Enclosure 2

(Ref. Technical Letter F063-L08-040)

MITRE

Center for Advanced Aviation System Development

Exploratory Feasibility Analysis of Independent Approach Procedures in the Texcoco Area

Prepared for

Dirección General de Aeronáutica Civil
Secretaría de Comunicaciones y Transportes

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1.0 Introduction

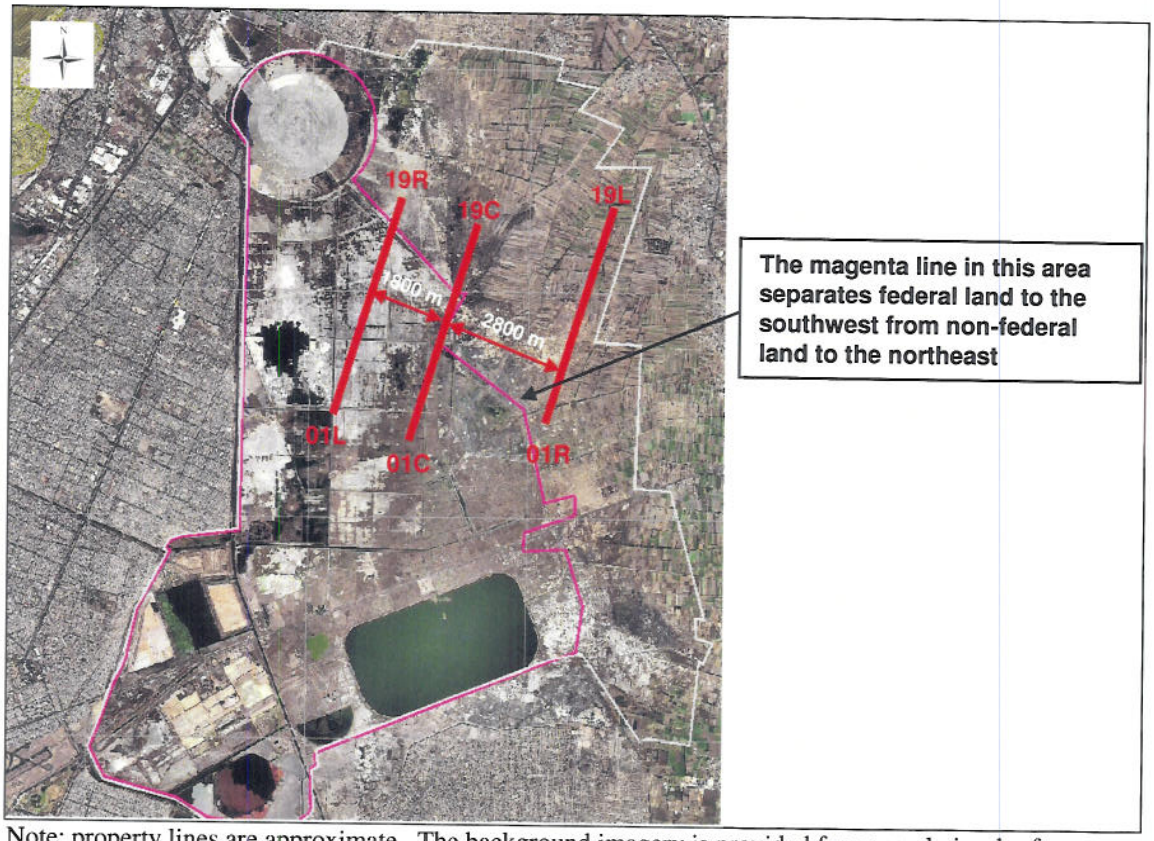
As part of MITRE's support to Mexico's Dirección General de Aeronáutica Civil (DGAC), MITRE performed an exploratory analysis to examine the feasibility of conducting independent parallel approach procedures in the Texcoco area. The examination included independent approaches to two and three runways. The analysis, however, assumed a predetermined runway orientation and fixed runway locations (referred to as a "configuration"). Thus, as orientation and locations can be modified, there is nothing "ultimate" about this analysis, except for the very important test of whether independent approach feasibility appears promising. Additionally, the analysis demonstrated issues that procedure designers need to contend with once final orientation and locations are determined. Overall, MITRE's team investigated independent approach feasibility only within federally-owned land. The potential interaction with nearby Santa Lucía Military Base airspace was also considered.

This paper starts with an overview of previous MITRE-performed Texcoco area procedure design work and information on potential terrain and airspace issues. Next, the procedure development methodology, as well as assumptions and limitations used in this analysis are described. Finally, interim procedure design results are given.

MITRE utilized throughout this exploratory analysis conventional Instrument Landing System (ILS) Category (CAT) I approaches, as well as more advanced procedural concepts, such as Required Navigation Performance (RNP) with Special Aircraft and Aircrew Authorization Required (SAAAR). RNP SAAAR has narrower obstacle clearance surfaces and allow for curved approaches to be made.

