Enclosure 1

(Ref. Technical Letter F500-L14-012)

MITRE

Center for Advanced
Aviation System Development

Alternative Runway Configurations for the Nuevo Aeropuerto Internacional de la Ciudad de México

Prepared for

Aeropuertos y Servicios Auxiliares

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1. Introduction

As part of MITRE's support to Aeropuertos y Servicios Auxiliares (ASA), MITRE has analyzed several variations of a six-parallel runway configuration located in the proximity of the town of Texcoco, referred to in this document as the Nuevo Aeropuerto Internacional de la Ciudad de México site (hereinafter referred to as NAICM). There were two runway configurations being considered until recently. One configuration, which is MITRE's preferred runway configuration, was developed during a previous study for the Dirección General de Aeronáutica Civil (DGAC) that ended in July 2012. That configuration, hereinafter referred to as the *MITRE-Recommended Runway Configuration (July 2012),* was developed under the assumption that additional land to the north and east of the boundary of federally-owned land would be acquired. Federal officials were confident at the time that the land required for this runway configuration would be purchased by the federal government.

Nevertheless, ASA requested that MITRE examine in 2013 an alternative runway configuration under the assumption that the above-mentioned land (impinging on the eastern two runways) may not be acquired. In response to that request, a new runway configuration, hereinafter referred to as the *NAICM Alternative 1 Runway Configuration*[1], is being investigated by MITRE (an aeronautical feasibility analysis is in progress).

Both of the above runway configurations are described in detail in Enclosure 1 of MITRE Technical Letter F500-L14-004, November 2013, which any interested party should read, and are described in a general manner in Sections 2 and 3 of this document.

On 26 November 2013 MITRE received an additional alternative runway configuration from ASA. Per ASA's request, a fast-response team was assembled at MITRE to conduct a high-level examination of the proposed runway configuration, hereinafter referred to as the *NAICM Alternative 2 Runway Configuration,* in order to provide ASA with a quick assessment and opinion. It is important to mention at the outset, however, that in order to be quickly responsive, MITRE only conducted a cursory examination of the new configuration. For example, MITRE did not consider critical aeronautical factors such as procedural and airspace matters. Therefore, MITRE is only providing its opinion regarding this configuration from a landside perspective. The configuration and the results of that high-level review are presented in Section 4 of this document.

Section 5 presents an additional alternative explored by MITRE, hereinafter referred to as the *NAICM Alternative 3 Runway Configuration.* Specifically, MITRE performed a high-level examination of the potential of adjusting the *MITRE-Recommended Runway Configuration (July 2012)* in a manner that would allow additional room between the center and eastern pairs of closely-spaced runways to accommodate a terminal building. However, an aeronautical analysis of this alternative has not been performed.

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[1] Note that in Enclosure 1 of MITRE Technical Letter F500-L14-004, this configuration was referred to as the NAICM Alternative Runway Configuration.

Section 6 provides a number of closing remarks, and finally, Appendix A provides the coordinates of the runway ends for each of the four configurations.

2. MITRE-Recommended Runway Configuration

As mentioned above, the development of the *MITRE-Recommended Runway Configuration (July 2012)* was conducted under assumptions provided to MITRE by the DGAC concerning the acquisition of a moderate-to-small area of non-federally-owned land. This configuration is shown in Figure 1.

This runway configuration allows a distance of at least 3 km from the ends of Runways 01L and 01R to Lago Nabor Carrillo and other wildlife attractants located south of the Autopista Peñón-Texcoco, which meets the United States (U.S.) Federal Aviation Administration (FAA) recommendation for separation between runways and wildlife attractants. The placement of the runways in this configuration was mainly based on confidence expressed at that time by federal officials that additional land to the north and east of the boundary of federally-owned land would be acquired. See the red triangular shaped area shown in Figure 1.

The *MITRE-Recommended Runway Configuration (July 2012)* shown in Figure 1 provides the minimum lateral separation for conducting triple independent parallel approaches (1707 m) between arrival runways for a number of alternative runway-use scenarios, as determined by MITRE through collision-risk analysis and simulations. The nominal runway-use scenario would be to assign arrivals to Runways 35L, 36R, and 01R in north flow, or Runways 17R, 18L, and 19L in south flow. While the runways would operate in mixed mode initially (approaches to and departures from the same runways), ultimately departures would use the other three runways (i.e., Runways 35R, 36L, and 01L in north flow, or Runways 17L, 18R, and 19R in south flow). This runway configuration also provides 400 m between arrival and departure runways, and 200 m spacing between all runways and taxiways. Tentative lengths of the runways are given in Table 1.

