Enclosure 2

(Ref. Technical Letter F500-L14-022)

MITRE

Center for Advanced
Aviation System Development

Exploratory Analysis of Potential New Airport Sites in Hidalgo

Status Report

Prepared for

Aeropuertos y Servicios Auxiliares

March 2014

1. Introduction

MITRE is assisting Aeropuertos y Servicios Auxiliares (ASA) in collaboration with the Office of the Governor of the State of Hidalgo (Hidalgo) in identifying a feasible site for developing a new, one-runway airport in the State of Hidalgo. The new airport is intended to accommodate commercial airline and cargo operations. It has also been considered as a site to replace some of the activities of the Santa Lucía Military Base (Santa Lucía), as some of its activities must be relocated in order to avoid airspace interactions once a major airport is constructed in the proximity of the town of Texcoco, referred to in this document as the Nuevo Aeropuerto Internacional de la Ciudad de México (NAICM).

MITRE's exploratory airport siting work originally focused on potential new airport sites near the towns of Tepeji del Río-Tlahuelilpan (Tepeji del Río), Actopan-Santiago de Anaya (Actopan), and Tulancingo. Later on, Hidalgo suggested two additional potential airport sites near the towns of Apan and Zempoala. Finally, MITRE identified the area near the town of Tetepango as an additional candidate site. Actopan, however, is now considered to be less desireable due to land acquisition concerns reported by Hidalgo. Moreover, MITRE found the Actopan site to be somewhat complicated for the siting of an airport due to high terrain surrounding the site and potential airspace interactions with NAICM. Nevertheless, MITRE has included information on the Actopan site in this report for informational purposes.

MITRE's initial exploratory examinations include a multi-factor assessment of the airport sites. MITRE engineers specializing in airport planning, instrument procedure design, airspace analysis, obstacle assessment, and other related areas are currently conducting studies to determine the basic viability of the airport sites. The advantages and disadvantages of each site are being identified and evaluated in an integrated manner, and other potential alternatives are being explored. For example, at some sites more than one runway orientation is being considered in order to provide options that could assist in the development of instrument approach and departure procedures, as well as with mitigating potential airsapce interactions with operations at NAICM or at an expanded Toluca Airport.

In mid-February, the MITRE team, along with Lic. Manuel Ángel Núñez and representatives from Hidalgo, conducted helicopter tours of the sites under consideration. The helicopter tours helped MITRE visually assess the characteristics of the sites and collect first-hand information. This is when the Tetapango site, previously mentioned, was identified. Following the tour, extremely useful discussions with state officials presided by the Governor, were held. The trip was very successful.

The objective of this document is to provide ASA with an update on the work that MITRE has been performing on the potential airport sites and to discuss some of MITRE's initial findings. The assessment of the sites, however, is on-going, so this is very preliminary. For example, MITRE has only identified potential airspace interactions between the new airport sites at Hidalgo and NAICM, but has not completed its

examination of ways to mitigate those interactions. **Therefore, the initial findings discussed in this document should not be considered final and are subject to change.**

It is also important to note that at this stage of the project MITRE is conducting analyses to determine which sites warrant further, more detailed examination. Once this stage is completed, three preliminary sites that warrant further analysis by MITRE will be selected. At that point, appropriate weather and obstacle data will need to be collected at those sites. Automated Weather Observing Systems (AWOS) will be installed at the preferred sites, and a detailed survey of terrain and man-made obstacles will be conducted. This information will allow MITRE to more accurately determine runway orientation, develop instrument approach and departure procedures, and to conduct other important analyses, such as the assessment of International Civil Aviation Organization (ICAO) Annex 14 Obstacle Limitation Surfaces (OLS).

The rest of the document is organized into the following sections. Section 2 discusses the key aeronautical factors that MITRE is examining at the Hidalgo airport sites. Section 3 provides a description of the potential Hidalgo airport sites, including preliminary findings this far. Section 4 discusses the initial development of MITRE's three-dimensional (3D) computerized visualization Out-the-Window (OTW) model, which is being used to support Hidalgo airport siting analyses. Section 5 explains the next steps of MITRE's work.

2. Key Aeronautical Factors Being Considered by MITRE

There are many factors that need to be considered when siting an airport. In this section, examples of some key considerations are discussed, such as instrument approach and departure procedures, airspace interaction, ICAO Annex 14 OLS, site topography, etc.

As mentioned above, detailed obstacle (both terrain and man-made) and meteorological data will be required to conduct a more thorough feasibility study of the selected airport sites. At this stage of the project, MITRE is using publicly available terrain data and satellite imagery, topographic maps, as well as images obtained from MITRE's aerial investigation of the airport sites for its exploratory assessment work. MITRE is using Shuttle Radar Topography Mission (SRTM) Digital Terrain Elevation Data (DTED) as a source of terrain elevation information. SRTM DTED is a uniform matrix of terrain elevation values indexed to specific points on the ground. SRTM DTED can be manipulated a number of ways for analytical and presentation purposes, and is very useful at the exploratory stage of this analysis. However, it does not contain information on man-made obstacles, which is one of the reasons why the previously mentioned survey of the selected preliminary airport sites is so important.

2.1 Instrument Approach and Departure Procedure Assessment

An important factor in determining the overall feasibility of a new airport site is the assessment of instrument approach and departure procedures. Therefore, it is necessary to investigate if both arrival and departure procedures appear possible given the terrain environment surrounding the sites and other considerations, such as airspace matters.