2.0 Overview

In 2000, MITRE completed a study to determine the suitability of the Texcoco area to accommodate a large metropolitan airport to replace Mexico City International Airport (AICM). The site being considered at that time was located in the northern portion of the Texcoco area, which MITRE now refers to as Texcoco North. The analysis considered three parallel runways oriented roughly north-south, and separated far enough apart (1800 m/2800 m) to allow for independent approaches. Figure 1 shows the location of the runways originally analyzed by MITRE. As can be seen in the figure, portions of the runways were located on non-federally owned land.



Note: property lines are approximate. The background imagery is provided for general visual reference and orientation purposes only.

Figure 1. Texcoco North Runway Locations (from the original MITRE 2000 study)

Procedure design criteria are constantly evolving to keep pace with changing technologies. The original MITRE 2000 study was conducted using United States Federal Aviation Administration's (U.S. FAA) Order 8260.3B *United States Standard for Terminal Instrument Procedures (TERPS)* through Change 17. However, just prior to the completion of the original MITRE 2000 study, Change 18 was issued. (Change 18 was a relatively minor change.) In 2002, the U.S. FAA issued Change 19, which significantly modified precision approach, specifically ILS, and departure procedure design criteria. Change 20 became effective in December of 2007.[1]

Due to issues regarding the acquisition of non-federal land, the Mexican government withdrew its plans to construct a new airport at the Texcoco North site. Instead, the government is now investigating the possibility of constructing the airport in the southern Texcoco area, which MITRE refers to as Texcoco South. This is a greenfield area mostly located on federal land.

[1] Since Change 20 has only recently been released and MITRE is still going through a period of review, MITRE decided to use Change 19 for the exploratory analysis of the Texcoco area presented in this paper.

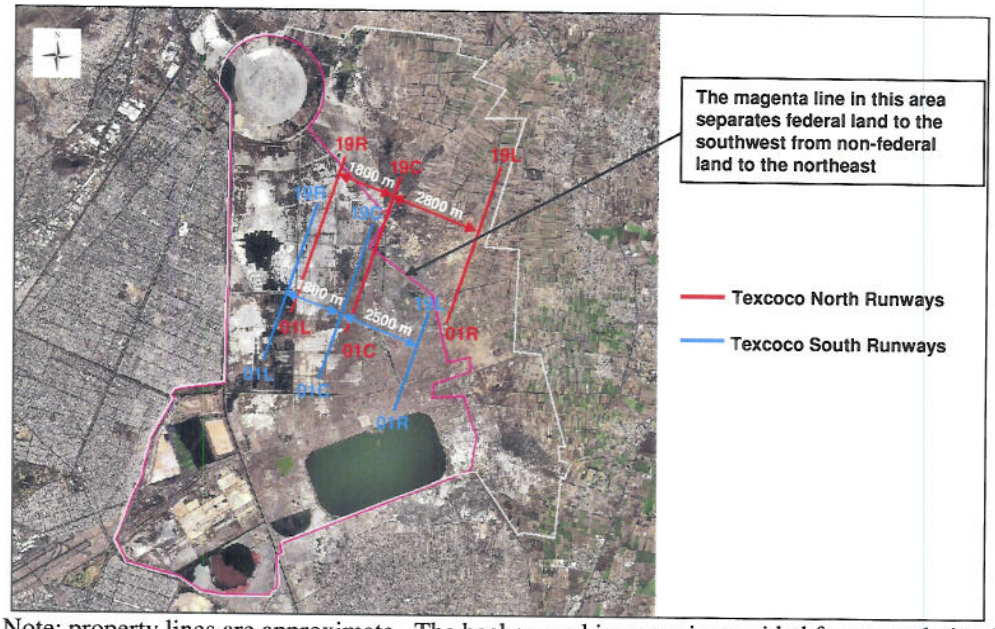
Figure 2 shows the runway locations for both Texcoco North and Texcoco South. As shown, it appears that all three Texcoco South runways can be located on federally-owned land, but to do so the length of Runway 01R/19L may need to be reduced. Also, note that shifting the runways to the south moves them closer to Lago Nabor Carrillo, which could be problematic due to the potential presence of birds.

There are a number of additional factors of relevance that need to be taken into consideration which the exploratory analysis has not yet fully examined. The following three factors are especially important:

- **Runway Spacing.** MITRE has not yet analyzed the appropriateness of the spacings depicted in Figure 2 (1800 m/2500 m) using its Simultaneous Instrument Approach Model (SIAM), a fast-time simulation model that analyzes potential collision rates between aircraft on independent parallel approaches. However, MITRE performed a preliminary analysis of feasible minimum spacings (see Enclosure 1 to Ref. F063-L08-040, dated 6 June 2008, delivered at the same time as this paper). Therefore, the exploratory runway locations and spacings utilized in this paper should not be considered conclusive.