Table 1. Runway Lengths (July 2012)

Runway	Length (m)
35L/17R	4500
35R/17L	5000
36L/18R	5000
36R/18L	4500
01L/19R	4500
01R/19L	4500

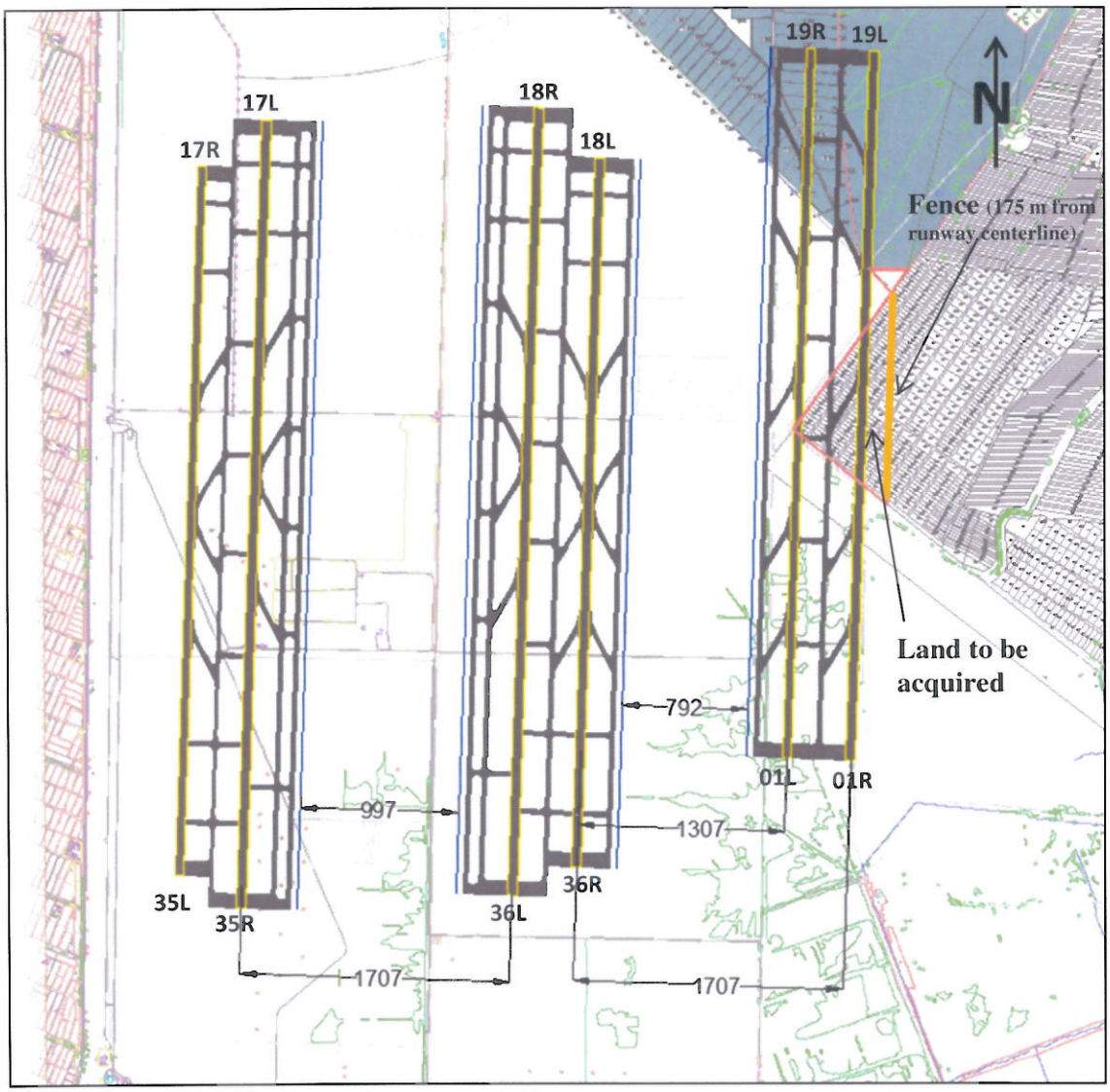


Figure 1. MITRE-Recommended Runway Configuration (July 2012)

Due to overall capacity considerations, MITRE considers that it is necessary to maintain the possibility of operating three independent arrival streams and three independent departure streams even if one of the six runways should close for maintenance or for other reasons. The *MITRE-Recommended Runway Configuration (July 2012)* provides this flexibility for the north-flow case as follows:

- If Runway 35L is closed, arrivals would be assigned to Runway 35R, which would then operate in mixed mode.
- If Runway 36R is closed, arrivals would be assigned to Runway 36L, which would operate in mixed mode.