Therefore, MITRE has been examining initial instrument approach and departure procedures for potential runway(s) at the sites, based on the United States (U.S.) Standard for Terminal Instrument Procedures (TERPS) criteria. The objective of these analyses is to determine the likelihood of developing reasonable instrument approaches (including missed approaches) and instrument departures to support aircraft operations. In addition, these analyses allow assessing how the aircraft would transition from the en route phase of flight to the airport terminal environment.

Figure 1 below shows the Initial, Intermediate, and Final segments of an Instrument Landing System (ILS) Category I (CAT I) approach at the Tulancingo site for an approach to the north. The contour lines on the figure depict SRTM DTED terrain, while the "empty" areas under the TERPS approach surfaces show no penetrations to those surfaces, indicating that the procedure might be feasible.

Similar instrument approach and departure procedure assessments were conducted at other airport sites as well.

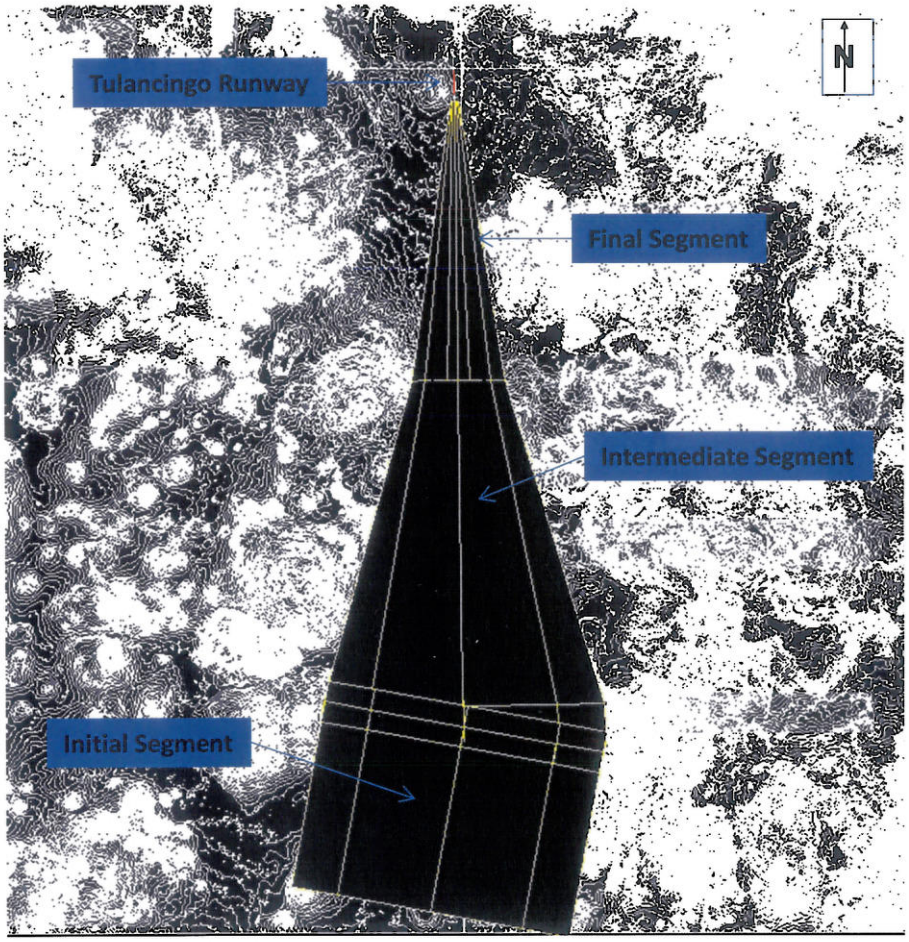


Figure 1. Preliminary Instrument Approach Assessment using SRTM DTED (Tulancingo Site, North Flow)

2.2 Airspace Interaction Assessment

Another important consideration for siting an airport is the potential for interaction with operations at nearby airports, including future airports, such as NAICM. A new airport should be located a sufficient distance away from other airports to prevent aircraft interactions and high-controller workload issues, which can affect safety and overall capacity.

MITRE is conducting airspace interaction assessments for all of the potential airport sites in Hidalgo. The interaction assessments consider MITRE's previous airspace design work for NAICM and an expanded Toluca Airport. The objective of the interaction assessments is to determine whether operations at any of the potential new airports sites in Hidalgo may cause adverse interactions with operations at the future NAICM or at the current (or expanded) Toluca Airport. It is critical to avoid creating a complicated airspace environment and/or a situation that would result in significant capacity penalties to the future NAICM and Toluca airports.

Figure 2 below shows a preliminary airspace interaction assessment at the Tepeji del Río site that was conducted using the MITRE-developed Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS) tool.

Figure 2. Preliminary Airspace Interaction Assessment (Tepeji del Río Site)

2.3 ICAO Annex 14 OLS Assessment

MITRE is examining the ICAO OLS at each site in order to get a better understanding of the surrounding terrain environment. ICAO OLS are established around and over an airport for identifying potential obstacles to air navigation, and for preventing the development of obstacles through new construction that could adversely impact aircraft operations. The OLS assessment is also based on the SRTM DTED data, and will need to be re-evaluated and re-assessed for the selected sites once more accurate terrain and obstacle survey data are available. However, at this early stage of the project, the initial ICAO OLS assessment, in combination with the instrument procedure and airspace interaction analyses mentioned above, assists in determining possible weather-independent runway orientations at the sites (that is, before all-important weather data is obtained to ensure which runway orientations are appropriate, if any).