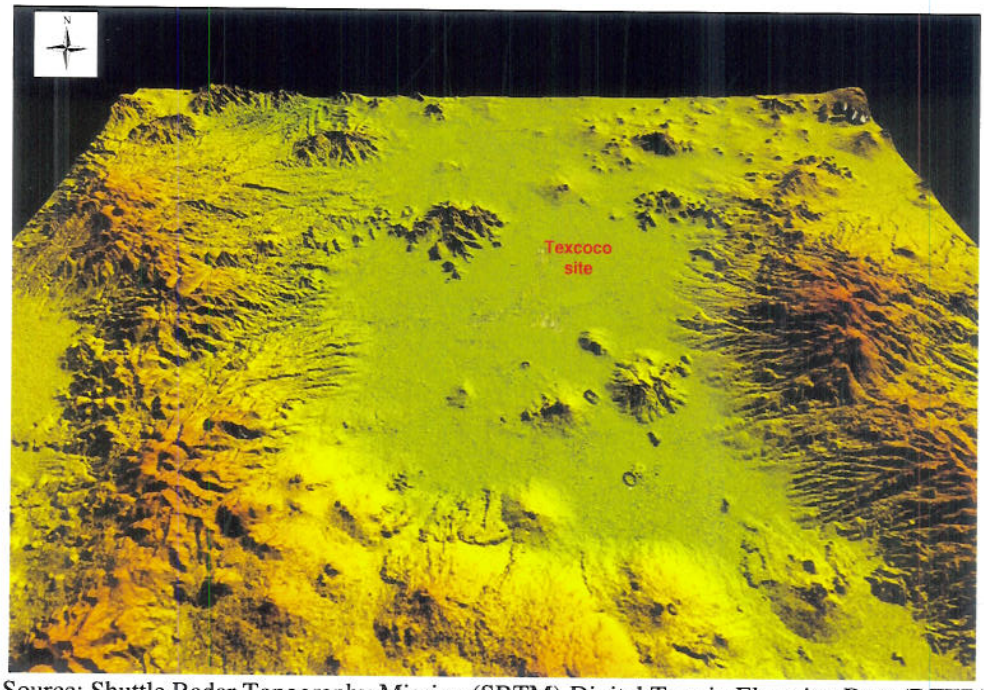
- **Terrain.** Mountainous terrain surrounding the Texcoco area complicates the development of instrument procedures, especially when considering independent approaches. This exploratory analysis did not utilize recently issued topographic maps and did not consider all man-made obstacles. It did utilize, however, NASA Shuttle-based information (see Section 3.0). Yet, this is not sufficiently comprehensive and an upcoming photogrammetric study will complement these data. Figure 3 illustrates the terrain surrounding the Texcoco area.

- **Santa Lucía Military Base.** Santa Lucía is located to the north of the Texcoco area. The airspace surrounding the base complicates the development of instrument procedures. MITRE's procedure design experts have attempted to avoid impacting Santa Lucía's airspace. There are initial indications that Santa Lucía's airspace may need to be modified. It may also be necessary to relocate Santa Lucía, but it is far too early in the project to consider that option. Much more detailed runway siting, procedure design, airspace analyses, and other tasks must be completed before the base's impact can be assessed.



Note: property lines are approximate. The background imagery is provided for general visual reference and orientation purposes only.

Figure 2. Texcoco North vs. Texcoco South Runway Locations



Source: Shuttle Radar Topography Mission (SRTM) Digital Terrain Elevation Data (DTED).

Figure 3. High Terrain Surrounding the Texcoco Area

3.0 Procedure Development Methodology, Assumptions and Limitations

MITRE utilizes a variety of processes and sophisticated computerized tools at its disposal to examine instrument procedures. These tools facilitate the design of procedures and assessment of obstacles. For example, AutoCAD-based procedure design tools, such as PD Toolkit, as well as MITRE's Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS) model and other supporting programs were used in the examination of instrument procedures. In the case of RNP SAAAR procedure design, MITRE based its work on U.S. FAA Order 8260.52 *United States Standard for Required Navigation Performance Approach Procedures with Special Aircraft and Aircrew Authorization Required.*

MITRE also utilized a wide variety of data sources for its procedure development work. The following is a brief description of those data types and sources:

- **NASA Shuttle-Based Information.** NASA's Shuttle Radar Topography Mission (SRTM) Digital Terrain Elevation Data (DTED) is a uniform matrix of elevation values indexed to specific points on the ground. The horizontal datum is the World Geodetic System 1984 (WGS 84) and the vertical datum is Mean Sea Level (MSL) as determined by the WGS 84 Earth Gravitational Model (EGM 96) geoid. The elevation data are with respect to the reflective surface, which may be vegetation, man-made features or bare earth. Although SRTM DTED is an excellent tool, it has limitations. For example, a higher elevation point between two SRTM DTED postings may not be accounted for in the data. Therefore, MITRE has requested a photogrammetric survey (see Enclosure 4 to Ref. F063-L08-040, dated 6 June 2008, delivered at the same time as this paper) and other sources of data to provide an extra margin of safety.

