

Enclosure 4

(Ref. Technical Letter F500-L16-013)



**Center for Advanced
Aviation System Development**

Nuevo Aeropuerto Internacional de la Ciudad de México

*Feasibility of Independent Category II/III Approach
and Area Navigation Departure Procedures*

Prepared for

Aeropuertos y Servicios Auxiliares

January 2016

REVISIONS

This document was originally provided by MITRE in late September 2015 (see enclosure No. 1 to MITRE Technical Letter F500-L15-032). 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 30, Figure 12
 - Replaced with corrected Missed Approach instructions
- Page 31, Figure 13
 - Replaced with corrected Missed Approach instructions
- Page 33, 5.4.8 Runway 19L
 - Clarification of greatest amount of penetration (19.1 m / 62.66 ft) by Chiconautla (see re-worded paragraph)

Principal Acronyms and Abbreviations

AGL	Above Ground Level
AICM	Aeropuerto Internacional de la Ciudad de México
AIP	Aeronautical Information Publication
ASA	Aeropuertos y Servicios Auxiliares
ATC	Air Traffic Control
AWOS	Automated Weather Observing System
CAT	Category
CG	Climb Gradient
DA/H	Decision Altitude/Height
DME	Distance Measuring Equipment
ELOS	Equivalent Level of Safety
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
L-IMC	Low-Instrument Meteorological Conditions
MAP	Missed Approach Point
MITRE	The MITRE Corporation
MMP	Mexico Prohibited Area
MMR	Mexico Restricted Area
MSL	Mean Sea Level
MTBO	Mean Time Between Outages
MVAC	Minimum Vectoring Altitude Chart
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México

NM	Nautical Mile
OCS	Obstacle Clearance Surface
OLS	Obstacle Limitation Surface
OpSpecs	Operation Specifications
PAOA	Parallel Approach Obstruction Assessment
PAOAS	Parallel Approach Obstruction Assessment Surface
PFAF	Precise Final Approach Fix
RNAV	Area Navigation
RNP AR	Required Navigation Procedures Authorization Required
ROC	Required Obstacle Clearance
RVR	Runway Visual Range
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	Standard for Terminal Instrument Procedures
U.S.	United States
VOR	Very High Frequency Omni Directional Range
WGS84	World Geodetic System 1984
WP	Waypoint

1. Introduction

The MITRE Corporation (MITRE) is assisting Aeropuertos y Servicios Auxiliares (ASA) 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, MITRE previously 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.

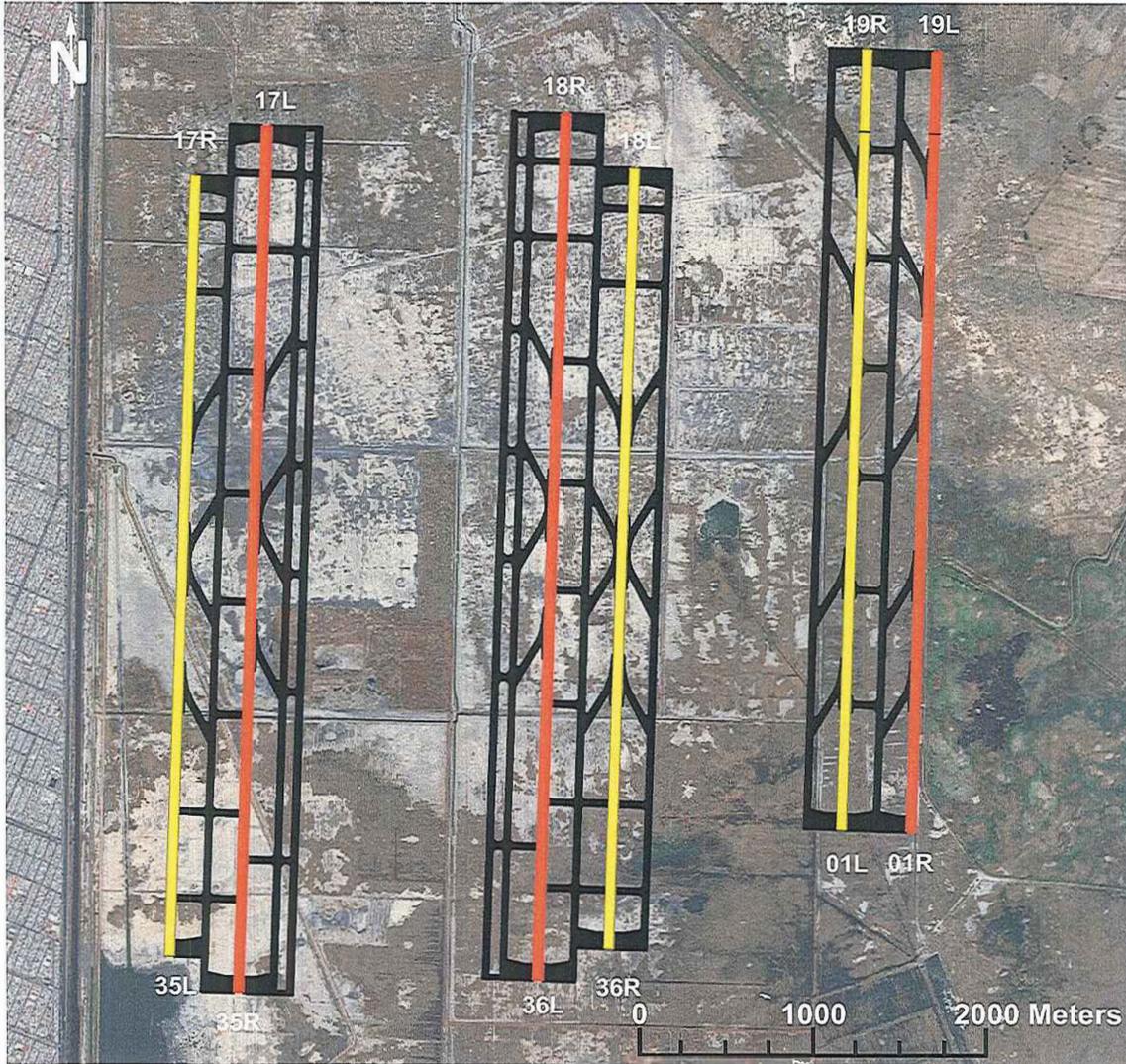
More than four years have passed since the original above-mentioned 2010 survey was conducted, and MITRE felt it prudent that a new survey be performed to account for any recent construction that could affect the development of instrument approach and departure procedures. Therefore, a new satellite-based 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). Enclosure 1 to Technical Letter F500-L15-021: *Nuevo Aeropuerto Internacional de la Ciudad de México—Feasibility of Independent Approach and Departure Procedures*, dated 24 June 2015 described findings specific to MITRE’s reassessment of Category (CAT) I Instrument Landing System (ILS) and Required Navigation Procedures Authorization Required (RNP AR) approach procedures and conventional departure procedures. The purpose of this document is to provide results on MITRE’s CAT II/III ILS approach and Area Navigation (RNAV) departure procedure 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 triple independent CAT II/III ILS approach procedures. Section 6 describes MITRE’s triple independent parallel RNAV departure procedures. Finally, Section 7 provides a summary of key results.

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)

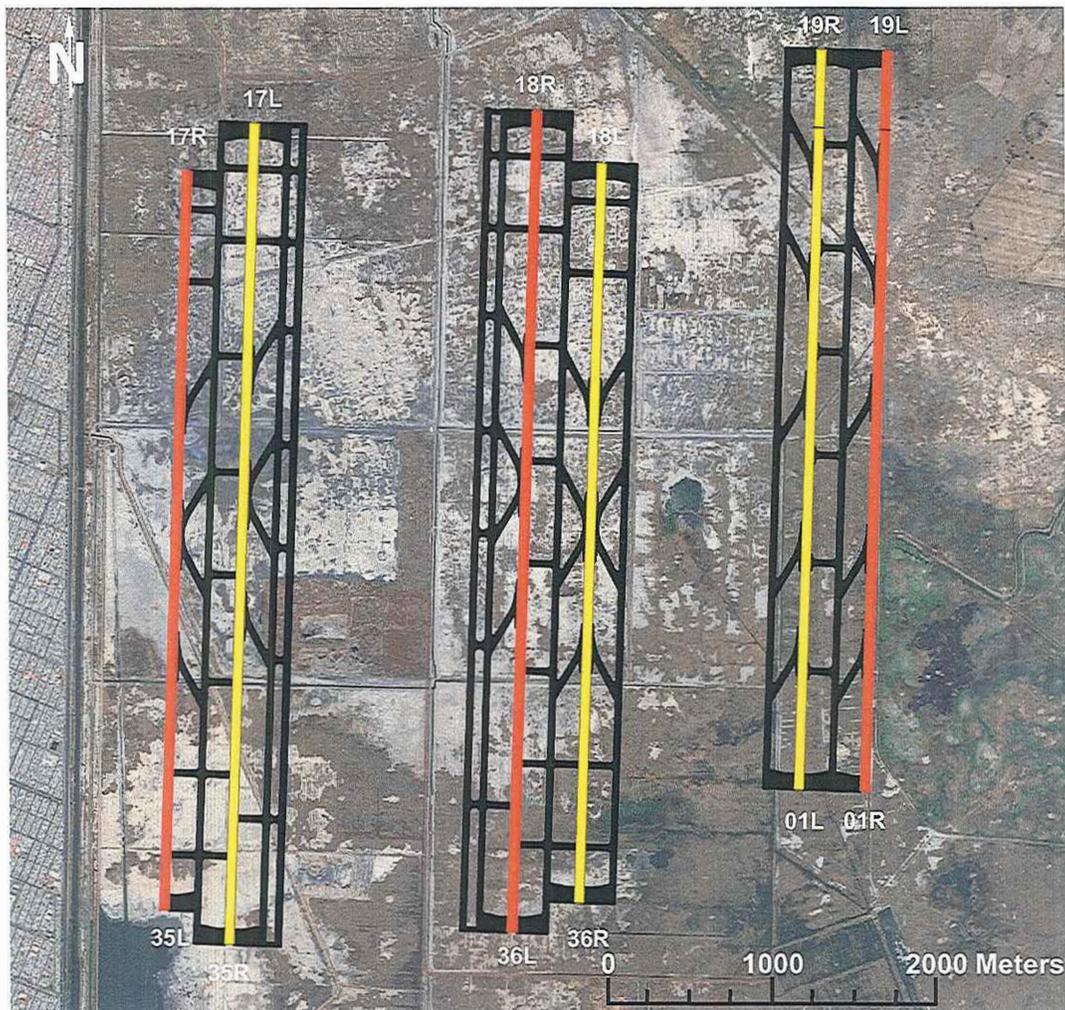
The MITRE team, however, is concerned about plans to construct Runway 35R/17L before Runway 35L/17R, as that event will jeopardize in all likelihood subsequent construction of Runway 35L/17R due to public protests over noise concerns. Due to these concerns, MITRE recommends that the opening-day runway 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 2015. 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. Figure 2 shows MITRE's recommended opening-day runway configuration (shown as red lines).

MITRE was later informed that the authorities had decided to construct Runway 35R/17L first. The information, however, was provided informally and second-hand. In any case, MITRE decided to also reassess the feasibility of instrument approach and departure procedures for Runway 35L/17R in the event that aviation authorities decide to construct Runway 35L/17R first as part of the opening-day runway configuration. Therefore, the results for Runway 35L/17R are also included in this document.

It is important to note that in early June 2015, Dr. Bernard Lisker met with Capt. Gilberto López Meyer to discuss important project-related matters. During that meeting, Capt. López Meyer requested that MITRE investigate a request by Arup, the company developing the NAICM Master Plan, to shift NAICM Runway 35R/17L and Runway 35L/17R to the west by 10 m, and the remaining runways (i.e., 36L/18R, 36R/18L, 01L/19R and 01R/19L) to the east by 10 m. As a result, MITRE formulated a specially assigned team to investigate this matter so that an initial (not final) opinion could be provided to Capt. López Meyer as soon as possible. Refer to MITRE letter F500-L15-025 dated 24 June 2015 for additional details.

MITRE, however, has not received official confirmation that the above-mentioned runway shifts are going to be implemented. Therefore, MITRE's procedure design work described in this document do not take the 10-m runway shift proposal into account. Furthermore, if the runway shift proposal is to be implemented, MITRE may need to conduct a full and detailed aeronautical analysis of the shifted runway locations to ensure feasibility. As a result, some of MITRE's previously conducted work may need to be redone (out of contractual scope).