- If Runway 01R is closed, arrivals would be assigned to Runway 01L, which would operate in mixed mode. Additionally, the nominal roles of Runways 36L/R would be reversed, with arrivals assigned to Runway 36L (to provide 1707 m lateral separation with Runway 01L, and departures assigned to Runway 36R. Departures requiring the full 5000 m runway length would be assigned to either Runway 36L or 35R.
- If any of the nominal departure runways (35R, 36L, 01L) is closed, the departures would be assigned to the other runway of the closely-spaced pair, which would operate in mixed mode.

The runway configuration designed by MITRE provides similar operational flexibility in south flow. Furthermore, with this configuration triple parallel approaches could still be maintained with the closure of both, Runway 35L/17R and Runway 36R/18L.

Note that complete feasibility of this *MITRE-Recommended Runway Configuration (July 2012)*, from an aeronautical perspective, was established in MITRE's previous study.

3. NAICM Alternative 1 Runway Configuration

As mentioned above, the recommended runway configuration shown in Figure 1 was developed under the assumption that additional land to the north and east of the boundary of federally-owned land would be acquired. Federal officials were confident at the time that the land required for this runway configuration would be purchased by the federal government. Nonetheless, ASA requested that MITRE examine an alternative runway configuration under the assumption that the triangular area of land to the east (and impinging on Runway 01R and Runway 01L) may not be acquired. In response to that request, a new runway configuration was investigated by MITRE.

The new configuration, referred to in this document as the *NAICM Alternative 1 Runway Configuration,* utilized, to determine the federal boundary, an AutoCAD drawing provided by Comisión Nacional del Agua (CONAGUA) in June 2011.

As mentioned in Section 2, because the *MITRE-Recommended Runway Configuration (July 2012)* provided 1707 m of separation between Runway 35R and Runway 36L, triple parallel approaches could still be maintained with the closure of both Runway 35L and Runway 36R. Although having this much flexibility is advantageous, planning for the closure of only one runway may be sufficient since maintenance activities would not likely be simultaneously scheduled for more than one runway. Therefore, the 1707 m separation required to operate independent parallel approaches only needs to be applied between Runway 35L and Runway 36L, and between Runway 35R and Runway 36R.

The *NAICM Alternative 1 Runway Configuration* is shown graphically in Figure 2. Runway lengths are unchanged from those given in Table 1.