- **Topographic Maps.** A series of 1:50,000 and 1:250,000 scaled area maps, used during MITRE's previous year 2000 analysis of the Texcoco North area were used to obtain information on peaks of hills and mountains in order to complement the SRTM DTED data. It is important to note that these maps are several years old. Therefore, MITRE has requested current topographic maps (see Enclosure 3 to Ref. F063-L08-040, dated 6 June 2008, delivered at the same time as this paper).

- **Aeronautical Information Publication (AIP) for Mexico.** The AIP for Mexico provides a wealth of information on navigational aids, air traffic control procedures, airway structure, special use airspace, instrument procedures, etc. Relevant information was utilized so that procedure development could be further evaluated for feasibility within the existing aviation structure.

As with all projects of this size and complexity, certain assumptions and limitations exist. For example:

- MITRE assumed the same runway orientation that was used in the original MITRE 2000 study, which was at that time provided by Aeropuertos y Servicios Auxiliares (ASA). The appropriateness of that and other orientations will be confirmed after MITRE receives and analyzes at least one year of reliable on-site weather data collected by an automated meteorological observation system. Therefore, to assist in the observation system acquisition process, MITRE has provided specifications for such a system (see Enclosure 5 to Ref. F063-L08-040, dated 6 June 2008, delivered at the same time as this paper).

- All land-based navigational aids used in the design of the procedures were assumed to be fully functional and without restrictions. This needs to be verified by a flight check.

- MITRE assumed that use of RNP SAAAR to conduct independent approach procedures to two- or three-parallel runways will be authorized in the future. This may not prevent, however, a single runway operating under RNP SAAAR, while the other(s) operate under conventional procedures, once a safety case is made and operating under a waiver.
- Modifications to the airway structure (e.g., new airways, new fixes, etc.) would be incorporated as appropriate to accommodate the procedures. This may also include the installation of new navigational aids.

- MITRE added 30 m to terrain data to account for potential trees. MITRE also assumed that any close-in trees that may impact procedures would be removed or trimmed as appropriate.

- MITRE did not consider the existence of all man-made obstacles (e.g., antennas) within and surrounding the Texcoco area. Therefore, the existence or absence of man-made obstacles needs to be verified through a detailed obstacle survey. MITRE assumed that any man-made obstacles (e.g., utility poles, power lines, buildings, etc.) that may impact a procedure in a negative way would be removed and/or modified so as to no longer pose a problem.

- Complete instrument procedures were not developed. Only the final and missed approach segments of procedures were examined to determine initial feasibility. CAT II/III approach procedures were not developed, as well as departure and engine-out procedures.

- The existence of nearby airports (e.g., Toluca, Puebla, Querétaro, Cuernavaca) and the possible construction of a new airport in the proximity of Pachuca were not considered. Furthermore, a major redesign of the Mexico City airspace

required to accommodate planned operations and procedures at a new airport in Texcoco was not conducted.

4.0 Exploratory Procedure Development

MITRE's procedure design experts conducted an exploratory examination of instrument approaches to potential runways in the Texcoco South area. The runways were located for exploratory planning purposes only and should not be considered as final. Independent approaches to two- and three-parallel runways using conventional ILSs were examined. RNP SAAAR approach procedures to conduct independent approaches to three parallel runways were also considered. It is important to note, however, that approval for the use of RNP SAAAR to conduct independent approach procedures to two- or three-parallel runways has not yet been authorized.

For this study, MITRE provides estimates of the approach minimums as Height Above Touchdown (HAT) only. Visibility minimums have not yet been estimated.[2] The HAT estimates are not to be considered final, and are only intended to provide an indication of the feasibility and usability of procedures.