Figure 3 below shows an example of an OLS assessment for a theoretical runway at the Actopan site. The contour lines on the figure depict SRTM DTED terrain. The "empty" areas under the OLS surfaces show no penetrations, while contour lines within those surfaces represent penetrations to those surfaces. As shown in the figure, the ICAO OLS approach surfaces in both runway directions, as well as the Inner-Horizontal and Conical surfaces to the east of the site are penetrated by high terrain. MITRE also examined OLS for other potential runway orientations at the Actopan site. However, those other potential runway orientations do not appear to provide an improvement, making Actopan a very difficult location for siting an airport.

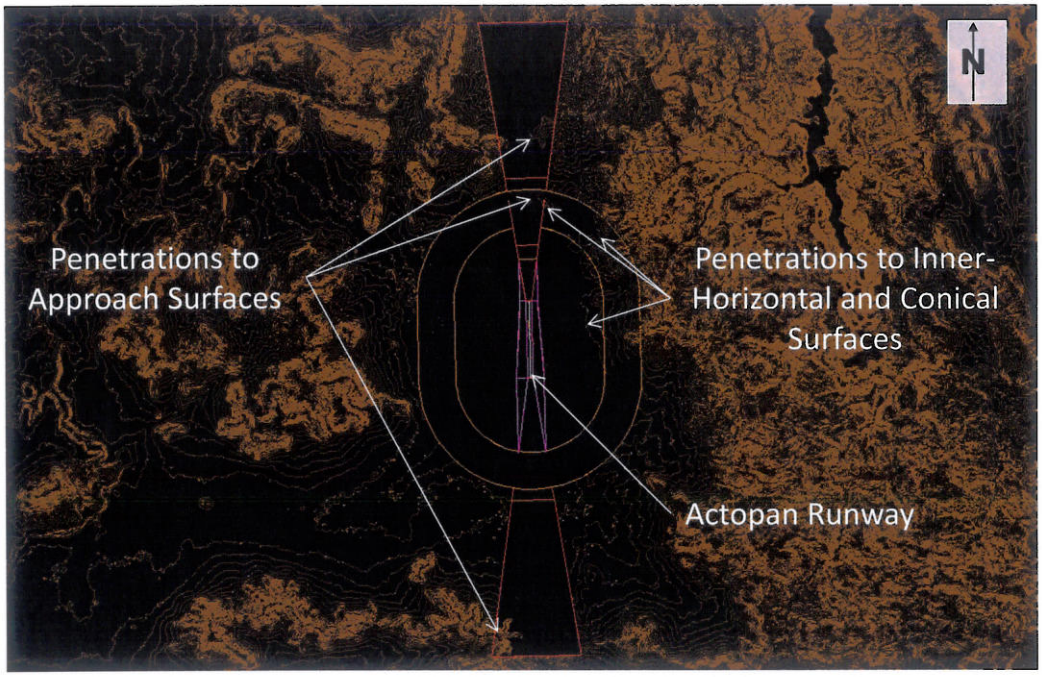
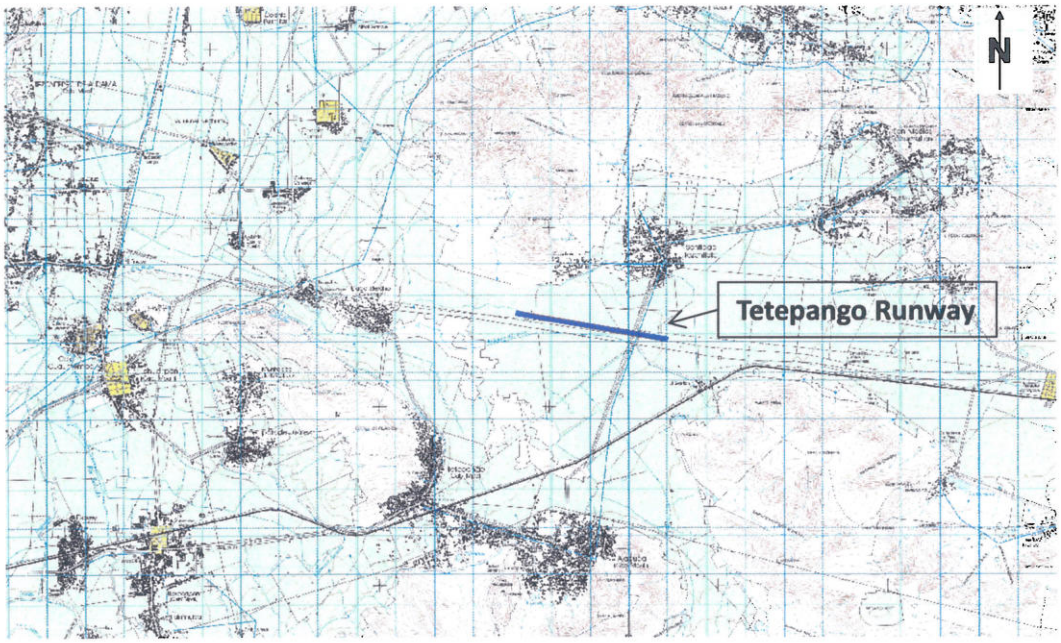


Figure 3. Initial ICAO Annex 14 OLS Assessment (Actopan Site)

2.4 Other Considerations

MITRE uses topographic maps and satellite imagery, including photographs from the helicopter tours of the sites to examine factors such as land-use, ground transportation access, impact on residential or commercial areas, and potential wildlife attractants. Satellite imagery combined with the use of tools like Google Earth and Global Mapper allow for the assessment of site characteristics (e.g., size and shape), as well as distances to obstacles and populated areas. Figure 4 shows a digital topographic map of the Tetepango site.