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

For this report MITRE analyzed both conventional CAT II/III ILS as well as RNAV departure procedures for the opening-day runway configuration at NAICM, including the option of constructing Runway 35L/17R instead of Runway 35R/17L. It is important to note that while the CAT II/III ILS instrument approach procedures proved viable there are concerns that must be addressed. They are detailed later in the report.

RNAV departure procedures allow for greater design flexibility and other operational benefits, such as predictability of flight paths. Therefore, MITRE examined the feasibility of RNAV departure procedures for NAICM.

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 the 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 instrument 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 instrument procedures. The second step is the creation of a Master Basemap drawing, generally within a computer aided design program (MITRE uses AutoCAD). Subsequent steps involve using the Master Basemap drawing to formulate, test, and analyze various instrument 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 instrument 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 instrument 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 instrument procedures were developed in accordance with U.S. TERPS. It

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.

is important to mention that Mexico has also used U.S. TERPS for instrument 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 feet (ft) relative to Mean Sea Level (MSL), coordinates are in World Geodetic System 1984 (WGS84) and distances are in Nautical Miles (NM). All instrument approach procedures utilized a glideslope (for ILSs)/glidepath angle of 3°.

3.2. Software Tools

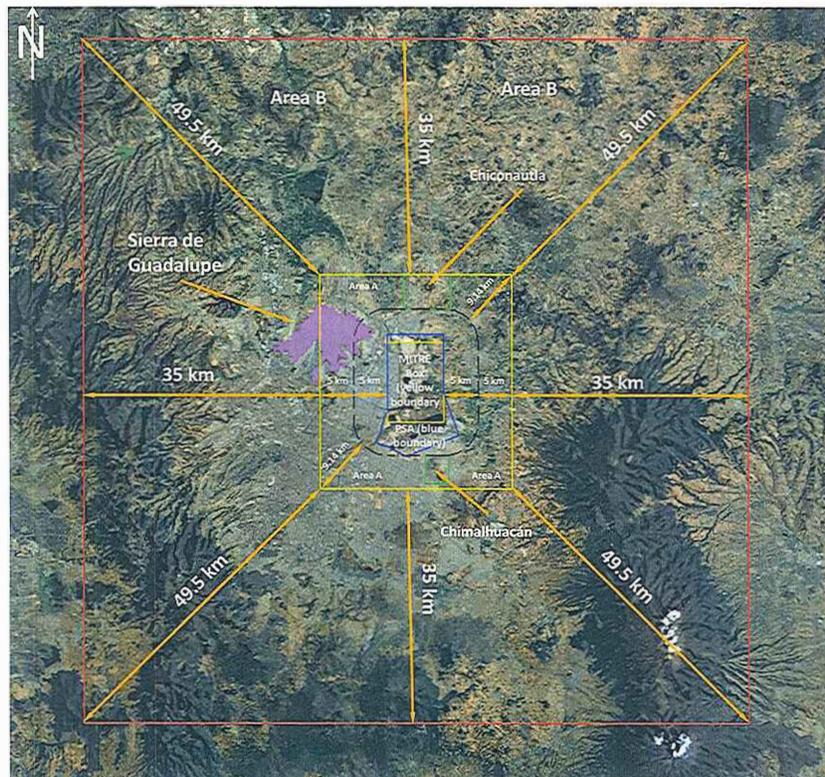
MITRE uses a variety of software applications and other tools when designing instrument procedures, such as AutoCAD, PDToolKit and the MITRE-developed Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS) software.

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 assist in the development of the RNAV departure 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 datum's
- 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 instrument procedure design are dependent on the currency, accuracy, and completeness of data used to develop the instrument 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 (AIP) of Mexico provided key aeronautical information used in the development of the instrument 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 Mexico Prohibited Areas (MMP) over and around Mexico City only affect Visual Flight Rules operations and do not need to be changed. Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) informed MITRE that MMP 11 “Primer Cuadro” and MMP 12 “San Lazaro” are rarely activated, should not significantly affect future operations and therefore do not need to be changed.
- 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’s runway is closed). 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 instrument 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 instrument 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 coverage were 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 II/III ILS (e.g., localizer, glideslope, approach lighting system) will be installed as necessary and meet operational requirements. All equipment will be flight-inspected and certified for use beyond normal operating distances (i.e., Expanded Service Volume) to accommodate instrument 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 initiated 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 Obstacle² of 200 ft was applied to terrain 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 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. 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 (AGL):
 - 99 00 45.2W, 19 29 17.7N (based on WGS84)
 - X: 498682.2500, Y: 2154853.1600 (based on Universal Transverse Mercator, Zone 14 North)
- All structures located on top of the Chiconautla hill must to be removed. Additionally, the Chiconautla hill itself penetrates the U.S. TERPS final approach OCS and must be graded appropriately.
- Future airport facilities (e.g., terminal buildings, aircraft parking stands, aprons, and other airfield components) must be located so as to 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
- Strict adherence to FAA criteria would not allow for the development of CAT II/III ILS approach procedures for NAICM. However, MITRE assumes that a reasonable safety case can be made that would allow for development of CAT II/III ILS approach procedures. See Appendix A for a more in-depth discussion.
- An Equivalent Level of Safety (ELOS) can be developed to address precipitous terrain in the final segment of all northbound ILS procedures
- Instrument approach and departure procedures to all runways were developed based on an assumed runway threshold elevation of 7293 ft (2223 m). This

² An Adverse Assumption Obstacle is intended to compensate for an overlooked or unaccounted for obstacles in the database.

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 instrument procedures.

3.5. 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 to the final approach. 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 Navigational Aids, 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.

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 used in the development of all instrument procedures described in this document.

4. Triple Independent Operations at NAICM

Triple independent operations require, at a minimum, well-designed arrival, approach and departure instrument procedures, extensive air traffic controller training, and well-defined regulatory guidance and 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 (e.g., operational practices at Atlanta), 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.

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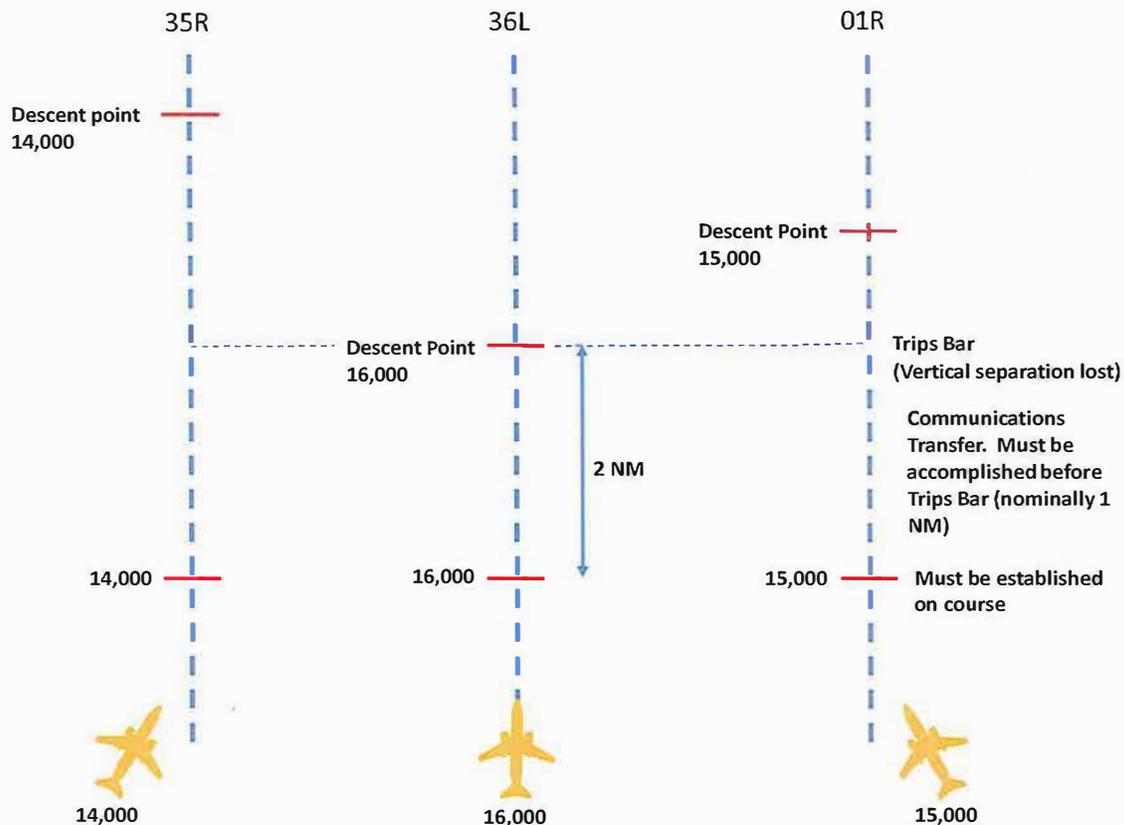


Figure 4. Northbound Triple Independent Approach Concept at NAICM

The operation of triple independent departures requires that their courses 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. NAICM CAT I/II/III ILS Approach Procedures

NAICM presents an interesting albeit difficult set of conditions for the development of CAT I/II/III ILS approach procedures. Procedure design criteria, airspace planning and ATC all have requirements that further complicate the procedure development process.

U.S. rules for the development for CAT II/III ILS procedures are relatively stringent. If strictly followed, CAT II/III ILS approach procedures for NAICM would not be allowed. Special instrument procedures could be developed for specific users, but they would not be made available to the general public and would almost certainly require the operator to meet a number of specific requirements, and would require special approval. However, MITRE assumed a suitable solution could be developed that would still allow for CAT II/III ILS procedures while still providing appropriate safety measures.

Appendix A provides a general discussion for the development of CAT II/III ILS approach procedures for NAICM.

The type of ILS equipment needed for CAT II/III operations is also important to understand. Appendix B provides useful information on the U.S. ILS classification system. It also contains information concerning the minimum class of performance required for an ILS to support a published CAT II or CAT III ILS standard approach procedure.

CAT II/III ILS procedures allow for very low approach minima. They should be considered when weather conditions or some other requirement at an airport warrant such procedures. MITRE conducted a detailed analysis of on-site weather data collected over a 5-year period. The results of that analysis are discussed below.

5.1. The Need for CAT II/III ILS Approach Procedures at NAICM Based on Collected Weather Data

MITRE conducted a detailed analysis of weather conditions at the NAICM site on the basis of over five years of data (i.e., 1 May 2009 to 11 October 2014) from an on-site Automated Weather Observing System (AWOS) located at El Caracol. Important information on the potential need for CAT II/III ILS approaches was included as well. See enclosure No. 1 to Technical Letter F500-L15-007: *Weather Analysis for the Nuevo Aeropuerto Internacional de la Ciudad de México Site*, dated 12 January 2015.

In the report, MITRE defined various weather categories in terms of ceiling height above the airport in ft and visibility in Statute Miles (sm). Weather conditions below a ceiling height of 200 ft and less than $\frac{1}{2}$ sm³ were deemed to be Low-Instrument Meteorological Conditions (L-IMC) where CAT II/III approach procedures may be needed. MITRE's analysis concluded that from 1 May 2009 to 11 October 2014, L-IMC conditions occurred on 81 days for a total of 111 hours. These conditions:

- Equated to approximately 20 hours of CAT II/CAT III weather per year
- Occurred on average over the course of 15 days per year
- Lasted a short duration (e.g., in 29 out of the 81 days L-IMC conditions lasted only 0.5 hours) and rarely exceeded 2.5 hours per day

The net result of the findings were that weather conditions requiring CAT II and CAT III ILS approach procedures were rare, occurring only about 0.15 percent and 0.09 percent of the time, respectively. These conditions primarily occurred between 3:30-9:30 am local, which makes the occurrence of such weather during typical high-demand operational time periods (e.g., 7:00 am to 11:30 am) even rarer. Note that

³ Weather information was collected from an installed AWOS at the NAICM site. The AWOS system does not have an RVR collection capability. However, the visibility data from the AWOS visibility sensor was used as a surrogate.

in such conditions winds were usually calm or favored a north flow, with a crosswind component rarely exceeding 10 kt.

Considering the above-mentioned findings, MITRE recommended that a thorough review be conducted by the Mexican aviation authorities to determine if CAT II and CAT III ILS approach procedures are required. This is important given the investment needed to provide CAT II and CAT III ILS capabilities, including navigation equipment, lighting and markings. At the same time, not to perform such a review would not be appropriate, given potential capacity disruptions, albeit for just 30 to 90 minutes, at such a major airport.