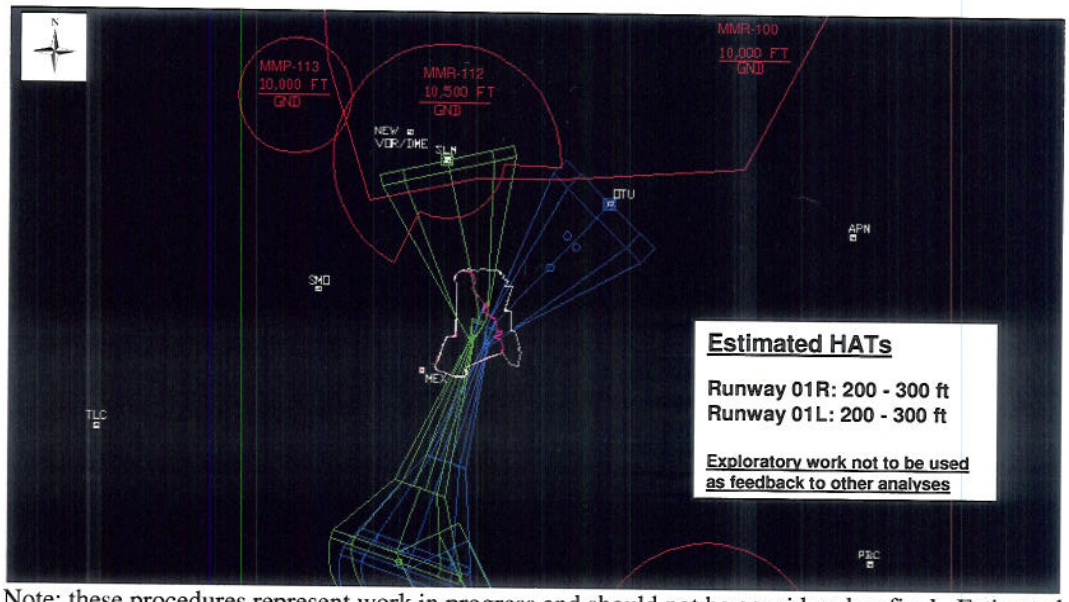
4.1 Independent ILS CAT I Approaches to Two Parallel Runways

For approaches from the south (i.e., Runways 01R and 01L), HATs of 200-300 ft appear feasible. However, the missed approach surface for Runway 01L slightly penetrates Santa Lucía's airspace. For approaches from the north (i.e., Runways 19R and 19L), the HATs are higher. The estimated HATs for Runways 19R and 19L are about 400-500 ft.

ILS CAT I missed approach climb gradients, which have recently been authorized in the U.S., may allow aircraft to clear any potential obstacles, thereby allowing for a lower HAT and for aircraft to climb over Santa Lucía's airspace. However, the effect of increased climb gradients on aircraft operations would also need to be considered.

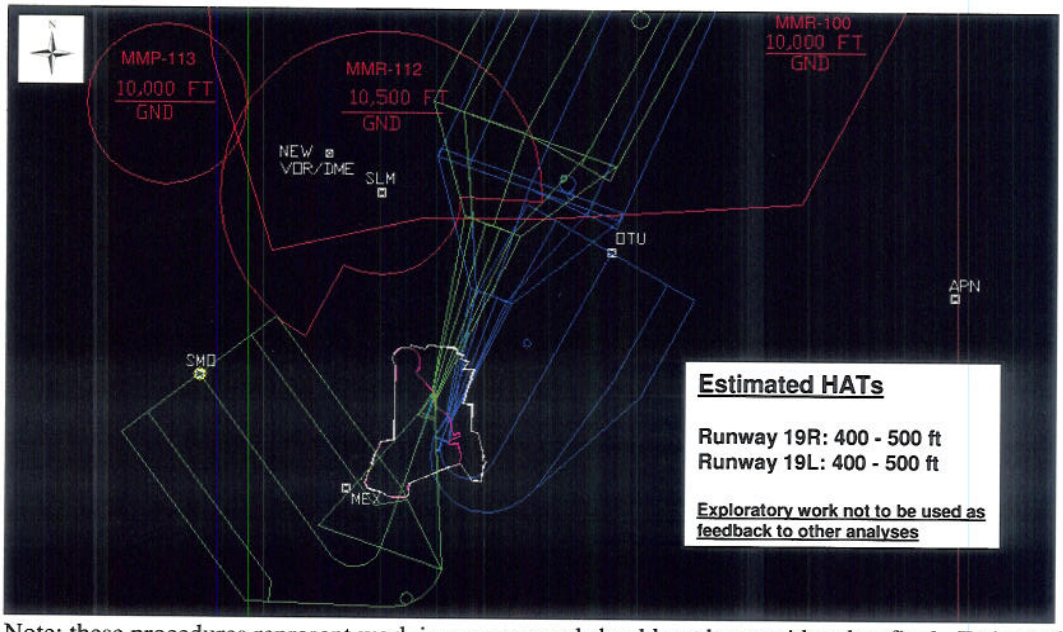
Figures 4 and 5 show the independent approaches using conventional ILS procedures to two potential parallel runways located in the Texcoco South area.

[2] Instrument approach minimums are given as a decision altitude (DA) height above MSL in feet and visibility in statute miles. Another minimum is the HAT. The HAT is the lowest height an aircraft can descend to before the pilot has to make a decision to either continue with the approach or execute a missed approach.



Note: these procedures represent work in progress and should not be considered as final. Estimated HATs are rough approximations and are subject to change.

Figure 4. Independent ILS CAT I Approaches to Two Parallel Runways from the South



Note: these procedures represent work in progress and should not be considered as final. Estimated HATs are rough approximations and are subject to change.