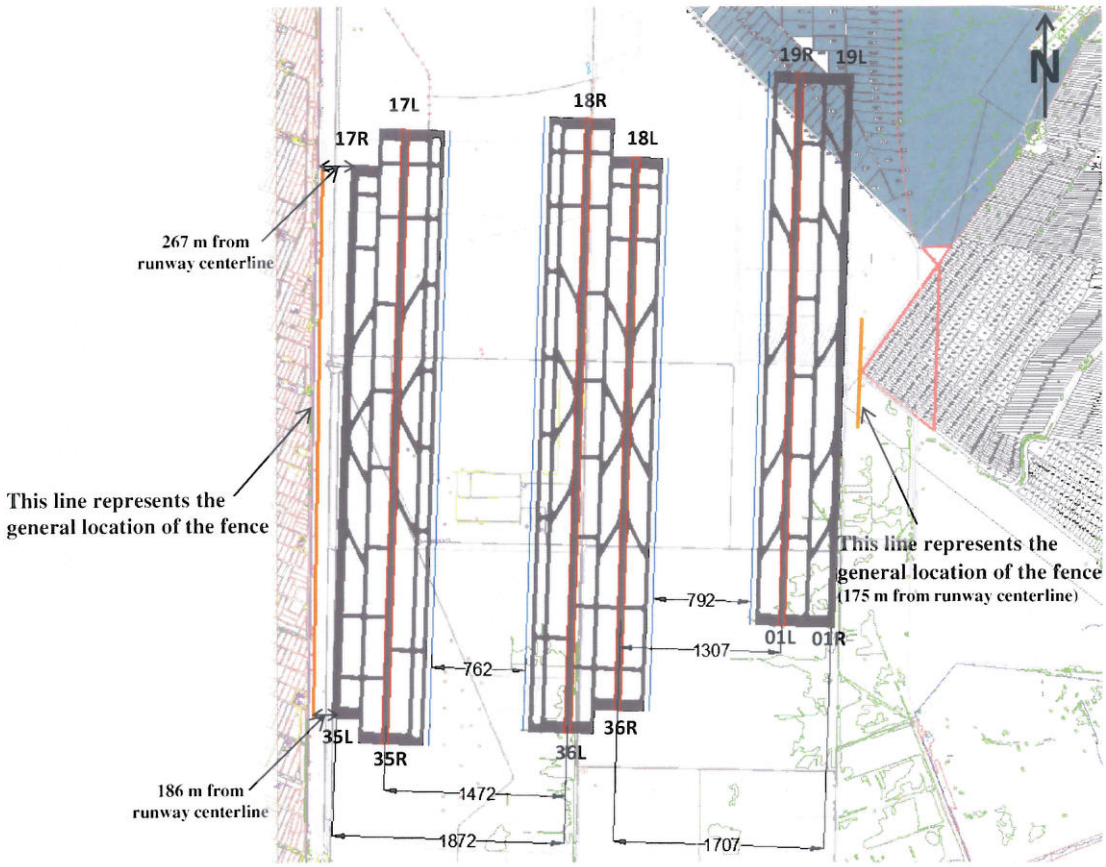


Figure 2. NAICM Alternative 1 Runway Configuration

A major concern in the development of the *NAICM Alternative 1 Runway Configuration* is the amount of space between runways that could be used for terminal facilities. While the *MITRE-Recommended Runway Configuration (July 2012)* had a large area between the western and center pairs of runways, due to the minimum spacing required by aeronautical considerations for independent approaches being applied between Runways 35R and 36L (rather than between Runways 35L and 36L and Runways 35R and 36R), the available space for terminal facilities between these runways has been reduced in the *NAICM Alternative 1 Runway Configuration*. Note that at the time this runway configuration was developed, MITRE considered that ASA intended to locate the terminal building between Runways 35R and 36L. Therefore, MITRE considered dual parallel taxiways adjacent to those runways. Dual parallel taxiways were not considered between Runways 36R and 01L. As shown in Figure 2, there is 762 m of spacing available for terminal facilities between Runways 35R and 36L.

Note that MITRE is currently analyzing the *NAICM Alternative 1 Runway Configuration* to establish feasibility from an aeronautical perspective.

4. NAICM Alternative 2 Runway Configuration

On 26 November 2013, MITRE received from ASA an AutoCAD drawing and graphic depicting a runway configuration for NAICM different than those proposed by MITRE earlier. This configuration, referred to in this document as the *NAICM Alternative 2 Runway Configuration*, is shown in Figure 3. A graphical comparison of the *NAICM Alternative 2 Runway Configuration* to the *MITRE-Recommended Runway Configuration (July 2012)* is shown in Figure 4. Also, a graphical comparison of the *NAICM Alternative 2 Runway Configuration* to the *NAICM Alternative 1 Runway Configuration* is shown in Figure 5.

For the sake of discussion in this document, runways are numbered from 1 to 6, starting with the westernmost runway. Thus, the easternmost Runway 6 is located outside federally-owned land.

A high-level review of the *NAICM Alternative 2 Runway Configuration* was conducted from several perspectives, including runway length and width; terminal location; nominal runway use and operational flexibility; separations between runways, taxiways, boundaries, infrastructure, and wildlife attractants; and airspace ramifications. These are discussed below.