To perform such a review, detailed visibility measurements are required. Therefore, to do this, in early 2015 a Runway Visual Range (RVR) system was installed at the NAICM site near the AWOS. However, a vehicle struck the utility pole that provides commercial power to the AWOS and RVR that are installed at the NAICM site and, as a result, there is no commercial power to either the AWOS or RVR systems. It is essential that commercial power be restored to these systems as soon as possible. It is especially important that power be restored to the RVR system immediately as MITRE requires that data to examine CAT II and CAT III weather conditions to support important decisions.

Regardless of the decision by Mexican aviation authorities concerning the need for CAT II/III approach procedures, there are other factors that need to be considered in the decision-making process. These are described in the following sections.

5.2. CAT I Operations

The CAT I ILS approach procedure must be unrestricted for CAT II/III development to proceed. There are two significant issues (i.e., precipitous terrain and/or the use of a Climb Gradient [CG] to achieve a 200 ft Height Above Touchdown [HAT]) that prevent the NAICM CAT I ILS approach procedures from being “unrestricted”. Both are discussed in greater detail below. MITRE has assumed that a successful resolution for both these issues can be reached in order to allow for the development of CAT II/III approaches at NAICM. See Appendix A for additional information.

5.2.1. 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 to be taken should these conditions exist. The process involves using a complicated set of algorithms that evaluates variations in terrain elevation within a given segment. If precipitous terrain conditions are present in the initial or intermediate segments of an approach procedure, an adjustment is determined and applied to that segment’s Required Obstacle Clearance (ROC). If precipitous terrain conditions are present in the final segment, the HAT must be raised above 200 ft, which means the CAT I ILS approach procedure is no longer considered to be unrestricted.

Precipitous terrain conditions are present in all NAICM northbound final segments. Therefore an adjustment to the HAT is required. While this adjustment may be small (i.e., 9-12 ft) it does raise the HAT above 200 ft (i.e., 209 ft or 212 ft).

As a reminder, the final segments for all the northbound instrument procedures are very long. MITRE's analysis indicates that precipitous terrain conditions exist at the far end of the final segment (i.e., furthest from the runway approach end). While additional studies should be conducted, this information could be used to support an ELOS⁴ finding as justification to satisfy the 200 ft HAT requirement.

5.2.2. Missed Approach Climb Gradients

With the exception of Runway 36L, all opening-day CAT I ILS approach procedures, to include Runway 35L/17R, require a CG. Procedure designers use CGs as a method to achieve the lowest landing minima possible. If the CG becomes unreasonable, the landing minima may be adjusted upward to help lower the CG. This works well for CAT I procedures. However, when CAT II/III procedures are required, FAA rules stipulate that the CAT I ILS approach must be unrestricted. The FAA also infers that use of a CG to achieve the 200 ft HAT does not meet the intent of an unrestricted CAT I ILS approach procedure.

Please note there is at least one known case in the U.S. of a CAT I ILS that has a 200 ft HAT with a CG, but also has a CAT II/II ILS procedure developed to the same runway. The ILS or LOC RWY 28R at San Francisco International Airport has a 200 ft HAT and ½ mile sm visibility, but requires a 350 ft/NM CG to 1900 ft. The CAT II/III approach procedure developed to the same runway also requires a 350 ft/NM CG. Although not in accordance with FAA criteria, it does point to at least one situation in the U.S. that does not meet the stated interpretation of the unrestricted CAT I ILS standard.

It is important to note that ICAO procedure design requirements and criteria differ from U.S. standards when it comes to the development of CAT II/III ILS approach procedures. Specifically, there is no requirement for an unrestricted CAT I ILS approach procedure in order to have a CAT II/III ILS approach procedure on the same runway. There are examples of ICAO CAT I ILS approach procedures that have a HAT greater than 200 ft and/or a CG in the missed approach segment, yet still allow for CAT II/III instrument approach procedures to the same runway⁵. Again, these situations are rather unique but do serve to show that given a set of circumstances there are design options that could be explored and considered.

MITRE believes that if all appropriate factors are considered and examined, an ELOS could be developed that would allow CAT II/III ILS approach procedures to be published

⁴ ELOS findings are made when literal compliance with an airworthiness standard cannot be shown and compensating factors exist that can be shown to provide an ELOS.

⁵ Tegel Airport in Germany (EDDT) has a CAT I ILS approach procedure with a higher than 200-ft HAT, but still has a CAT II/III approach procedure to that runway. Hong Kong International Airport (VHHH) has a CAT I ILS approach procedure with a 5% CG that is needed to achieve a 200 ft HAT, but still has a CAT II approach procedure to that runway. The CAT II approach procedure also requires a 5% CG.

at NAICM despite the presence of a non-standard CG and/or a precipitous-terrain adjustment. However, MITRE's view is only advisory and preliminary, and the entire matter should be the subject of a thorough review by all interested parties.

5.3. CAT II/III Operations

Because of their nature (e.g., lower authorized landing minima), CAT II and CAT III ILS approaches require special certification for operators, pilots, aircraft, and airborne/ground equipment. The U.S. requires that air carriers and commercial operators desiring lower than CAT I ILS minimums obtain Operation Specifications (OpSpecs) authorization from the FAA. OpSpecs are unique regulations applicable to a particular operator. They are specifically applicable to and tailored to a particular operator's aircraft, routes, and operating circumstances. They are developed by the FAA and provided to FAA field offices to aid in development and issuance of the particular and unique OpSpecs issued to each operator. The OpSpecs of individual air carriers and commercial operators detail the requirements for these types of approaches as well as their performance criteria. The following section provides additional information related to and specific to the development of the CAT II/III ILS approach procedures described in this report.

5.3.1. CAT II Operations

A Class II/T/2 ILS system is the minimum class of performance authorized for CAT II operations (See Appendix B). Standard (i.e., unrestricted) CAT II minima are reported in the form of a Decision Altitude/Height⁶ (DA/H) and an RVR. The lowest CAT II HAT/RVR is 100 ft/1200 ft if there are no obstacle penetrations of the final segment, portions of Section 1 of the missed approach and the inner-approach Obstacle Free Zone (OFZ). Fortunately, none of those surfaces for the CAT II ILS approach procedures at NAICM have been penetrated, so the lowest landing minimums are possible.

Additionally, CAT II approach procedures for all opening-day runways (including Runway 35L/17R), with the exception of Runway 36L, require CGs. A CG on a CAT II ILS procedure would normally trigger a collision risk analysis. However, that type of analysis only evaluates obstacles located in and near the final, OFZ and straight portion of the missed approach. All obstacles generating CGs for the CAT II ILS approach procedures are located six or more miles from the airport. Therefore, the CG itself provides an appropriate level of obstacle protection. As a result, a collision risk analysis in this case for NAICM is not appropriate.

5.3.2. CAT III Operations

In 2012, the U.S. determined that the CAT IIIa, CAT IIIb and CAT IIIc operations definitions were outdated, unnecessary, and overly restrictive. Therefore, the CAT IIIa, CAT IIIb and CAT IIIc definitions are no longer used for aircraft certification or

⁶ Decision Altitude is an altitude on final referenced to MSL. Decision Height is at the same location of the Decision Altitude, but is referenced as an AGL height above touchdown zone elevation.

operational authorization, instead deferring to the demonstrated capabilities of the aircraft to land and rollout on the runway. These operations definitions were divided into specific RVR (visibility) bands. For example, the lowest RVR for CAT IIIa was 700 ft (200 m), for CAT IIIb 600 ft (175 m) and for CAT IIIc 150 ft (50 m). Currently, the U.S. considers any approach and landing below 1000 ft RVR a CAT III operation⁷. While ICAO has not formally retired these operations definitions there is an effort underway to rationalize and standardize CAT III approach minima internationally.

The lowest publishable CAT III RVR is based on the performance classification of the ILS equipment. The ILS equipment performance classification is determined by FAA Tech Ops in accordance with FAA Order 6750.24, and the RVR associated with each classification is provided in the Memorandum of Understanding dated 16 August 2011, *Interim Criteria for Precision Approach Obstacle Assessment and Category II/III Instrument Landing System (ILS) Requirements*.

Standard CAT III minima are stated in terms of RVR. Table 1 shows the lowest authorized CAT III RVR when the runway supports unrestricted CAT II operations. A restricted CAT II ILS approach procedure is one where penetrations exist to any applicable surfaces described in the above-mentioned FAA Memorandum. None of the CAT II/III approach procedures at NAICM have obstacle penetrations to the surfaces mentioned in the Memorandum.

Table 1. Lowest Authorized CAT III RVR When the Runway Supports Unrestricted CAT II Operations

Equipment Performance Class	RVR (ft)
Class III/D/3*	≥ 700
Class III/E/3	≥ 600
Class III/E/4	< 600

*CAT III procedures with facility class III/D/3 performance require the notation “Localizer not suitable for Electronic Rollout Guidance.” See Appendix B.

To be approved for CAT III operations, the airplane and its associated systems should be capable of safely completing an approach, touchdown, and rollout and permitting a safe go-around from any altitude to touchdown following any failure condition not shown to be extremely improbable.

Cockpit design, instrumentation, annunciations and warning systems, should be adequate in combination to assure that the pilot can verify that the aircraft should touch down within the touchdown zone and safely rollout if the controlling visibility is reported at or above applicable minima. Systems based on automatic control to touchdown, or

⁷ CAT III operational approvals and instrument procedures are described in terms of RVR.

touchdown and rollout and manually flown flight guidance system (e.g., heads up display), have been approved by the FAA. Other concepts may be acceptable if proof of concept testing can demonstrate an equivalent or greater level of safety as presently specified for approval of automatic systems (e.g., hybrid systems or vision enhancement systems).

Operators determine the minima for a particular approach by comparing the lowest minima shown on the chart with the lowest minima they are allowed in their OpSpec. They then use no lower than the higher of the two numbers. Therefore, there is no need to show any minima on the chart other than the lowest allowed based on the ILS equipment classification.

While there are slight variations of these definitions as used within ICAO and various countries internationally, the broad objectives and practical operational applications are similar. For example, in other States, a CAT I ILS approach may only apply to a straight-in ILS procedure. Also, in certain States, lowest authorized minima may be slightly different than that promulgated by the U.S. or ICAO criteria. In a few States, these approach categories relate more closely to aircraft configuration or ILS facilities used, rather than directly to landing minima and visibility or RVR.

5.4. Assessment of the CAT II/III ILS Approach Procedures

This section describes the results of MITRE's assessment of CAT II/III ILS approach procedures for the NAICM opening-day runway configuration (Runways 35R/17L, 36L/18R, and 01R/19L) currently being considered by the aviation authorities of Mexico. Results for Runway 35L/17R are included as well. 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 Section 6. Figure 5 provides an explanation of the CAT II/III lines of minima in the profile figures.