Figure 5. Independent ILS CAT I Approaches to Two Parallel Runways from the North

4.2 Independent ILS CAT I Approaches to Three Parallel Runways

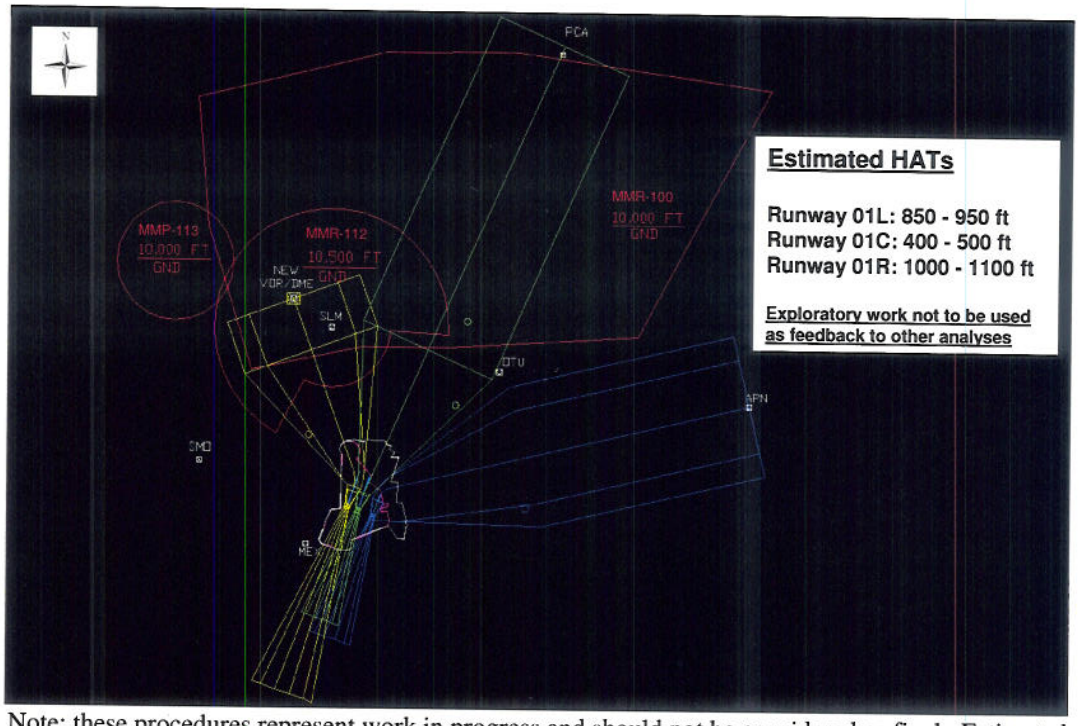
The development of independent approaches to three parallel runways is a much more involved process requiring additional planning and consideration than that associated with the development of independent approaches to two parallel runways. For example, a three-parallel runway configuration supporting independent ILS approaches requires a much greater area that must be considered for obstacle clearance purposes. Additionally, there is less procedure design flexibility. For example, procedure design criteria require that missed approach paths diverge by at least 45 degrees. In a three-runway configuration this typically requires the missed approach path for the center runway to proceed straight ahead and the left and right runways to turn away from the center runway missed approach path. This could be problematic if terrain or airspace issues do not accommodate such requirements.

For approaches from the south to Runways 01L, 01C and 01R, estimated HATs of 850-950 ft, 400-500 ft and 1000-1100 ft, respectively, were determined. The higher HATs are due to terrain in the missed approach segment of the procedures. Evidently, these HATs are too high to be practical. Also, the missed approach for Runway 01L penetrates into Santa Lucía's airspace.

For approaches from the north to Runways 19L, 19C and 19R, some HATs are also very high. The estimated HAT for Runway 19L is 350-450 ft, whereas the estimated HAT for Runways 19C and 19R are 1000-1100 ft and 1400-1500 ft, respectively. The higher HATs are due to obstacles in the missed approach segments. The procedures avoid Santa Lucía's airspace.