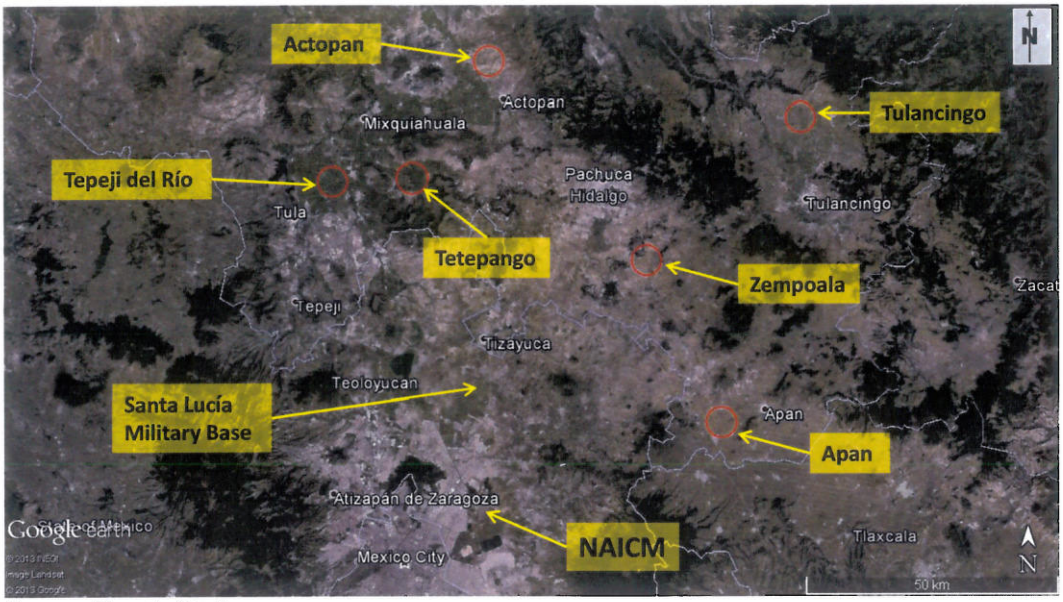


Source: Mexico's Instituto Nacional de Estadística y Geografía (INEGI)

Figure 4. Preliminary Site Assessment Using Digital Topographic Maps (Tetepango Site)

3. Description of Potential Hidalgo Airport Sites and Preliminary Findings

As previously mentioned, MITRE's exploratory airport siting work originally focused on potential new airport sites near the towns of Tepeji del Río, Actopan, and Tulancingo. MITRE provided to ASA a detailed description of the characteristics of those sites in late November 2013 (see Enclosure No. 4 to MITRE technical letter F500-L14-004). As mentioned in this document's Section 1, three additional potential airport sites near the towns of Apan, Zempoala, and then Tetepango have been identified as candidate sites. Figure 5 shows the six potential new airport sites (shown as red circles). Once again, the Actopan site is considered to be less desireable due to land acquisition and some aeronautical concerns, but MITRE has included information on that site in this document for overall completeness.



Source: Google Earth

Figure 5. Potential Airport Sites in the State of Hidalgo

The paragraphs below summarize preliminary findings at each site based on both the recently conducted aerial investigation as well as MITRE's exploratory siting work this far.

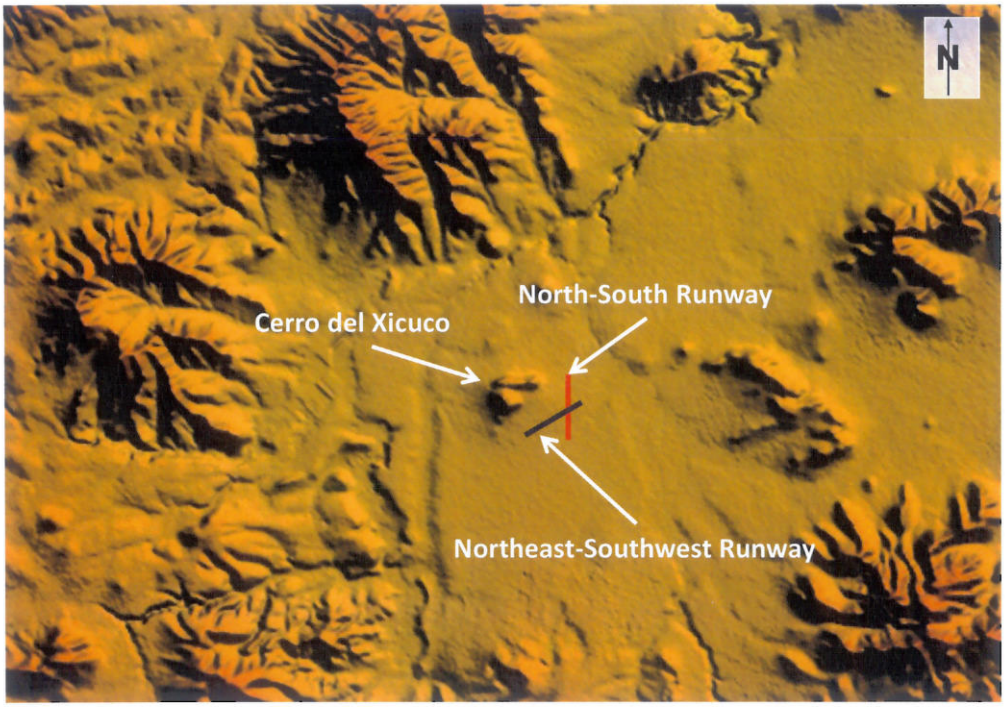
3.1 Tepeji del Río

The Tepeji del Río site is located at an economically dynamic and growing region. The site is a reasonably sized, being an open area that is mostly used for agricultural purposes. The site is relatively flat with the exception of one area of dramatically rising terrain, Cerro del Xicuco (see Figure 6).