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Radio Altimeter (RA):
 Difference between ground elevation (ft)
 and DA (MSL) at DA distance

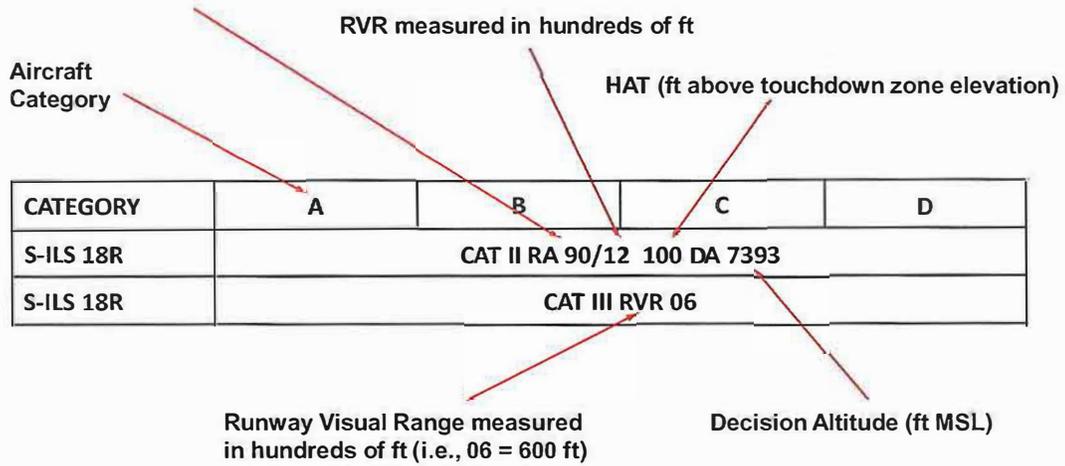
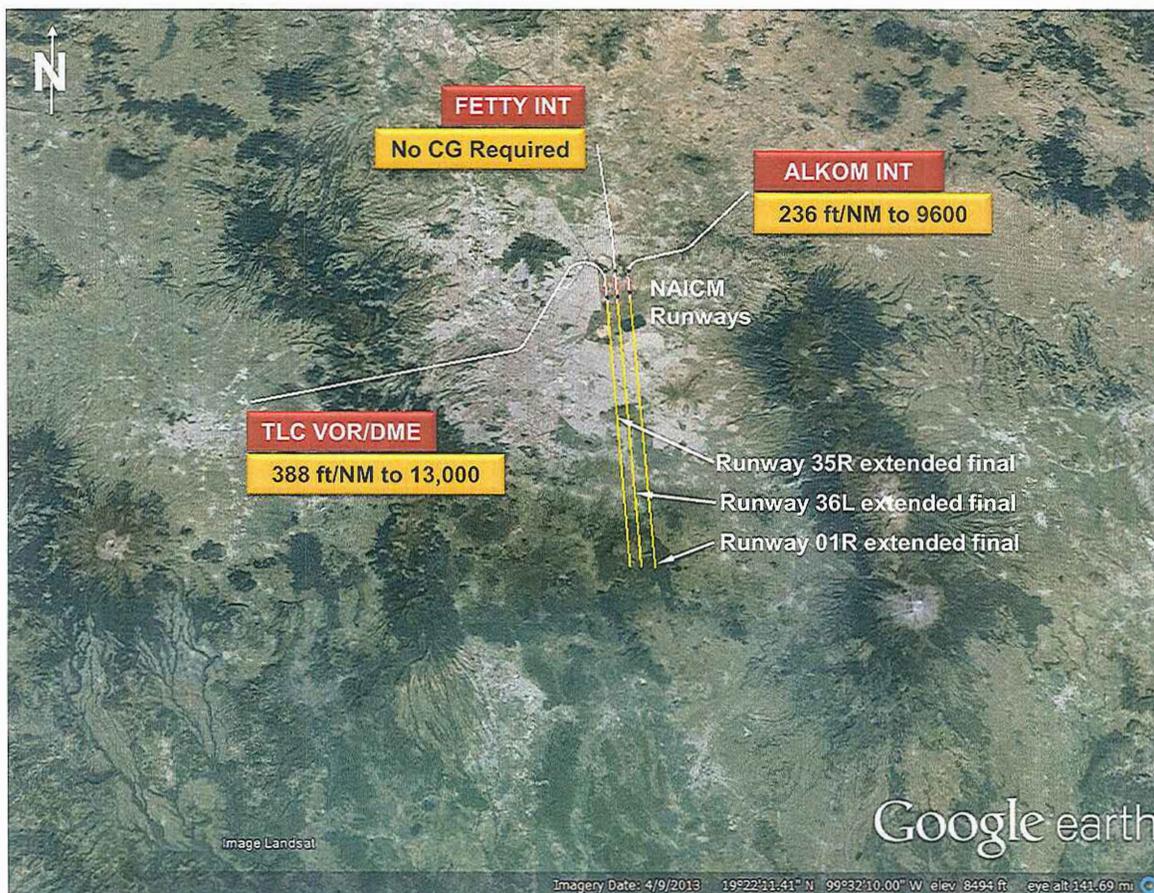


Figure 5. CAT II/III Lines of Minima Explained

Figures 6 and 7 show an overhead view of the CAT II/III 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.

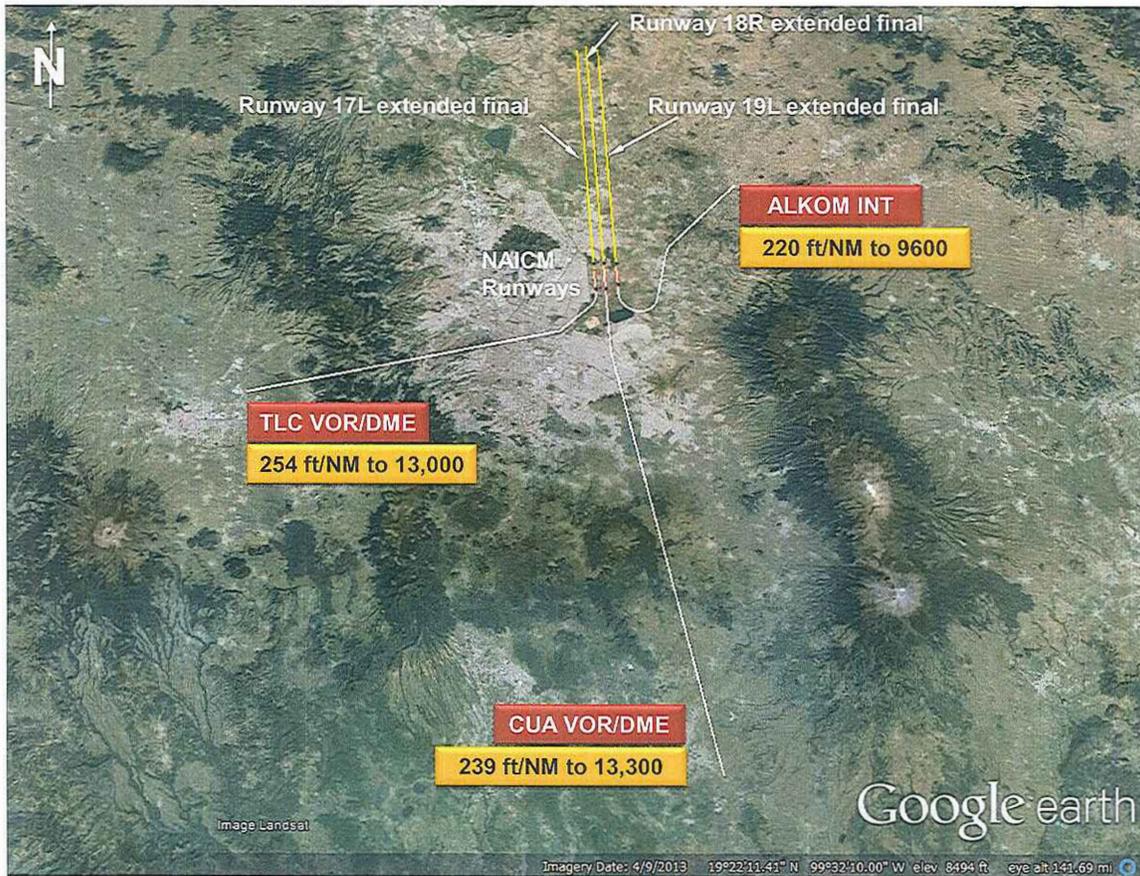
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Source: GoogleEarth Pro

**Figure 6. CAT II/III ILS Final and Missed Approach Nominal Flight Tracks:
North Flow**

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Source: GoogleEarth Pro

**Figure 7. CAT II/III ILS Final and Missed Approach Nominal Flight Tracks:
South Flow**

5.4.1. Runway 35R

Intermediate Segment: The IF is located 35.4 DME⁸ 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 Precise Final Approach Fix [PFAF]). Precipitous terrain is present so an additional 12 ft adjustment has been applied to the HAT.

⁸ DME distances are in NM

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.

Controlling obstacles for each segment of the Runway 35R CAT II/III ILS approach are shown in Table 2.

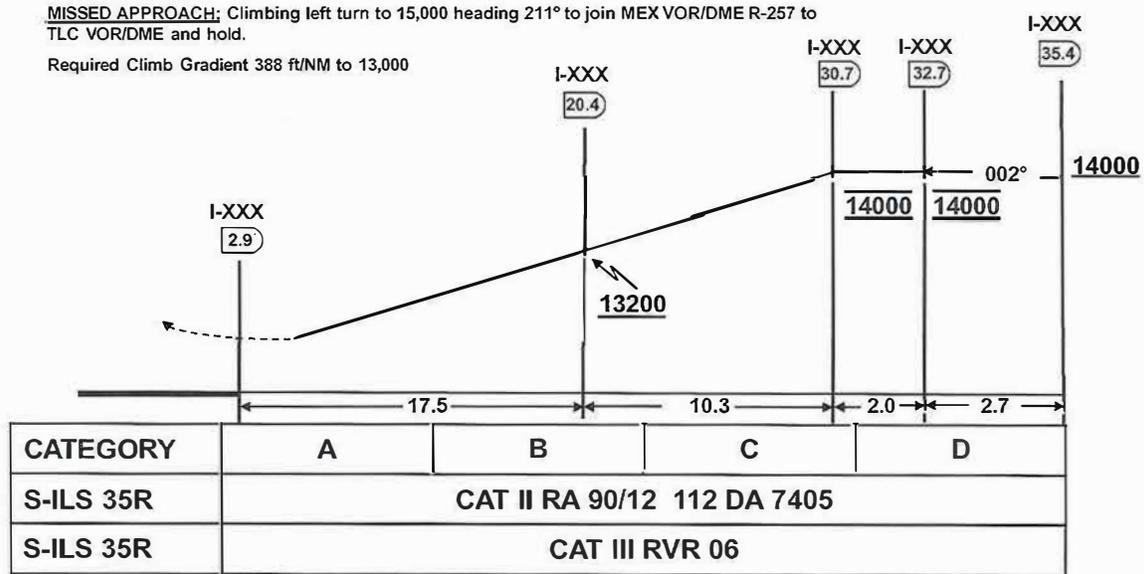


Figure 8. Runway 35R CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 2. Runway 35R CAT II/III 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 35 18.60N	99 05 43.09W	9357
	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

5.4.2. 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 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. A CG is required.

Controlling obstacles for each segment of the Runway 35L CAT II/III ILS approach are shown in Table 3.

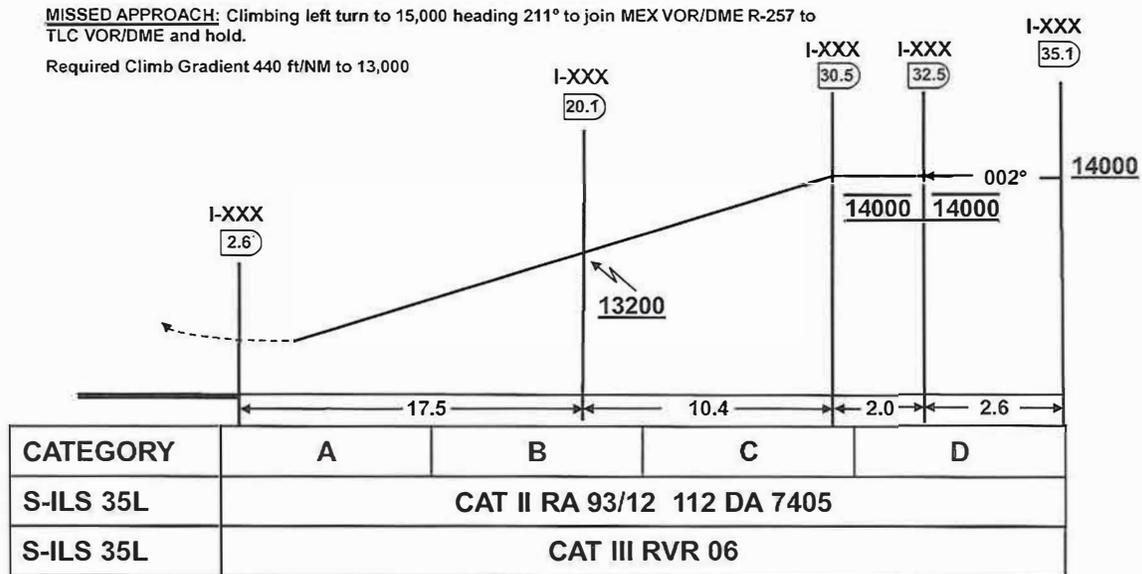


Figure 9. Runway 35L CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 3. Runway 35L CAT II/III 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 35 18.29N	99 06 01.42W	9617
	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

5.4.3. 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 10. No CG is required.

Controlling obstacles for each segment of the Runway 36L CAT II/III ILS approach are shown in Table 4.