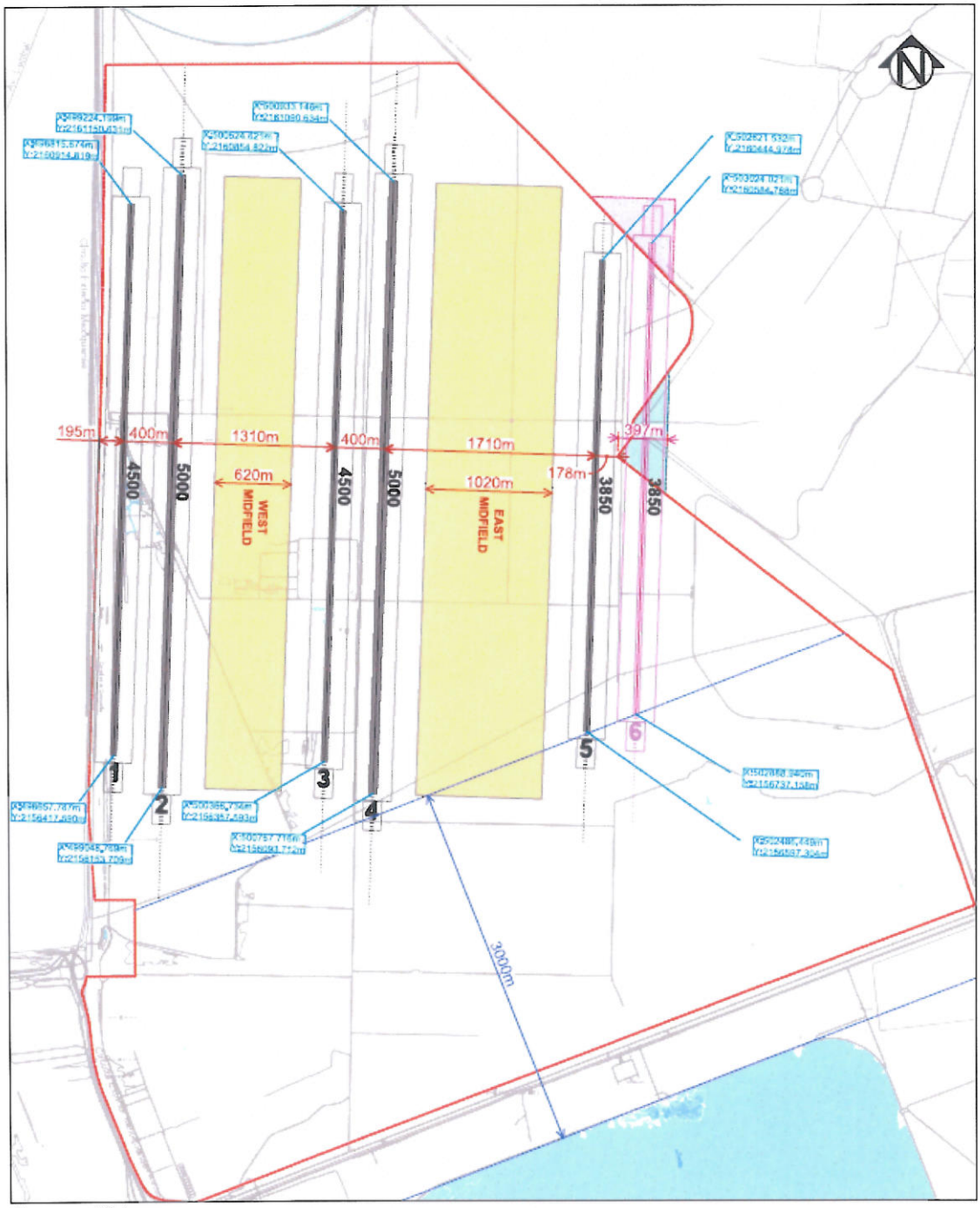
Runway Lengths and Widths

The eastern runway pair (Runways 5 and 6) are only 3850 m in length. This is a significant reduction from the 4500 m runways being proposed in MITRE's configurations. Although this length is just slightly shorter than the runways at the existing Benito Juárez International Airport in Mexico City, it is likely that in the future there may be a significant number of aircraft that would require one of the other longer runways, especially for takeoff. Although there are two 5000 m runways in the design, the need to assign a significant number of aircraft departing to or even arriving from the eastern periphery of the terminal area will complicate the airspace design, as described below.

The width of the runways was measured in the ASA-provided AutoCAD drawing. The two 5000 m runways have a width of 60 m. However, the other four runways have a width of only 45 m. MITRE recommends that all runways have a width of 60 m.

Nominal Runway Use

It appears from the drawing and runway lengths that the nominal runway-use strategy would be to operate arrivals on Runways 1, 3, and 5 and departures on Runways 2, 4, and 5. Runway 5 would operate in mixed mode, which would reduce overall capacity. When Runway 6 is constructed, not a clear development from the information received by MITRE, arrivals would then shift to that runway, leaving Runway 5 as a departure runway.