The site has very good ground transportation access via major federal highways (including Arco Norte). There are some housing and buildings within the site and more densely populated areas surrounding the site. Therefore, noise exposure may be an issue. The MITRE team observed significant bird activity at the site during its helicopter tours, most likely due to the abundance of wildlife attractants in the area (e.g., water and food), which is common for such a developed agricultural area. In general, the site shows potential for building an airport.

Figure 6. Tepeji del Río Site

Based on the characteristics of the site and the surrounding orography, MITRE has been examining two potential runway orientation options at Tepeji del Río. Figure 7 shows a potential north-south (red) and northeast-southwest (blue) runway orientation. The team is now in the process of examining both runway orientations.



Note: wind and man-made obstacle data were not considered in determining the approximate runway orientations

Figure 7. Potential Runway Orientations at Tepeji del Río

MITRE's initial airspace interaction assessment shows that some instrument arrival and departure procedures at Tepeji de Río in either of the runway orientation options may interfere with operations at NAICM and an expanded Toluca Airport. For example, arrivals to the northeast-southwest runway in a northeast traffic flow may interfere with north flow departures from Toluca Airport, as well as south flow approaches to NAICM. Similar potential interactions were also identified for the north-south runway option, in both traffic flow directions. The team is now exploring the possibilities of mitigating the potential airspace interactions.

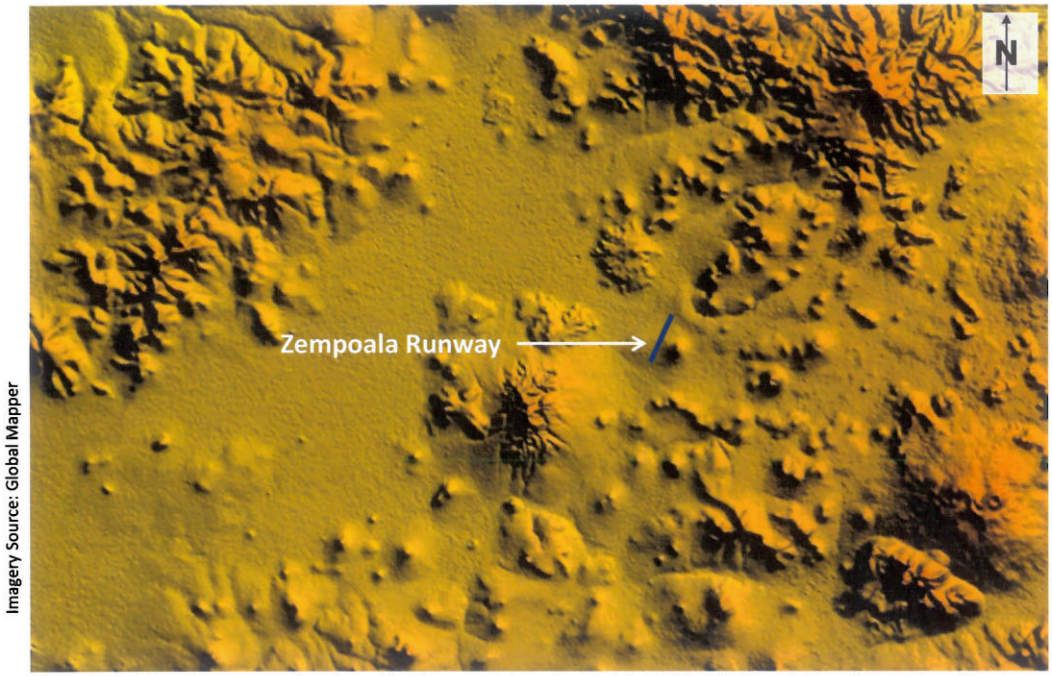
3.2 Zempoala

The Zempoala site is an open, relatively flat area, mostly used for agricultural purposes (see Figure 8). Ground transportation access is provided via a highway that connects the town of Zempoala to the city of Pachuca. The site is mostly free of housing and buildings. However, there is a small populated area to the southwest of the site, as well as some buildings and facilities to the west.

Figure 8. Zempoala Site

The proximity of the surrounding high terrain limits runway orientation options at the site. There is high terrain to the north, south, east, and west of the site. Terrain to the northeast and southwest, however, is relatively low and distant, making the siting of a runway in that direction possibly the only viable option (see Figure 9).

During conversations with local pilots and others familiar with the area, the MITRE team learned about possible strong wind activity at Zempoala during certain months. Therefore, given the limited runway orientation options at this site due to the surrounding orography, its potential to support an airport may largely depend on the analysis of prevailing winds. For example, if a detailed wind analysis reveals that strong and/or excessive crosswinds occur regularly, it may not be reasonable to develop an airport at this site.



Note: wind and man-made obstacle data were not considered in determining the approximate runway orientation

Figure 9. Potential Runway Orientation at Zempoala

One major disadvantage of the site from an airspace perspective is its proximity to NAICM. MITRE's initial airspace interaction assessment shows that some instrument arrival and departure procedures at Zempoala may interfere with operations at NAICM. For example, northeast flow arrivals to Zempoala may interfere with north flow departures at NAICM. Possible interactions were also identified between the northeast flow arrivals to Zempoala and south flow arrivals to NAICM. The team is now exploring the possibilities of mitigating the potential airspace interactions.

3.3 Tetepango

The Tetepango site is located to the east of the Tepeji del Río site, just east of the town of Tetepango. The site is a large, open, relatively flat area, mostly used for agricultural purposes (see Figure 10). The aerial investigation of the site shows that most of the site is sparsely populated. Unlike Tepeji del Río, Tetepango does not have direct access to Arco Norte. Secondary roads currently provide access to the site.