MISSED APPROACH: Climb to 13,000 on heading 002° and TEX VOR/DME R-358 to FETTY INT, then as directed by ATC.
 No Climb Gradient Required

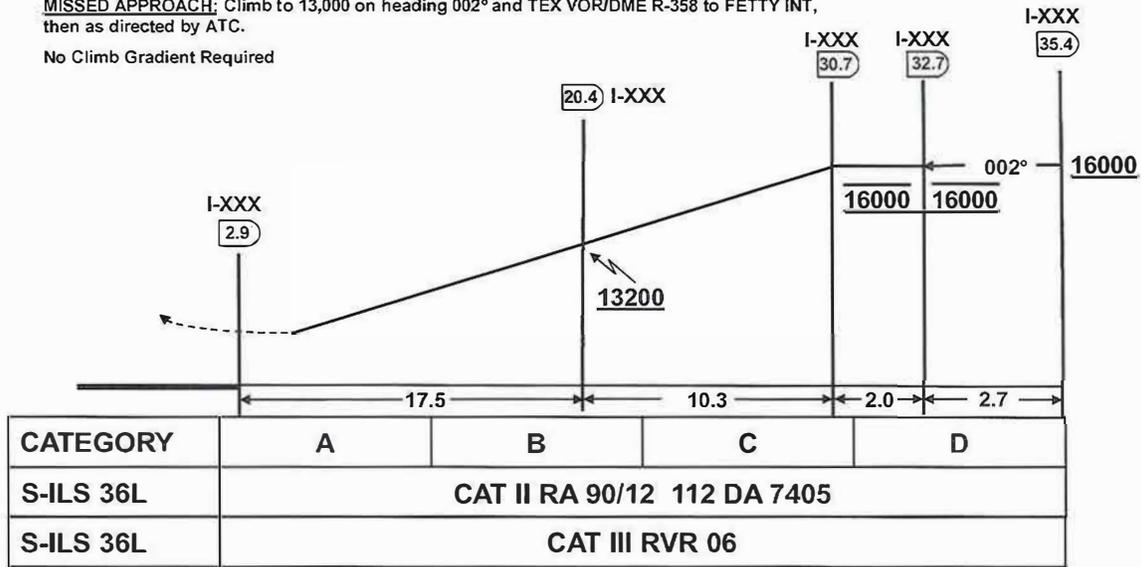


Figure 10. Runway 36L CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 4. Runway 36L CAT II/III 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

5.4.4. 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 11. A CG is required.

Controlling obstacles for each segment of the Runway 01R CAT II/III ILS approach are shown in Table 5.

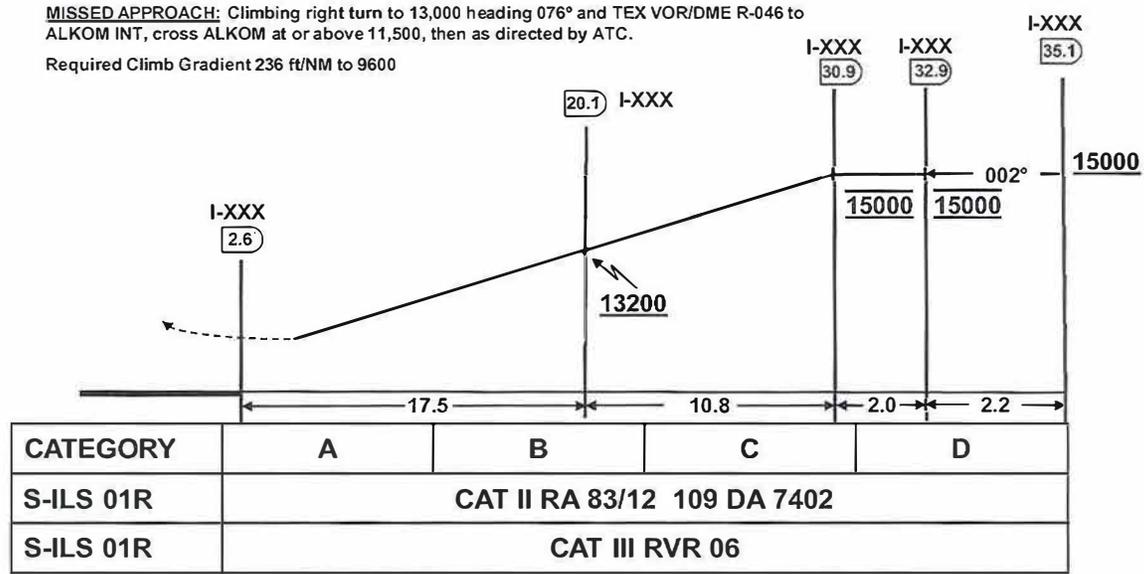


Figure 11. Runway 01R CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 5. Runway 01R CAT II/III 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	Building*	19 35 26.24N	98 52 08.44W	8639
	Terrain**	19 38 02.02N	98 50 29.23W	9072

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

5.4.5. 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).

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.

Controlling obstacles for each segment of the Runway 17L CAT II/III ILS approach are shown in Table 6.

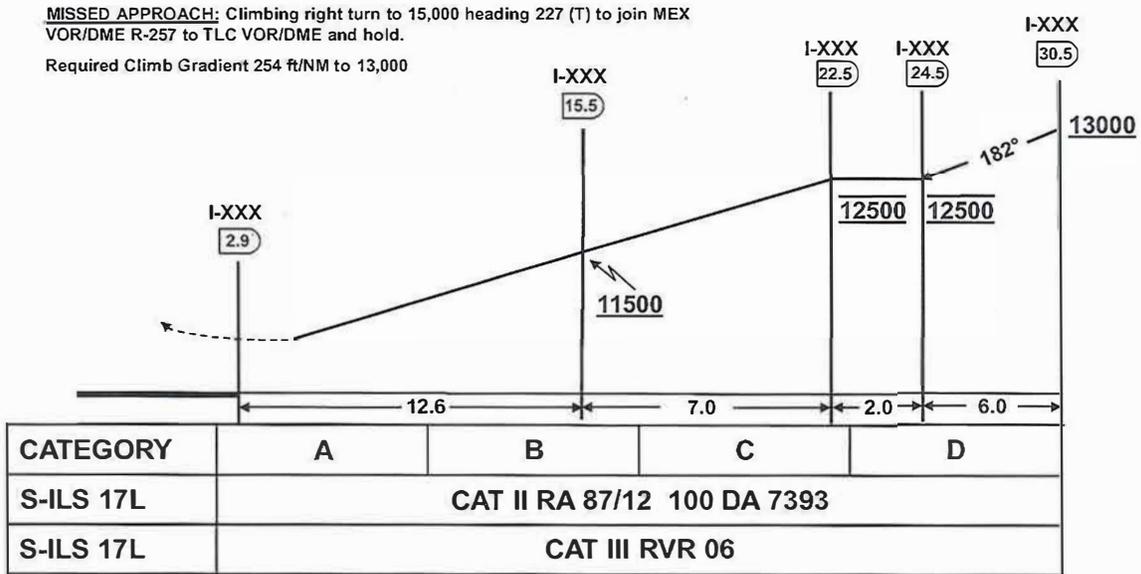


Figure 12. Runway 17L CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 6. Runway 17L CAT II/III 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

5.4.6. 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).

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.

Controlling obstacles for each segment of the Runway 17R CAT II/III ILS approach are shown in Table 7.

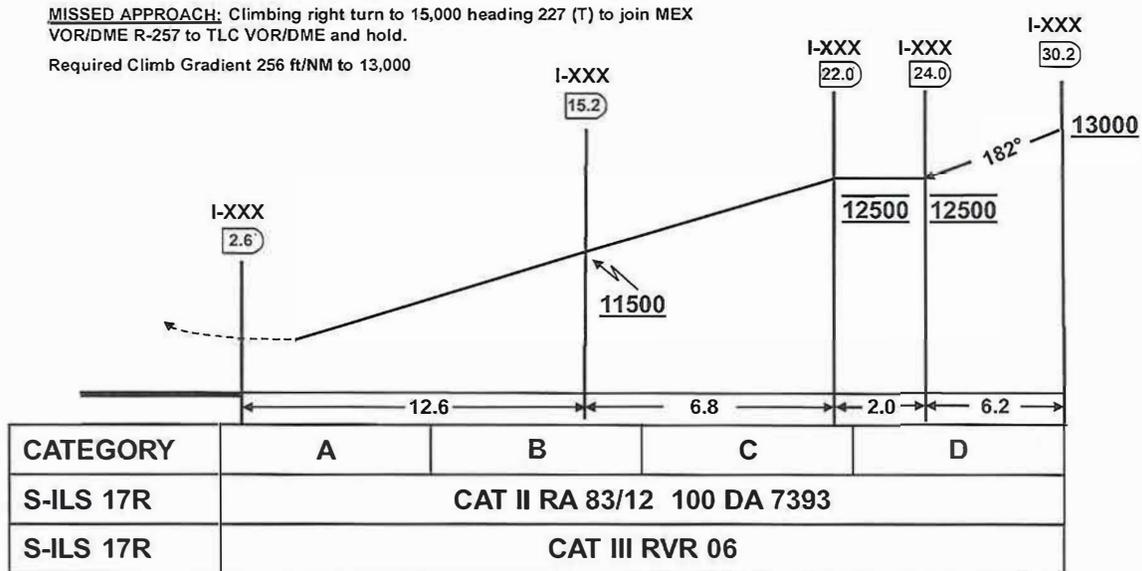


Figure 13. Runway 17R CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 7. Runway 17R CAT II/III 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

5.4.7. 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).

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.

Controlling obstacles for each segment of the Runway 18R CAT II/III ILS approach are shown in Table 8.

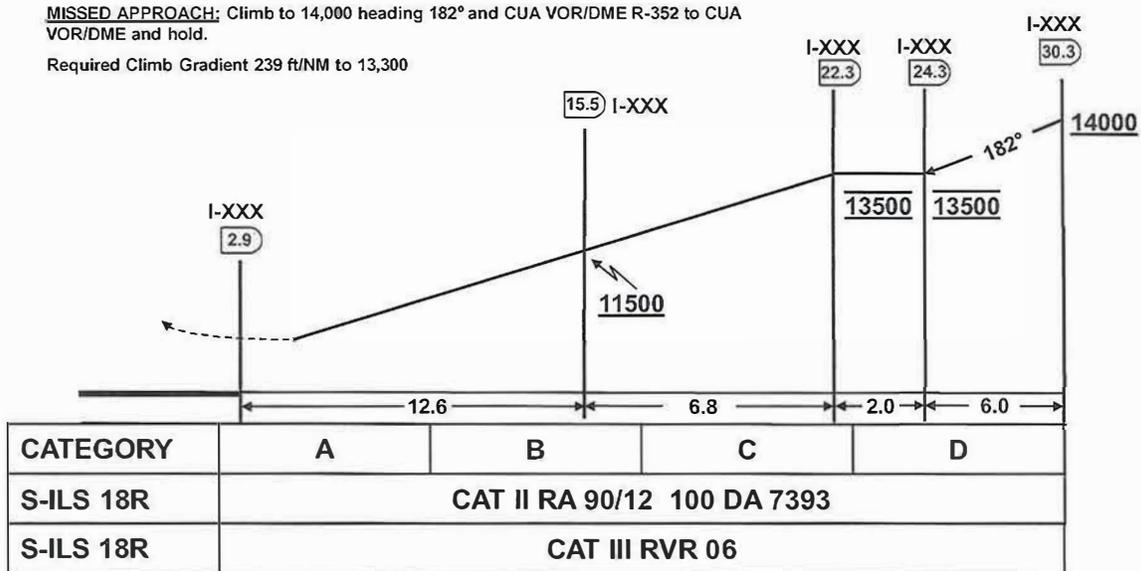


Figure 14. Runway 18R CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 8. Runway 18R 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

5.4.8. 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)⁹. 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 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 the 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 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).

Missed Approach Segment: The missed approach segment commences at the MAP. Missed approach instructions are described in the profile below shown in Figure 15. A CG is required.

Controlling obstacles for each segment of the Runway 19L CAT II/III ILS approach are shown in Table 9.

⁹ 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.

