E. At Point E, the aircraft would fly straight ahead for 17.92 NM to Point F. A CG of 300 ft/NM to 13,000 ft is required. The HAT and visibility for this procedure are 416 ft and 3/4 sm, respectively.



Source: GoogleEarth Pro

Figure 32. Runway 19L RNP AR Approach: Overhead View

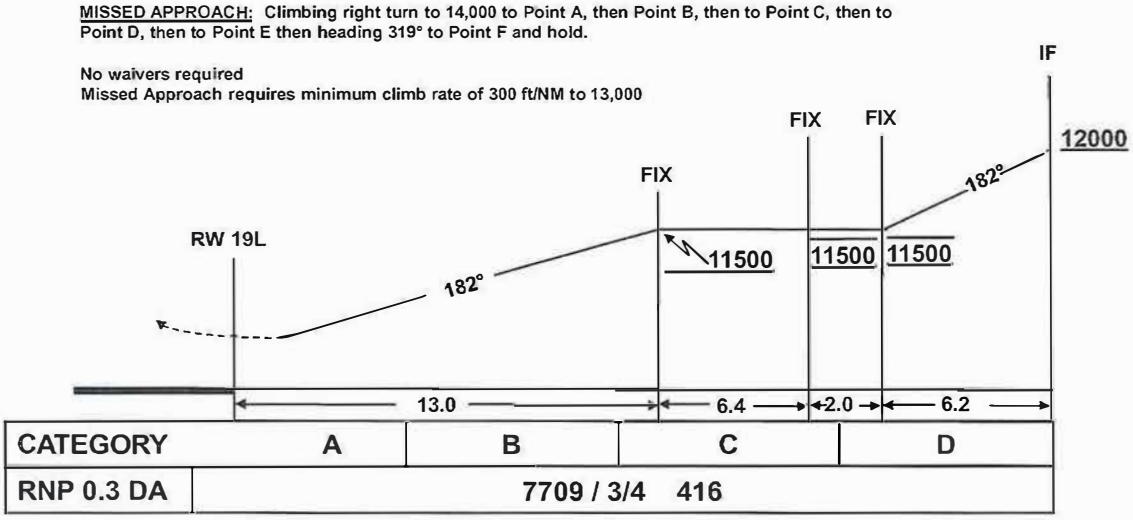


Figure 33. Runway 19L RNP AR: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 25. Runway 19L RNP AR: Segment Controlling Obstacles

Segment	Description	Position		Elevation (ft MSL)
		Latitude	Longitude	
Intermediate - PFAF	Terrain	20 00 09.00N	98 56 06.00W	9598
Final	Clear			
Missed Approach*	Terrain	19 33 33.00N	98 57 06.00W	7406
Missed Approach Climb Gradient**	Terrain	19 21 30.00N	98 44 00.00W	12,012

Coordinates are based on WGS84
*The missed approach obstacle controls the HAT
**The missed approach climb gradient obstacle controls the CG

8. Summary

MITRE examined the feasibility of triple independent approaches (both CAT I ILS and RNP AR) and conventional departures, in both directions, for the NAICM opening-day runway configuration being considered by the aviation authorities of Mexico. MITRE's work was based on the satellite-based photogrammetric survey of the NAICM site and its surroundings, which provided current and accurate information on man-made obstacles and terrain.

The following summarizes the most important findings:

- Triple independent CAT I ILS approaches are feasible. All approaches except one (i.e., to Runway 36L) require CGs on the MAP above standard to achieve

lowest possible minima. The CG for the MAP of Runway 35R is relatively high (i.e., 354 ft/NM).

- Triple independent RNP AR approaches are feasible. All approaches except two (i.e., Runways 18R and 19L) have standard CGs on the MAP. The CGs for Runways 18R and 19L, however, are reasonable.
- Triple independent conventional departures are feasible. All departure procedures except three have CGs. The CGs for the departure from Runways 35R or 35L that turn hard left and the departure from Runway 19L to the APN VOR/DME are relatively high and may be challenging for some aircraft.