Tetepango is surrounded by mountains very close to the site. The proximity and the height of the surrounding terrain limits runway orientation options to a roughly east-west direction (see Figure 11). Similar to Zempoala, such a limitation at Tetepango makes the feasibility of this site greatly dependent on the analysis of the prevailing winds.

Figure 10. Tetepango Site

Note: wind and man-made obstacle data were not considered in determining the approximate runway orientation

Figure 11. Potential Runway Orientation at Tetepango

MITRE has just started conducting the airspace interaction analysis for Tetepango, as this site was only recently identified. MITRE's initial instrument approach and departure procedure analysis shows that development of instrument approaches and departures appears promising. However, the close proximity of mountains to the Tetepango site may cause other aeronautical complications, which MITRE still needs to examine.

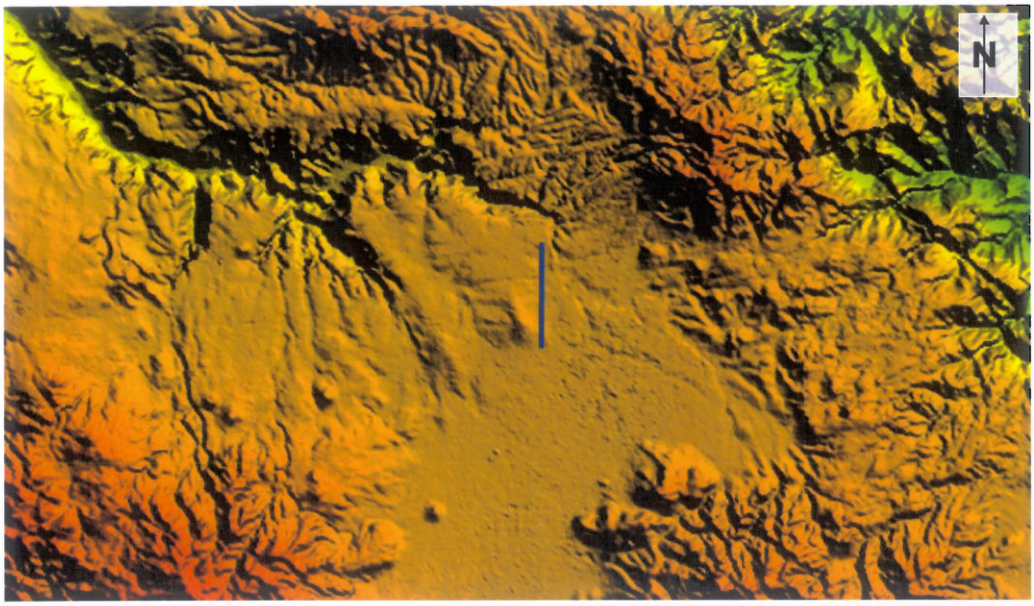
3.4 Tulancingo

The Tulancingo site is the largest of all the potential Hidalgo airport sites. As shown in Figure 12 below, it is an open, relatively flat area, used predominantly for agricultural purposes. There are many buildings, structures, and facilities in the area. However, those items are not clustered in densely populated areas, but rather are scattered around the site. Some creeks, small rivers, and water bodies were detected during the aerial investigation, which in addition to food and other attractants, could result in significant bird activity at the site.

There are asphalt roads to the east, southwest, and south of the site that all connect to Federal Highway 132, a major highway connecting eastern parts of the country to Mexico City. Some smaller asphalt and dirt roads exist within and around the area that provide access to local communities and farms.

Figure 12. Tulancingo Site

Another advantage of the site is that the surrounding orography is less of an issue. With the exception of some high terrain to the northeast, all other terrain surrounding the site is far away, which offers greater flexibility for runway siting (see Figure 13). MITRE is examining a north-south runway orientation at Tulancingo, since it creates less airspace interaction with NAICM. However, other runway orientations may be considered, if necessary (i.e., for better alignment with prevailing winds). The size of the site also allows for future expansion of the airport. In general, the site shows good potential for building an airport.



Imagery Source: Global Mapper

Note: wind and man-made obstacle data were not considered in determining the approximate runway orientation

Figure 13. Potential Runway Orientation at Tulancingo

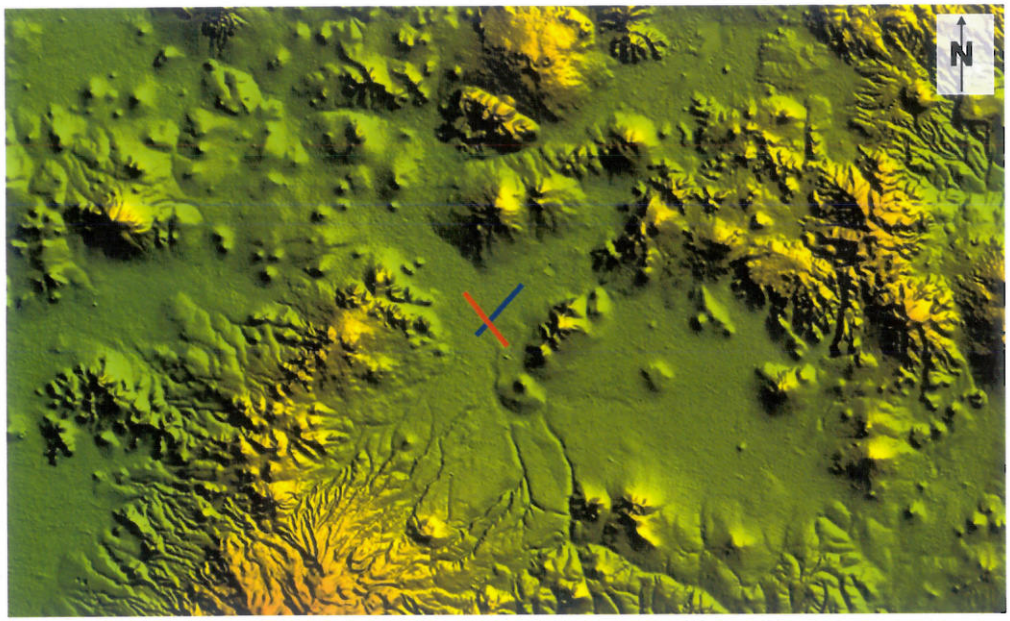
Due to its distance from NAICM and Toluca Airport, Tulancingo may have the least possible airspace interactions, compared to the other Hidalgo sites under consideration. Moreover, the site characteristics and surrounding orography offer flexibility for runway siting, which facilitates the mitigation of possible airspace interaction issues, if any.