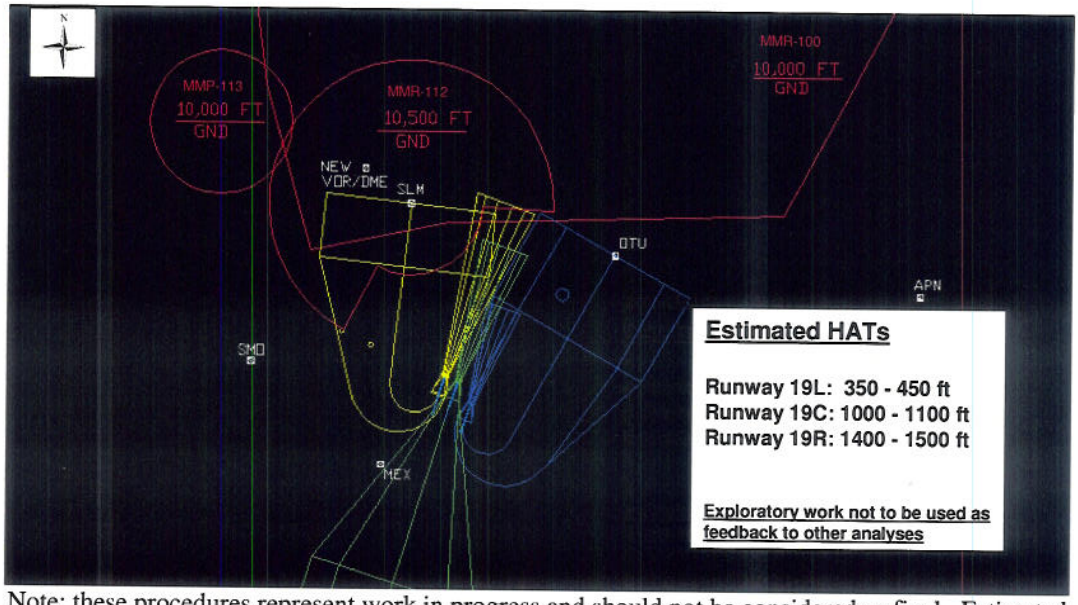
Most of the above-mentioned HATs would not be usable for a large metropolitan airport that requires a high degree of runway availability under most weather conditions. As previously mentioned, climb gradients in the missed approach segments may alleviate some obstacle and airspace issues. Furthermore, advanced procedures such as RNP SAAAR may allow for lower HATs (see Section 4.3).

Figures 6 and 7 show the independent approaches using conventional ILS procedures to three potential parallel runways located in the Texcoco South area.



Note: these procedures represent work in progress and should not be considered as final. Estimated HATs are rough approximations and are subject to change.

Figure 6. Independent ILS CAT I Approaches to Three Parallel Runways from the South



Note: these procedures represent work in progress and should not be considered as final. Estimated HATs are rough approximations and are subject to change.

Figure 7. Independent ILS CAT I Approaches to Three Parallel Runways from the North

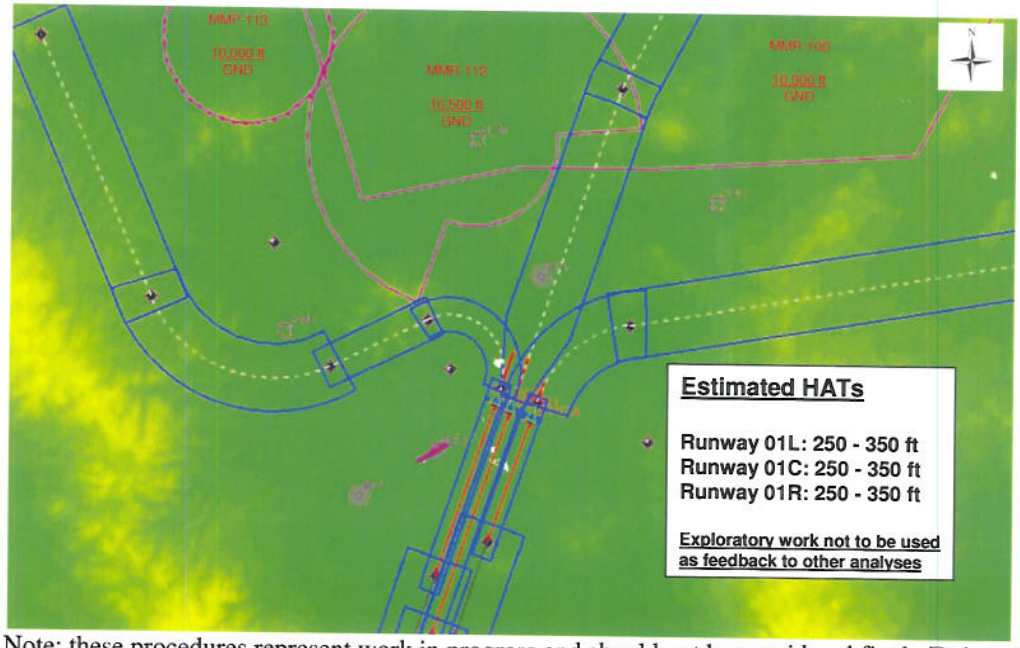
4.3 Independent Approaches to Three Parallel Runways using RNP SAAAR

RNP SAAAR approach procedures are in use in the U.S. These procedures require aircraft to be equipped with advanced on-board navigation systems and Flight Management Computers (FMCs) that conform to minimum accuracy requirements. Many new commercial aircraft such as the newer Boeing 737 models, as well as newer Airbus 320s are RNP SAAAR-capable. In the U.S., these procedures also require specialized pilot training and specific authorizations, including an airline-specific approval.

MITRE has begun to examine the potential application of these procedures in the Texcoco area in anticipation of their eventual implementation in Mexico sometime in the future. Implementation of these types of procedures in Mexico will only be practical when a significant percentage of the aircraft fleet will be appropriately equipped. A survey to determine future aircraft fleet capabilities is going to take place during this project.