Other principal factors pertaining to the final assessment of the procedures described in this document are as follows:

- Acceptance by all major Mexican airlines regarding conducting missed approach and departure procedures with CGs above standard. This also assumes that the Mexican aviation authorities will enact regulations required to conduct missed approach CGs above standard. Additionally, MITRE would like to stress the involvement of the airlines in key NAICM-related aeronautical matters, including instrument procedure designs. Early review and feedback from airlines are crucial to the success of procedure designs.
- Initiation of flight inspection activities by the Mexican aviation authorities to ensure that undetected obstacles and other safety and operational factors do not affect procedural designs. Additionally, due to the long final approaches at NAICM, MITRE recommends that pre-commissioning flight inspection activities be conducted to check ILS signal reception and other matters using actual ILS equipment (or equivalent equipment in accordance to experts). MITRE recommends that these flight inspection activities be conducted as soon as possible, before runways are constructed.
- As with all of MITRE's analyses, a validation of instrument procedures and other associated work must be accomplished by SENEAM, followed by approval from the Dirección General de Aeronáutica Civil.

References

FAA, 2012, *United States Standard for Performance Based Navigation (PBN)*, FAA Order 8260.58, FAA, Washington, District of Columbia, U.S.A.

FAA, 2014, *Air Traffic Control*, FAA JO 7110.65V, FAA, Washington, District of Columbia, U.S.A.

FAA, 2014, *Departure Procedure (DP) Program*, FAA Order 8260.46E, FAA, Washington, District of Columbia, U.S.A.

FAA, 2014, *United States Standard for Terminal Instrument Procedures (TERPS)*, FAA Order 8260.3B, FAA, Washington, District of Columbia, U.S.A.

ICAO, 2014, *Procedures for Air Navigation Services, Aircraft Operations, Volume II, Construction of Visual and Instrument Flight Procedures*, ICAO Doc 8168 OPS/611, ICAO, Montréal, Canada

Appendix A

Table A-1. MITRE-Recommended Runway Configuration (July 2012) for NAICM: Coordinates

Runway	Runway End and Displaced Threshold	World Geodetic System 1984 Coordinates on Runway Centerline	Universal Transverse Mercator X and Y Coordinates
17R/35L	17R Runway End	19 32 29.9N/99 00 27.8W	499190.7286/2160758.9760
	35L Runway End	19 30 03.5N/99 00 33.2W	499032.8418/2156261.7466
17L/35R	17L Runway End	19 32 39.3N/99 00 13.7W	499601.1598/2161049.0771
	35R Runway End	19 29 56.7N/99 00 19.7W	499425.7300/2156052.1556
18R/36L	18R Runway End	19 32 41.6N/98 59 15.0W	501311.7495/2161121.3721
	36L Runway End	19 29 59.1N/98 59 21.0W	501136.3197/2156124.4506
18L/36R	18L Runway End	19 32 31.3N/98 59 01.6W	501700.8294/2160803.3062
	36R Runway End	19 30 05.0N/98 59 07.1W	501542.9426/2156306.0768
19R/01L	19R Runway End	19 32 53.7N/98 58 15.9W	503032.7720/2161490.8303
	19R Displaced Threshold (Tentative)	19 32 39.8N/98 58 16.4W	503017.7903/2161064.0932
	01L Runway End	19 30 27.3N/98 58 21.4W	502874.8851/2156993.6009
19L/01R	19L Runway End	19 32 53.2N/98 58 02.2W	503432.5283/2161476.8694
	19L Displaced Threshold (Tentative)	19 32 39.3N/98 58 02.7W	503417.5466/2161050.1323
	01R Runway End	19 30 26.9N/98 58 07.6W	503274.6414/2156979.6392

Notes:

1. The runway coordinates contained in this table are associated with a runway configuration whose aeronautical feasibility has been proven. However, the coordinates are subject to changes due to factors such as detailed civil engineering analyses, flight checks, final runway lengths and thresholds, and approvals that must be obtained from the appropriate aviation authorities of Mexico.

2. The MITRE UTM coordinates have a precision of 1/10,000th of a meter (0.0001 m). MITRE then uses MSP GEOTRANS 3.4, a geographic translator available from the U.S. National Geospatial-Intelligence Agency (NGA) Mensuration Service Program, to convert UTM Northing (Y) and Easting (X) to geodetic latitude and longitude for reporting purposes only. In general, the accuracy of the geodetic coordinate output by MSP GEOTRANS 3.4 has only been tested to a level of approximately 1 m (0.1 second).