MISSED APPROACH: Climbing left turn to 13,000 heading 016 and TEX VOR/DME R-046 to ALKOM INT, cross ALKOM at or above 11,500, then as directed by ATC.
 Required Climb Gradient 220 ft/NM to 9600

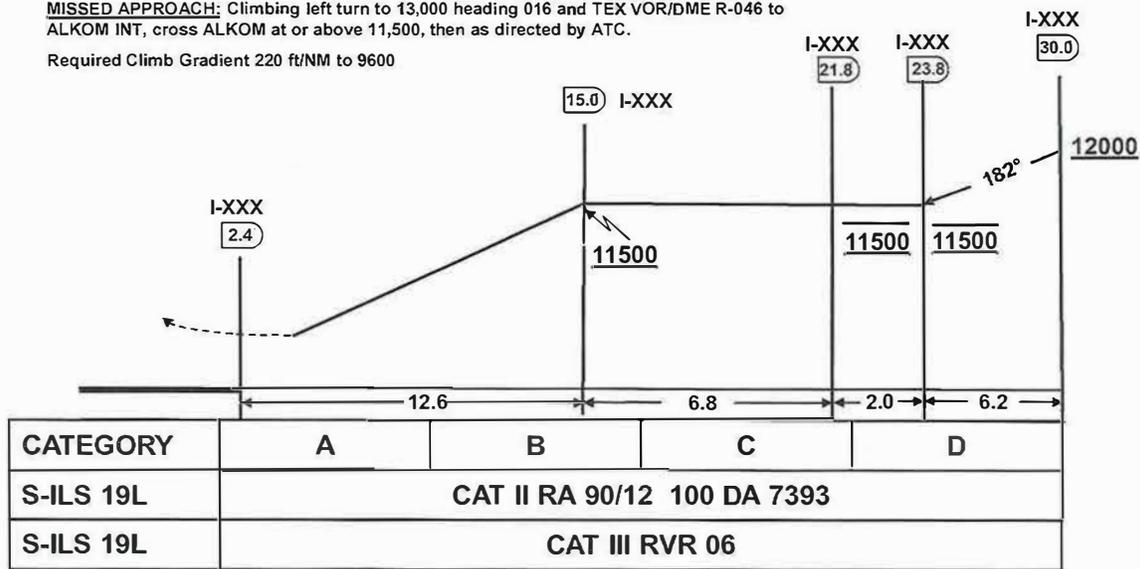


Figure 15. Runway 19L CAT II/III ILS: Profile View and Approach Minimums (Not Intended for Navigation/Publication)

Table 9. Runway 19L CAT II/III 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

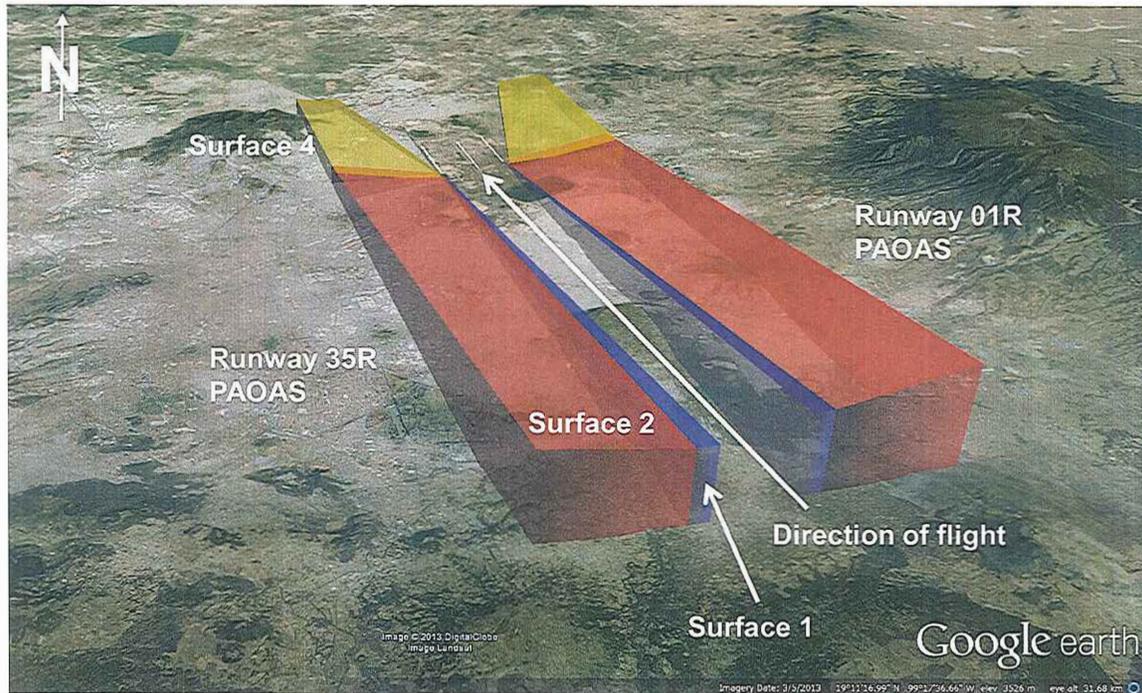
5.4.9. Parallel Approach Obstruction Assessment Surfaces

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. There are four PAOA surfaces. Surfaces 1 and 2 are common between CAT I/II/III approaches. Surface 3 is evaluated for the CAT I missed approach while Surface 4 is evaluated for the CAT II/III missed approach.

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 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 16 shows the PAOAS for Runways 35R¹⁰ and 01R. Figure 17 shows the PAOAS for Runways 17L and 19L.

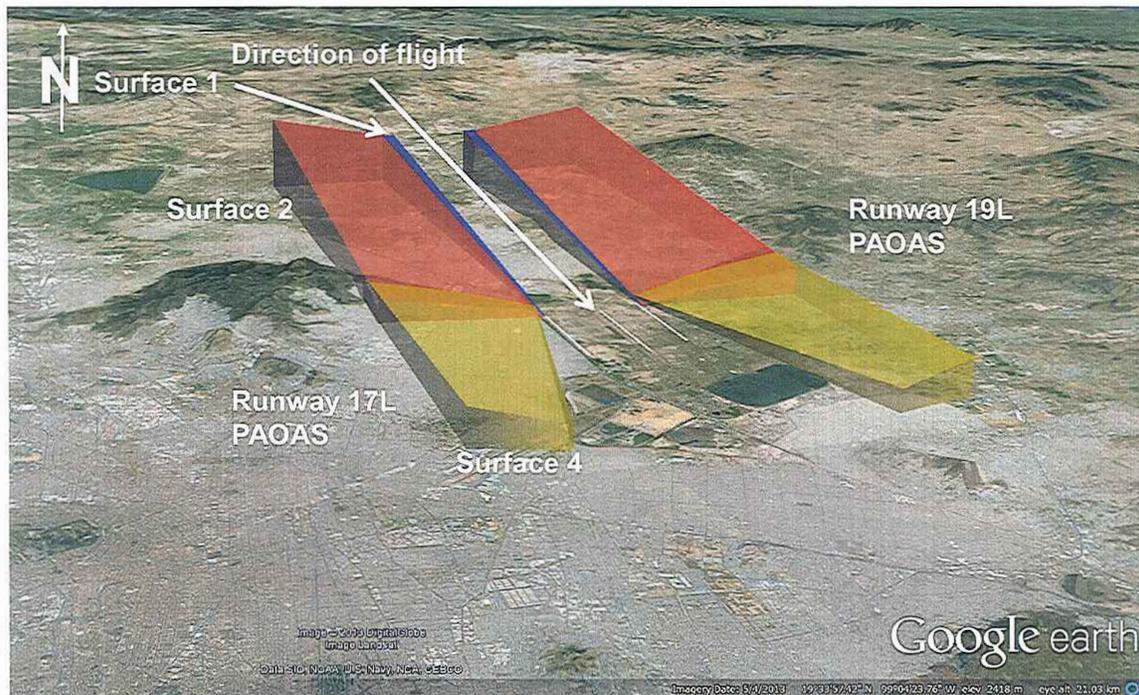
While not reflected in Figures 16 and 17, MITRE extended the PAOAS for Runway 35R/17L and Runway 35L/17R to the western side of Sierra de Guadalupe to ensure that the mountain, including the antennas on its peaks, did not penetrate the surfaces.



Source: GoogleEarth Pro

Figure 16. PAOAS for Runways 35R and 01R

¹⁰ MITRE also evaluated the PAOAS for Runways 35L/17R 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 17. PAOAS for Runways 17L and 19L

6. Independent Parallel RNAV Departure Procedures

RNAV is a method of navigation that permits aircraft operation on any desired flight path within the coverage of station-referenced navigation equipment or within the limits of the capability of self-contained equipment, or a combination of these. RNAV procedures help airlines enhance operational efficiency through increased airspace capacity and decreased flight times through a more efficient design. The procedures discussed in this section were developed to the default RNAV departure design specification RNAV 1, meaning an aircraft must have a 95% probability of being within 1 NM either side of the projected flight track.

The MITRE RNAV designs provide for navigation soon after takeoff by requiring an initial climb gradient, and supports course divergence of the initial route segments within 1 NM from the end of runway. This allows RNAV departure flows to access routings enabling ATC to make more efficient use of airspace and runway capacity. All RNAV departures are expected to climb at an initial rate of 500 ft/per NM to 7800 ft for RNAV navigation engagement, unless a higher CG is required for obstacle clearance. If there is a lower climb gradient required for obstacle clearance, that climb gradient becomes effective after the aircraft reaches 7800 ft.

For airspace design purposes, these procedures have been designed considering the conventional departure procedures that MITRE previously designed for NAICM as much as possible. However, as airport development matures, the airspace plan becomes more

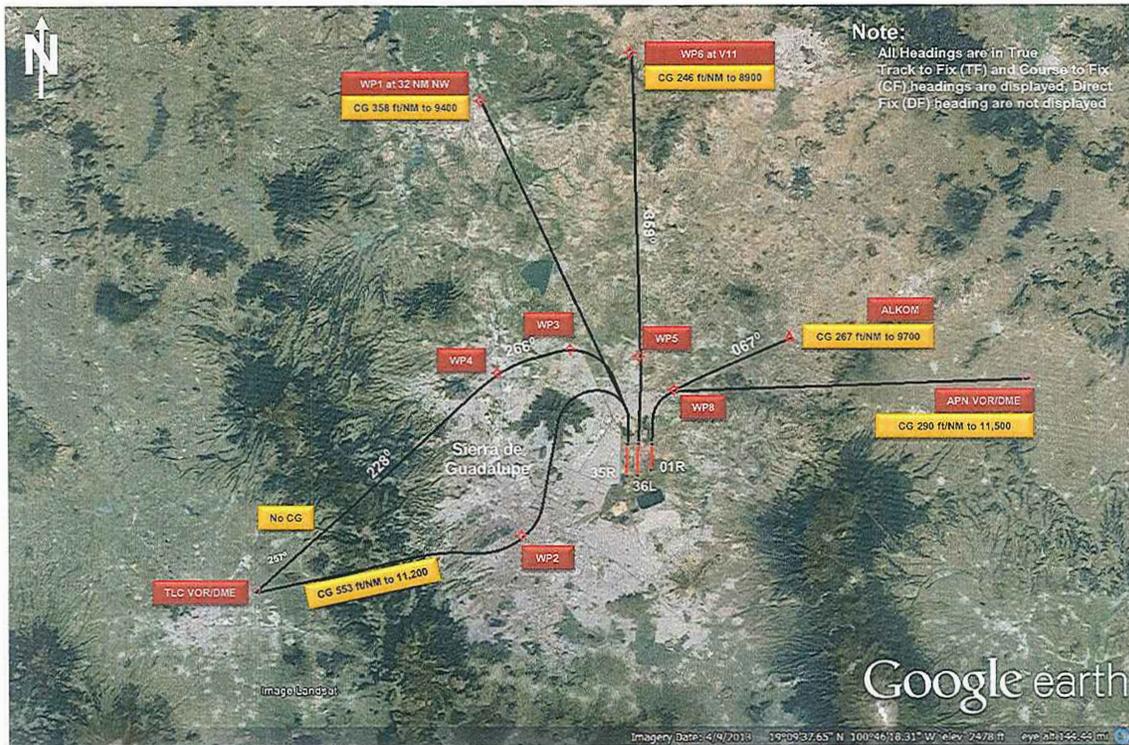
finalized and ATC procedures are formalized, these RNAV departure procedures can be further refined to meet a more optimized design.

MITRE recommends that RNAV departure procedure design strategies involve input from airline operators and Air Traffic Facilities. Airlines should establish and document RNAV environmental performance benefits for their operations, including fuel, emissions, distance, and time enhancements. Air Traffic Facilities should establish and document RNAV benefits that improve terminal traffic patterns which accommodate local traffic flows serving the main airport and nearby airports.