3.5 Apan

As shown in Figure 14, Apan is an open, relatively flat area, mostly free of buildings, structures, and facilities. The area is mainly used for agricultural purposes. The site has small water canals and some roads. There are some small towns near the site. There is good ground transportation access to Apan via Arco Norte and other nearby highways and roads.

The Apan site is surrounded by high terrain to the north, east, and west of the site. MITRE is currently investigating two different runway orientation options at Apan. Figure 15 shows northeast-southwest (blue) and northwest-southeast (red) runway orientations.

Figure 14. Apan Site



Note: wind and man-made obstacle data were not considered in determining the approximate runway orientations

Figure 15. Potential Runway Orientations at Apan

One major disadvantage of the site from an airspace perspective is its proximity to NAICM. MITRE's airspace interaction assessment shows that instrument arrival and departure procedures to and from Apan for either of the runway orientations may interfere with operations at NAICM. For example, arrivals to the northeast-southwest runway in a northeast traffic flow would interfere with south flow departures from the eastern-most runway at NAICM. The close proximity of the Apan site to NAICM may

cause significant airspace interaction issues and create a complicated airspace environment, which could impact capacity at NAICM.

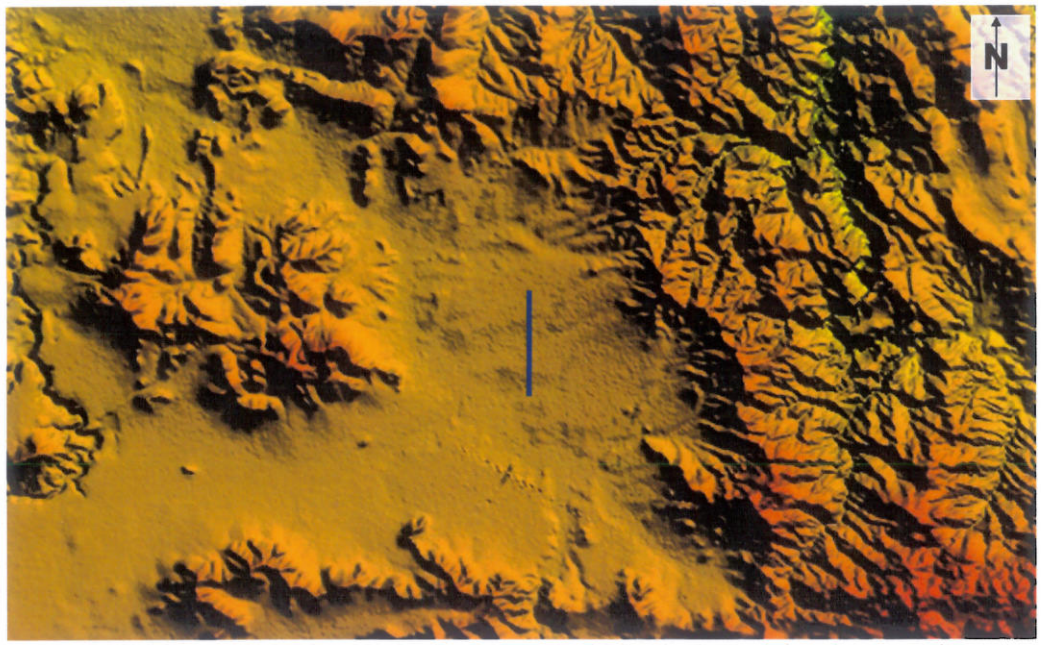
3.6 Actopan

Actopan is an open, relatively flat area that appears to be used for agricultural purposes (see Figure 16). There are many small towns and scattered buildings around the perimeter of the site. There is an access road from the town of Actopan to the site, however, the site is relatively far from major highways.

Actopan is surrounded by high terrain very close to the site. High terrain exists all the way from northwest of the site to the north, and then from the northeast to the southeast. A high mountain is also located to the west of the site. The high terrain limits the range of possible runway orientations at the site.

MITRE considered a runway oriented north-south, as shown in Figure 17. However, this orientation aligns the runway at Actopan with the NAICM extended runway centerlines. Such an alignment, combined with Actopan's location relative to NAICM, makes the airspace very complicated with many airspace interactions between both airports.

Figure 16. Actopan Site



Note: wind and man-made obstacle data were not considered in determining the approximate runway orientation

Figure 17. Potential Runway Orientation at Actopan

4. Initial OTW Model Development

MITRE has been progressing on the development of its 3D computerized visualization OTW model, which is being used to support Hidalgo airport siting analyses. MITRE is developing a photorealistic 3D computer visualization-simulation database model encompassing the potential Hidalgo airport sites and their contiguous areas. The database model can be extended up to 150 km north-south and 175 km east-west from each airport site.