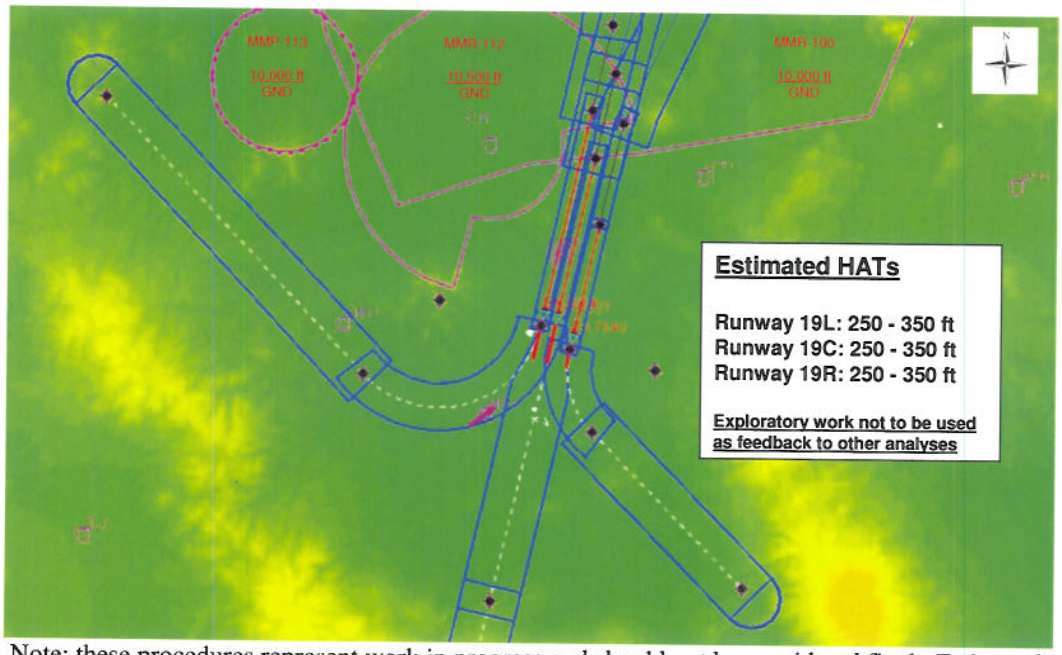
MITRE utilized its TARGETS model, a highly unique tool, to develop preliminary RNP SAAAR procedures. For RNP SAAAR approaches from the south to Runways 01L, 01C and 01R, estimated HATs of 250-350 ft appear feasible. The RNP SAAAR approaches from the north to Runways 19L, 19C and 19R may also be able attain HATs of 250-350 ft. Note that the best HAT that is currently authorized in the U.S. for an RNP SAAAR approach is 250 ft. All the missed approach segments of the procedures were able to avoid Santa Lucía's airspace either vertically or laterally.

Figures 8 and 9 show the independent approaches using RNP SAAAR approach procedures to three potential parallel runways located in the Texcoco South area.



Note: these procedures represent work in progress and should not be considered final. Estimated HATs are rough approximations and are subject to change. Approval for independent approaches to two- and three-parallel runways using RNP SAAAR has not been authorized.

Figure 8. Independent Approaches to Three Parallel Runways Using RNP SAAAR from the South



Note: these procedures represent work in progress and should not be considered final. Estimated HATs are rough approximations and are subject to change. Approval for independent approaches to two- and three-parallel runways using RNP SAAAR has not been authorized.

Figure 9. Independent Approaches to Three Parallel Runways Using RNP SAAAR from the North

5.0 Observations

Airport planning for Texcoco should consider independent approaches to multiple parallel runways, preferably three, to meet projected traffic levels. From an instrument procedure design point of view, the Texcoco area is very challenging, especially when considering independent approaches to three parallel runways. Additionally, the impact on Santa Lucía's airspace and the high terrain surrounding the site complicate any design.

On the basis of this exploratory analysis, MITRE engineers feel the site warrants further study. Although some of the HATs are too high to be practical, use of climb gradients in the missed approach segment may mitigate the impact of obstacles and Santa Lucía's airspace.

Independent approaches to three parallel runways using RNP SAAAR provide a significant benefit over conventional ILS procedures due to their narrower obstacle clearance surfaces and ability to avoid obstacles. RNP SAAAR approaches may provide estimated minimums of approximately 250-350 ft HAT.

In the future, if authorized, RNP SAAAR procedures may be able to increase airport capacity by allowing for independent approaches to three parallel runways with reasonable minimums. At the very least, the possibility of conducting a "mixed operation" consisting of one or even two conventional independent approaches and, simultaneously, an RNP SAAAR approach to a third runway, might also provide capacity benefits. These operations are not yet developed, however, and will require a careful safety investigation before they could be implemented.