One departure procedure each has been developed for Runways 18R and 36L (i.e., the center runway). Runway 35R (and Runway 35L) has three departures procedures. All other runways have two departure procedures. Two departure procedures will allow “fanned” departure operations (i.e., operations that employ 45° divergence between aircraft departing the same runway further maximizing airport capacity). A minimum of 15° divergence was used between departure procedures from parallel runways to allow independent departures to be conducted. Aircraft desiring to fly these RNAV departure procedures must be appropriately equipped.

Figures 18 and 19 show the nominal RNAV flight tracks for the NAICM opening-day runways: 35R/17L, 36L/18R, and 01R/19L. MITRE is also including an assessment of the RNAV departure procedures for Runways 35L/17R, in case authorities decide to include those runways in the opening-day runway configuration instead of Runways 35R/17L. The following paragraphs provide information pertaining to each RNAV departure to include takeoff minimums, departure instructions, and CGs.

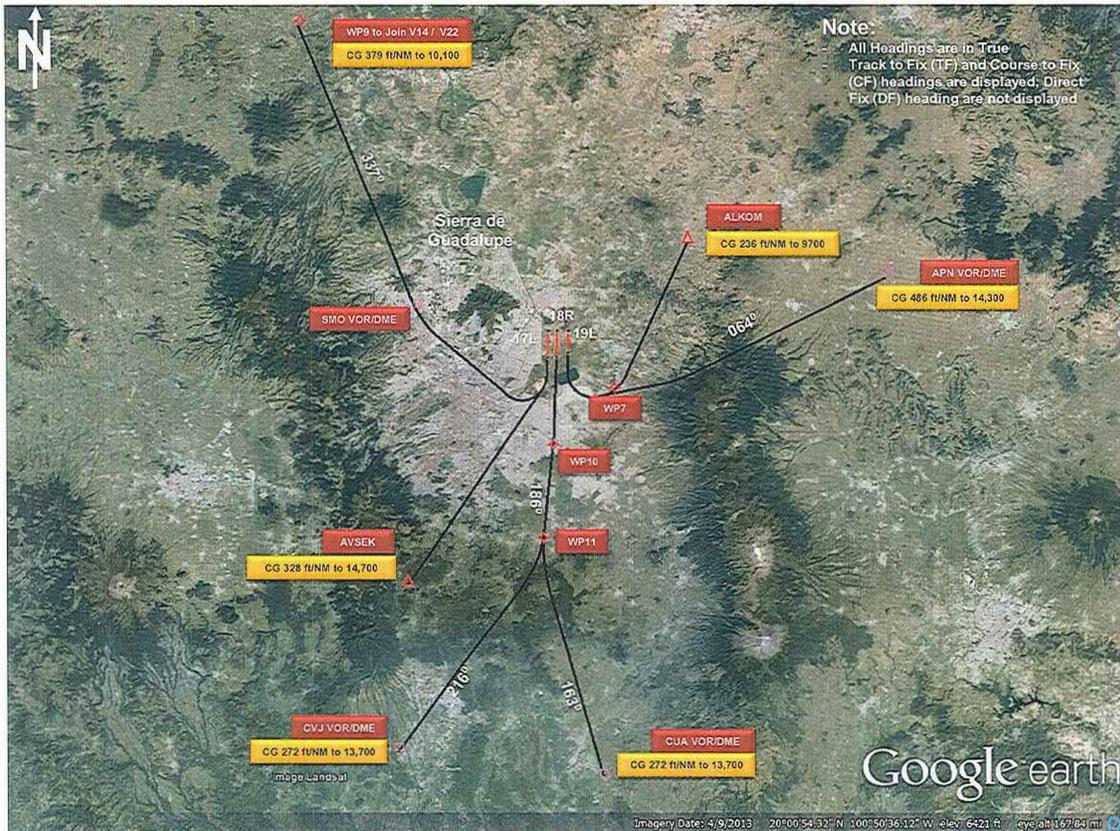
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Source: GoogleEarth Pro

Figure 18. Departure Nominal Flight Tracks: North Flow

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Source: GoogleEarth Pro

Figure 19. 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 TLC VOR/DME
2. A left turn around the north side of Sierra de Guadalupe then turning southwest to TLC VOR/DME
3. A left turn to the northwest proceeding 32 NM to Waypoint WP1

Information for RNAV departures from Runway 35R is provided below. See Table 10 for CG obstacle information.

6.1.1. TLC Departure (Hard Left Turn)

Takeoff Minimums: Standard with a minimum CG of 553 ft/NM¹¹ to 11,200 ft.

Departure Instructions: Climb heading 002° to 7800 ft, then climbing left turn direct to WP2, then on track 257° to TLC VOR/DME, maintain 16,000 ft, then on course.

¹¹ In the U.S., CGs in excess of 500 ft/NM require approval from an approving authority.

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

Takeoff Minimums: Standard

Departure Instructions: Climb heading 002° to 7800 ft, then climbing left turn direct to WP3, then on track 266° to WP4, then on track 228° to TLC VOR/DME, maintain 16,000 ft, then on course.

6.1.3. Northwest Departure

Takeoff Minimums: Standard with a minimum CG of 358 ft/NM to 9400

Departure Instructions: Climb heading 002° to 7800 ft, then climbing left turn direct to WP1, maintain 16,000 ft, then on course.

Table 10. Runway 35R Climb Gradient Controlling 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			
WP1	358 ft/NM to 9400	Terrain	19 36 11.62N	99 04 53.90W	8825

Coordinates are based on WGS84

*If takeoff weather minimums are not prescribed, FAA weather minimums for takeoffs under Instrument Flight Rules (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)

There are three proposed departure procedures from Runway 35L:

1. A hard left turn to TLC VOR/DME
2. A left turn around the north side of Sierra de Guadalupe then turning southwest to TLC VOR/DME
3. A left turn to the northwest proceeding 32 NM to WP1

Information for RNAV departures from Runway 35L is provided below. See Table 11 for CG obstacle information.

6.2.1. TLC Departure (Hard Left Turn)

Takeoff Minimums: Standard with a minimum CG of 564 ft/NM¹² to 11,200 ft.

Departure Instructions: Climb heading 002° to 7800 ft, then climbing left turn direct to WP2, then on track 257° to TLC VOR/DME, maintain 16,000 ft, then on course.

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

Takeoff Minimums: Standard

Departure Instructions: Climb heading 002° to 7800 ft, then climbing left turn direct to WP3, then on track 266° to WP4, then on track 228° to TLC VOR/DME, maintain 16,000 ft, then on course.

6.2.3. TLC Departure (Northwest)

Takeoff Minimums: Standard with a minimum CG of 412 ft/NM to 9600 ft.

Departure Instructions: Climb heading 002° to 7800 ft, then climbing left turn direct to WP1, maintain 16,000 ft, then as assigned by ATC.

Table 11. Runway 35L Climb Gradient Controlling 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			
WP1	412 ft/NM to 9600	Terrain	19 36 08.60N	99 04 57.11W	9039

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 to join V11. Information for the RNAV departure from Runway 36L is provided below. See Table 12 for CG obstacle information.

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

Departure Instructions: Climb heading 002° to 7800 ft, then direct to WP5, then on track 359° to WP6 to join V11, maintain 16,000 ft, then on course.

¹² In the U.S., CGs in excess of 500 ft/NM require approval from an approving authority.

Table 12. Runway 36L Climb Gradient Controlling Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
WP6 at V11	246 ft/NM to 8900	Terrain	19 39 00.86N	98 58 3.21W	8508

Coordinates are based on WGS84

6.4. Runway 01R

There are two proposed departure procedures from Runway 01R:

1. A right turn to ALKOM
2. A right turn to APN VOR/DME

Information for RNAV departures from Runway 01R is provided below. See Table 13 for CG obstacle information.

6.4.1. ALKOM

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

Departure Instructions: Climb heading 002° to 7800 ft, then climbing right turn direct to WP8, then on track 067° to ALKOM, maintain 16,000 ft, then on course.

6.4.2. APN VOR/DME

Takeoff Minimums: Standard with a minimum CG of 290 ft/NM to 11,500 ft.

Departure Instructions: Climb heading 002° to 7800 ft, then climbing right turn to APN VOR/DME, maintain 16,000 ft, then on course.

Table 13. Runway 01R Climb Gradient Controlling Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
ALKOM	267 ft/NM to 9700	Terrain	19 38 02.02N	98 50 29.23W	9071
APN VOR/DME	290 ft/NM to 11,500	Building*	19 35 26.24N	98 52 08.44W	8639
		Terrain**	19 32 46.31N	98 42 09.79W	10,449

Coordinates are based on WGS84

*Missed approach obstacle for CG

**Missed approach obstacle for climb to altitude

6.5. Runway 17L

There are two proposed departure procedures from Runway 17L:

1. A right turn to SMO VOR/DME, then WP9 (V14/V22)
2. A right turn to AVSEK

Information for RNAV departures from Runway 17L is provided below. See Table 14 for CG obstacle information.

6.5.1. SMO to WP9 (V14/V22)

Takeoff Minimums: Standard with a minimum CG of 379 ft/NM to 10,100 ft

Departure Instructions: Climb heading 182° to 7800 ft, then climbing right turn direct to SMO VOR/DME, then on track 337° to WP9 to join V14/22, maintain 16,000 ft, then on course.

6.5.2. AVSEK

Takeoff Minimums: Standard with a minimum CG of 328 ft/NM to 14,700 ft.

Departure Instructions: Climb heading 182° to 7800 ft, then climbing right turn to AVSEK, maintain 16,000 ft, then as assigned by ATC.

Table 14. Runway 17L Climb Gradient Controlling Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
WP9 (V14/22)	379 ft/NM to 10,100	Antenna	19 32 08.43N	99 07 49.13W	9422
AVSEK	328 ft/NM to 14,700	Terrain	19 12 26.55N	99 15 28.28W	12,910

Coordinates are based on WGS84

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

The RNAV departure procedures for Runway 17R are similar to the RNAV departures for Runway 17L described above.

Information for RNAV departures from Runway 17R is provided below. See Table 15 for CG obstacle information.

6.6.1. SMO to WP9 (V14/V22)

Takeoff Minimums: Standard with a minimum CG of 392 ft/NM to 10,200 ft.

Departure Instructions: Climb heading 182° to 7800 ft, then climbing right turn to SMO VOR/DME, then on track 337° to WP9 to join V14/22, maintain 16,000 ft, then on course.

6.6.2. AVSEK

Takeoff Minimums: Standard with a minimum CG of 328 ft/NM to 14,700 ft.

Departure Instructions: Climb heading 182° to 7800 ft, then climbing right turn to AVSEK, maintain 16,000 ft, then as assigned by ATC.

Table 15. Runway 17R Climb Gradient Controlling Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
WP9 (V14/V22)	392 ft/NM to 10,200	Antenna	19 32 08.43N	99 07 49.13W	9422
AVSEK	328 ft/NM to 14,700	Terrain	19 12 26.55N	99 15 28.28W	12,910

Coordinates are based on WGS84

6.7. Runway 18R

There is one departure procedure from Runway 18R that goes straight ahead.

Information for the RNAV departure from Runway 18R is provided below. See Table 16 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 7800 ft, then turn right direct WP10, then on track 186° to WP11, maintain 16,000 ft, thence... (i.e., to one of the two transitions described below).

CVJ TRANSITION: Track 216° to CVJ VOR/DME, then on course.

CUA TRANSITION: Track 163° to CUA VOR/DME, then on course.

Table 16. Runway 18R Climb Gradient Controlling 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 ALKOM
2. A left turn to APN VOR/DME

Information for RNAV departures from Runway 19L is provided below. See Table 17 for CG obstacle information.

6.8.1. ALKOM

Takeoff Minimums: Standard with a minimum CG of 236 ft/NM to 9700 ft.

Departure Instructions: Climb heading 182° to 7800 ft, then climbing left turn to ALKOM, maintain 16,000 ft, then on course.

6.8.2. APN VOR/DME

Takeoff Minimums: Standard with a minimum CG of 486 ft/NM to 14,300 ft.

Departure Instructions: Climb heading 182° to 7800 ft, then climbing turn left to WP7, then on track 064° to APN VOR/DME, maintain 16,000 ft, then on course.