The OTW model will eventually be used to display the runway, taxiways, airfield lighting, and conceptual airport structures for the final selected airport site for Hidalgo. The OTW model will also be used to support aeronautical analyses and to visualize approaches and departures to the potential new airport sites.

Figure 18 below shows an example of the OTW model display of the Tepeji del Río site, including a theoretical runway. Figure 19 shows the view from an "aircraft" approaching the Tepeji del Río site from the southwest.

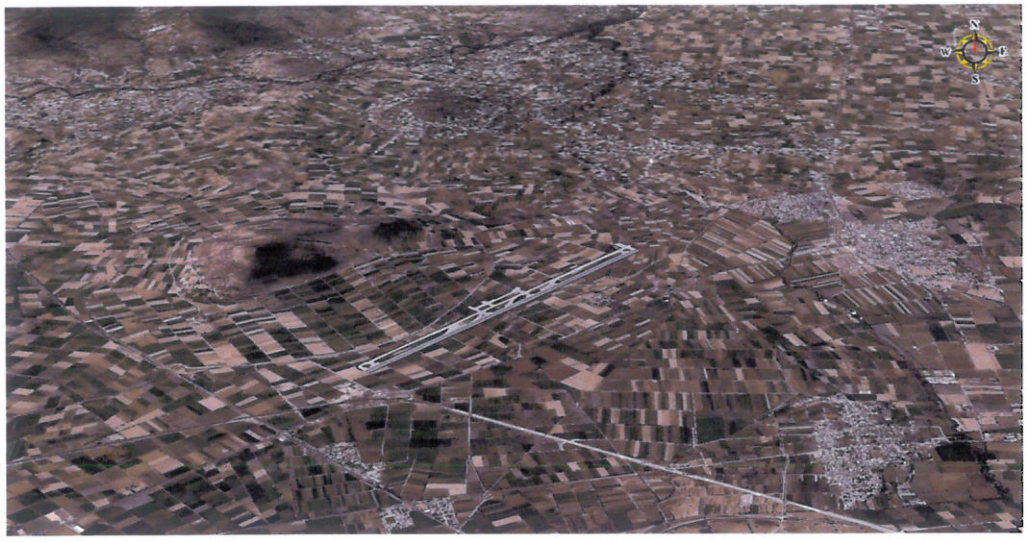


Figure 18. Tepeji del Río Northeast-Southwest Runway (View from the South)

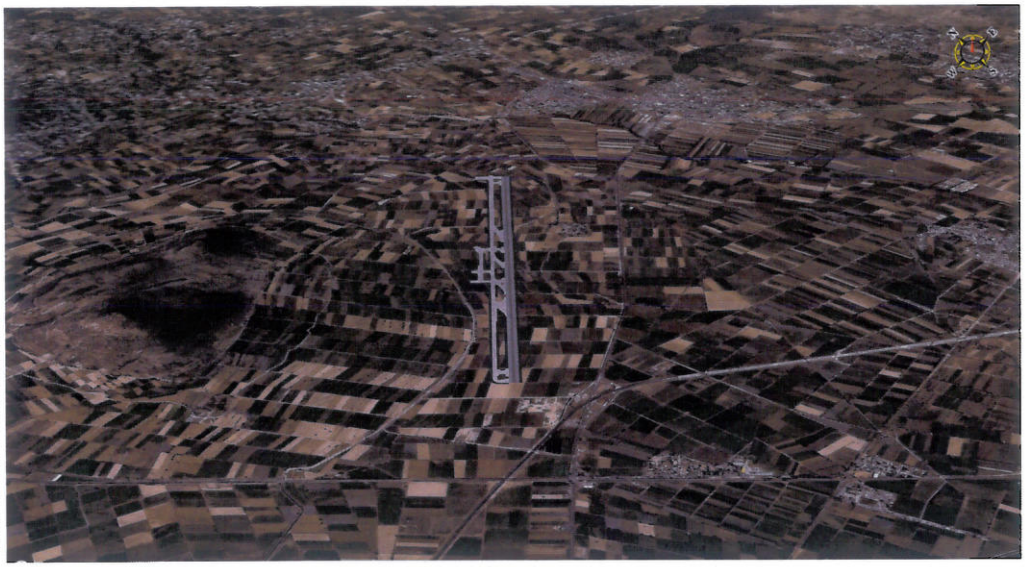


Figure 19. Tepeji del Río Northeast-Southwest Runway (View from the Southwest)

5. Next Steps

The MITRE team will continue investigating the potential airport sites near the towns of Tepeji del Río, Zempoala, Tetepango, Tulancingo, and Apan.

MITRE will discontinue its analysis of the Actopan site due to concerns expressed by officials from the State of Hidalgo regarding land acquisition matters, unless notified

otherwise. In any case, the Actopan site appears to have important aeronautical problems as well (e.g., high terrain environment and airspace interactions).

MITRE is planning to gradually complete the exploratory analyses of all five remaining sites over the next few months. As MITRE completes each airport analysis, it will inform ASA and State of Hidalgo officials of its results. This will allow both entities to be reasonably informed of MITRE's progress early on so that input and feedback to MITRE can also be provided as appropriate.

After MITRE completes its exploratory analyses of the above-mentioned sites, State of Hidalgo officials and other stakeholders will choose which three sites warrant further, more detailed investigation. Next, satellite-based photogrammetric surveys of the three potential airport sites and their surroundings will be conducted by MITRE. Furthermore, an AWOS, to be commissioned by ASA, will need to be installed at each of the three selected sites so that accurate weather data can be collected.