Table 17. Runway 19L Climb Gradient Controlling Obstacles

Clearance Limit	Climb Gradient (ft MSL)	Description	Position		Elevation (ft MSL)
			Latitude	Longitude	
ALKOM	236 ft/NM to 9700	Building*	19 35 26.24N	98 52 08.44W	8639
		Terrain**	19 38 02.03N	98 50 29.22W	9071
APN VOR/DME	486 ft/NM to 14,300	Terrain*	19 25 20.24N	98 46 05.66W	11,893
		Terrain**	19 26 59.04N	98 42 30.90W	12,648

Coordinates are based on WGS84

*Missed approach obstacle for CG

**Missed approach obstacle for climb to altitude

7. Summary

MITRE examined the feasibility of triple independent CAT II/III ILS approaches and RNAV departures in both directions for the NAICM opening-day runway configuration being considered by the aviation authorities of Mexico based on FAA TERPS criteria. Obstacle assessment was based on the satellite-based photogrammetric survey of the NAICM site and its surroundings completed in late 2014, which provided current and accurate information on man-made obstacles and terrain.

The following summarizes the most important findings:

CAT II/III ILS Approach Procedures

- Mexican authorities, in collaboration with airlines and other stakeholders, should determine if CAT II/III ILS approaches are required at NAICM given that CAT II/III weather conditions occur a relatively low percentage of all time. To do this, power issues at El Caracol (where an AWOS and an RVR are installed) should be urgently resolved. The authorities should conduct a cost-benefit analysis regarding the establishment of CAT II/III ILS approach procedures at NAICM before making any final decisions. This is important because CAT II/III ILS approach procedures have very expensive infrastructure requirements—considerably more than CAT I ILS approach procedures (i.e., a more complex runway lighting system, redundant localizer and glide slope transmitters and power supplies, surface movement systems, etc.). To support this decision-making process it is critical that commercial power be restored to the RVR installed at the NAICM so that appropriate data can be recorded and analyzed.
- CAT II/III ILS approach procedures are feasible. **However, an ELOS argument needs to be made by Mexican aviation authorities to mitigate the U.S. FAA policy regarding the requirement for an unrestricted CAT I ILS approach procedure prior to developing a CAT II/III capability. The ELOS should be conducted in collaboration with SENEAM, Dirección General de Aeronáutica Civil (DGAC), airlines, and other key stakeholders.**

- With the exception of Runway 36L, all CAT II/III approach procedures require missed approach CGs. This would normally trigger a collision risk analysis. However, that type of analysis only evaluates obstacles located in and near the final, OFZ and straight portion of the missed approach. All obstacles generating missed approach CGs for the CAT II ILS approach procedures are located six or more miles from the airport. Therefore, the missed approach CG itself should provide an appropriate level of obstacle protection. As a result, a collision risk analysis, in this case for NAICM, is not appropriate.

RNAV Departure Procedures

- Independent RNAV departures are feasible. Feedback from the airlines and ATC, as well as airspace and procedure designs will likely require some modifications to the RNAV departure procedures.
- With the exception of Runways 36L and 18R (i.e., the center runway), there are at least two departure procedures from each runway that allow for fanning.

Other principal factors pertaining to the final assessment of the instrument 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 will be 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 DGAC.

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Appendix A

CAT II/III Development Discussion

FAA criteria require that prior to the development of CAT II/III ILS approach procedures to a runway, the CAT I ILS to that runway must be unrestricted. An unrestricted CAT I ILS procedure must be able to support a 200-ft HAT and the lowest possible visibility (no restrictions incurred by lack of infrastructure or obstacle surface penetrations). Additionally, the FAA has inferred that a missed approach CG cannot be used to achieve the 200-ft HAT. The NAICM CAT I ILS approaches are affected by either precipitous terrain in the final segment, which requires a HAT adjustment (i.e., to a value greater than 200 ft), or they have a CG.

For NAICM, those two conditions would preclude the development of CAT II/III ILS approach procedures based on FAA rules leaving two options:

1. Follow the FAA rules and, as a result, CAT II/III ILS approach procedures would not be authorized for public use. Or,
2. Present a safety case (e.g., an ELOS) that would mitigate the restricted CAT I ILS approach procedure and allow for the development of CAT II/III ILS approach procedures.

Option 1

The FAA does allow for the development of special procedures. For example, if an air carrier or some other segment of the aviation industry requested a special procedure (e.g., CAT II/III ILS procedure) where one would not normally be allowed, the FAA would develop that procedure specifically for that operator alone. Special procedures are frequently dependent on the ability of the operator to meet certain requirements which may include, but are not limited to, aircraft performance, aircraft equipage, airport facility equipment, crew training, etc. They also require special approval and may be subject to additional procedural requirements. However, due to the unique circumstances at NAICM, option 2 may be preferable to Mexican authorities.

Option 2

All northbound CAT I ILS approach procedures have precipitous terrain in the final segment requiring an adjustment to the HAT. However, those terrain conditions are towards the far end of the segment (i.e., furthest away from the runway). As a reminder, all northbound final segments are very long (i.e., 17.5 NM from the runway). Making an adjustment to the HAT, where aircraft will be close to the landing environment, for precipitous terrain located far from the airport may not be a reasonable course of action. The other issue is the missed approach CGs. To preclude the development of CAT II/III ILS approach procedures based on the existence of CGs appears overly stringent.

In the south direction there are no precipitous terrain conditions in any of the CAT I ILS final segments. However, the CAT II/III ILS procedures require a missed approach CG, FAA criteria requires that a collision risk analyses be conducted to determine

CAT III landing minima. However, that type of analysis is intended to evaluate obstacles in the final, the OFZ, and the straight portion of the missed approach. None of the CAT II/III ILS procedures have penetrations to any of those surfaces. The missed approach controlling obstacles (i.e., the ones requiring the CG) for the CAT II/III ILS approach procedures are six or more miles from the airport.

In summary, MITRE feels that it may be possible for Mexican aviation authorities to develop a safety case (e.g., an ELOS) that would allow the development of CAT II/III ILS approach procedures at NAICM. Mexican aviation officials, however, should discuss this matter in more detail with procedure designers, airport planners, safety experts, governmental approving authorities and especially airlines, at a minimum, to determining an appropriate course of action. The need for CAT II/III ILS approach procedures given the weather conditions at the NAICM site should also be considered. Overall, the desired outcome is to develop approach procedures to the lowest minimums possible serving the needs of the airport users in a safe and efficient environment.

Appendix B

ILS Classification System

Historically, ground navigation equipment was designated to correlate with a specific operation. For example, ICAO Annex 10, Volume I (Radio Navigational Aids), states that a Facility Performance CAT II ILS is associated with an operational performance CAT II procedure. The basic assumption of this correlation is that a certain level of performance by the ground navigation equipment is necessary to support the corresponding airborne operation.

To fully maximize the benefits of modern aircraft automatic flight control systems, there was a related need for a method of describing the ground-based ILS more completely than could be achieved by reference solely to the Facility Performance Category¹³. Therefore, ICAO developed an ILS classification system using three designated characters. The classification system provides a description of those performance aspects which are required to be known from an operations viewpoint in order to decide the operational applications which a specific ILS could support. The ILS classification scheme provides a means to make known the additional capabilities that may be available from a particular ILS ground facility, beyond those associated with the facilities defined in Annex 10. These additional capabilities can be used to permit operational use, according to Annex 10, Attachment C, down to and below the values stated in the operational objectives described in Annex 10, Attachment C.

The U.S. adopted the ICAO ILS Classification System, but uses the term “type” to differentiate the ground facility from the category of flight operation (e.g., Type II ILS facility as opposed to CAT II operations). The FAA’s intent is to eliminate any possible confusion between facility establishment criteria and operational criteria for the approval of CAT I, CAT II, or CAT III flight operations. Typically, the “type” classification defines the ground equipment necessary to support precision approach and landing operations by aircraft and operators which meet the minimum airborne equipment requirements for that category of operations. While certain ground facility requirements are needed to support all levels of either CAT I, CAT II, or CAT III operations, a higher category of operations may be performed on different “types” of ground equipment if the airborne equipment, crew training, or other factors offset any changes in ground facility requirements. The higher performance capabilities of new and improved avionics have mitigated some of the performance requirements of the ground-based navigation equipment.

¹³ Facility Performance Categories describe guidance information to various locations on approach. For example, Facility Performance Category I, provides guidance to a height of 200 ft or less above the horizontal plane containing the threshold; Facility Performance Category II provides guidance to a height of 50 ft above the horizontal plane containing the threshold; and Facility Performance Category III is an ILS which, with the aid of ancillary equipment where necessary, provides guidance information from the coverage of the facility to, and along, the surface of the runway.

- A Type I facility is defined as all localizer and glideslope facilities not meeting the definition of Type II or Type III and which have a published straight-in course coincident with the centerline of the runway or an offset localizer which is not offset in excess of 3° from the centerline of the runway.
- A U.S. Type II facility meets or exceeds all requirements for an ICAO “facility performance CAT II ILS” as specified in Annex 10, Volume I, Chapter 3. U.S. Type II facilities are designated as such by Technical Operations, and meet all the requirements to support CAT II approach and landing operations.
- A U.S. Type III facility meets or exceeds all ICAO criteria as specified in ICAO Annex 10, Volume I, Chapter 3, and is identified as “CAT III” in standards, recommended practices, or guidance material. A Type III facility typically consists of a dual frequency localizer which meets all CAT III requirements to at least a point 3000 ft from the approach end of the runway, a glideslope which meets CAT III requirements to the threshold, executive integrity monitors which identify any degradation of signal integrity exceeding CAT III standards, a far field monitor to identify critical area incursions or signal variations in the far field which may affect signal integrity, backup transmitters, and backup power to ensure continuous power for critical systems. A Type III facility typically includes ancillary equipment such as full runway edge, end, and in-pavement lighting (e.g., high intensity runway lights, touchdown zone lights, and runway centerline lights), a full Approach Lighting System with Sequenced Flashers and power changeover requirements to ensure continuous power for critical lighting systems. Type III facility requirements reflect the fact that CAT III operations are highly dependent on the accuracy, integrity, and reliability of ground equipment throughout approach, landing, and rollout.

The following is the minimum class of performance required for an ILS to support a published U.S. CAT II or CAT III ILS standard approach procedure.

- Class II/T/2 for operations not less than RVR 1200
- Class II/D/2 for operations not less than RVR 1000
- Class III/D/3 for operations not less than RVR 700
- Class III/E/3 for operations not less than RVR 600
- Class III/E/4 for operations less than RVR 600

Class III/E/4 is required for takeoff operations less than RVR 500. Operators may be authorized takeoff minimums as low as RVR 300 via an operational authorization.

The first character (I, II, III) indicates conformance to the Facility Performance Category standards contained in ICAO Annex 10, unless superseded by an FAA directive. The second character defines the ILS point to which the localizer conforms to the Facility Performance CAT III course structure tolerances. These classifications indicate ILS conformance to a physical location on the approach or runway as follows:

- A: 4 NM before the threshold
- B: 3500 ft before the threshold (CAT I decision point)
- C: Glidepath altitude of 100 ft HAT (CAT II decision point)
- T: Threshold
- D: 3000 ft beyond the threshold (CAT III requirement only) and
- E: 2000 ft before the runway end (CAT III requirement only)

The third character indicates the minimum level of integrity and continuity of service given in Table A1.

Table A1. Minimum Localizer and Glideslope Integrity and Continuity Levels

Level	Integrity	Continuity	*MTBO (hours)
1	Not demonstrated, or less than required for Level 2		
2	1 – 1 x 10 ⁻⁷ in any one landing	1 – 4 x 10 ⁻⁶ in any period of 15 seconds	1000
3	1 – 0.5 x 10 ⁻⁹ in any one landing	1 – 2 x 10 ⁻⁶ in any period of 15 seconds	2000
4	1 – 0.5 x 10 ⁻⁹ in any one landing	1 – 2 x 10 ⁻⁶ in any period of: 30 seconds (localizer) 15 seconds (glideslope)	4000 (localizer) 2000 (glideslope)

*Mean Time Between Outages

- Level 1-rated ILS equipment supports low-visibility operations for which positioning guidance below an approximate 200 ft HAT is supplemented by other means, such as visual cues or advanced avionics
- Level 2-rated ILS equipment supports reduced visibility operations for which positioning guidance below 100 ft HAT is supplemented by other means, such as visual cues
- Level 3-rated ILS equipment supports operations that place a high degree of reliance on ILS guidance for positioning through touchdown
- Level 4-rated ILS equipment supports operations that place a high degree of reliance on ILS guidance throughout touchdown and rollout, or for low-visibility takeoff operations that require a localizer for lateral guidance throughout the takeoff roll