Source: ASA

Figure 3. NAICM Alternative 2 Runway Configuration

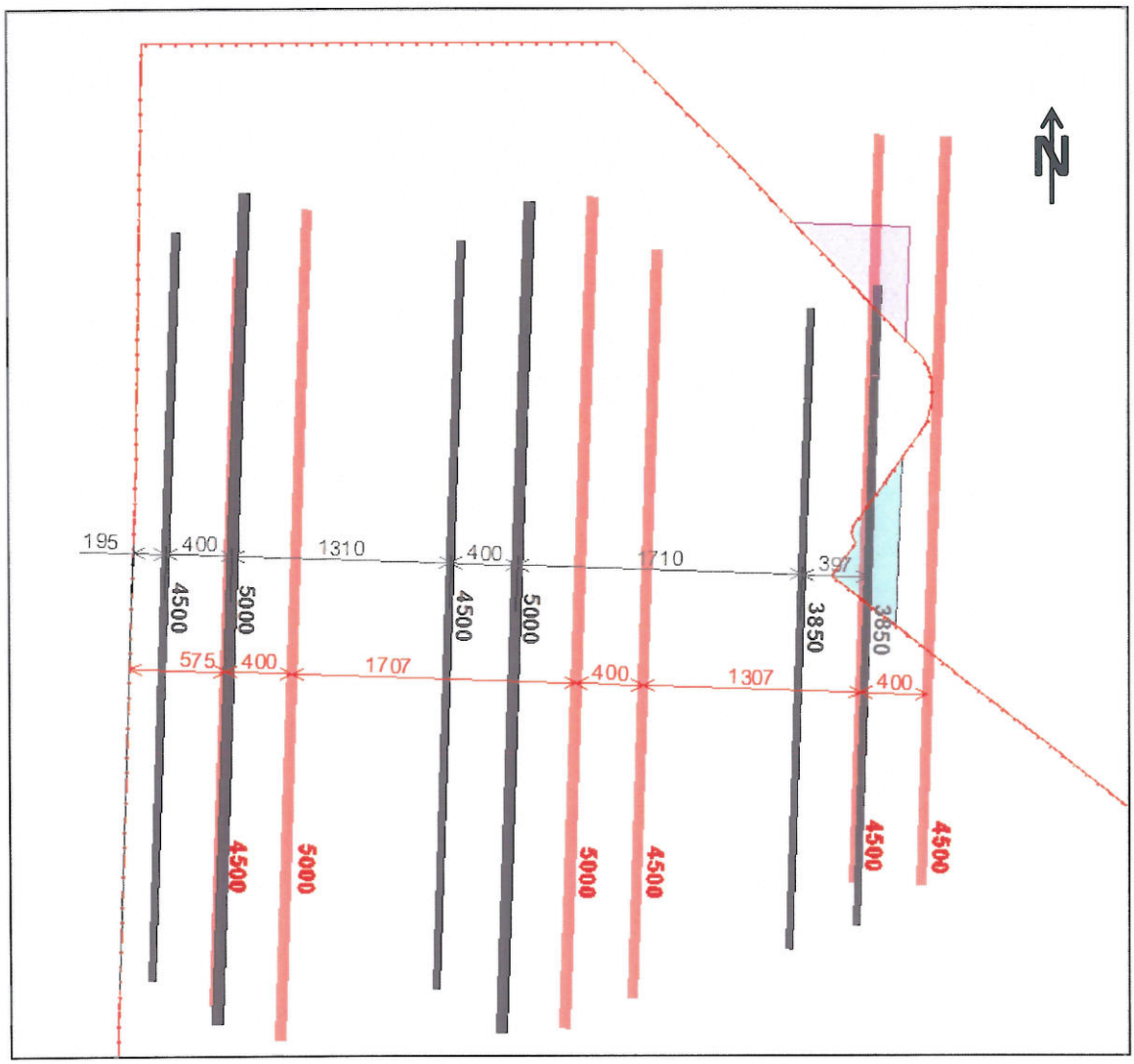


Figure 4. Comparison of the NAICM Alternative 2 Runway Configuration, Shown in Black, to the MITRE-Recommended Runway Configuration (July 2012), Shown in Red

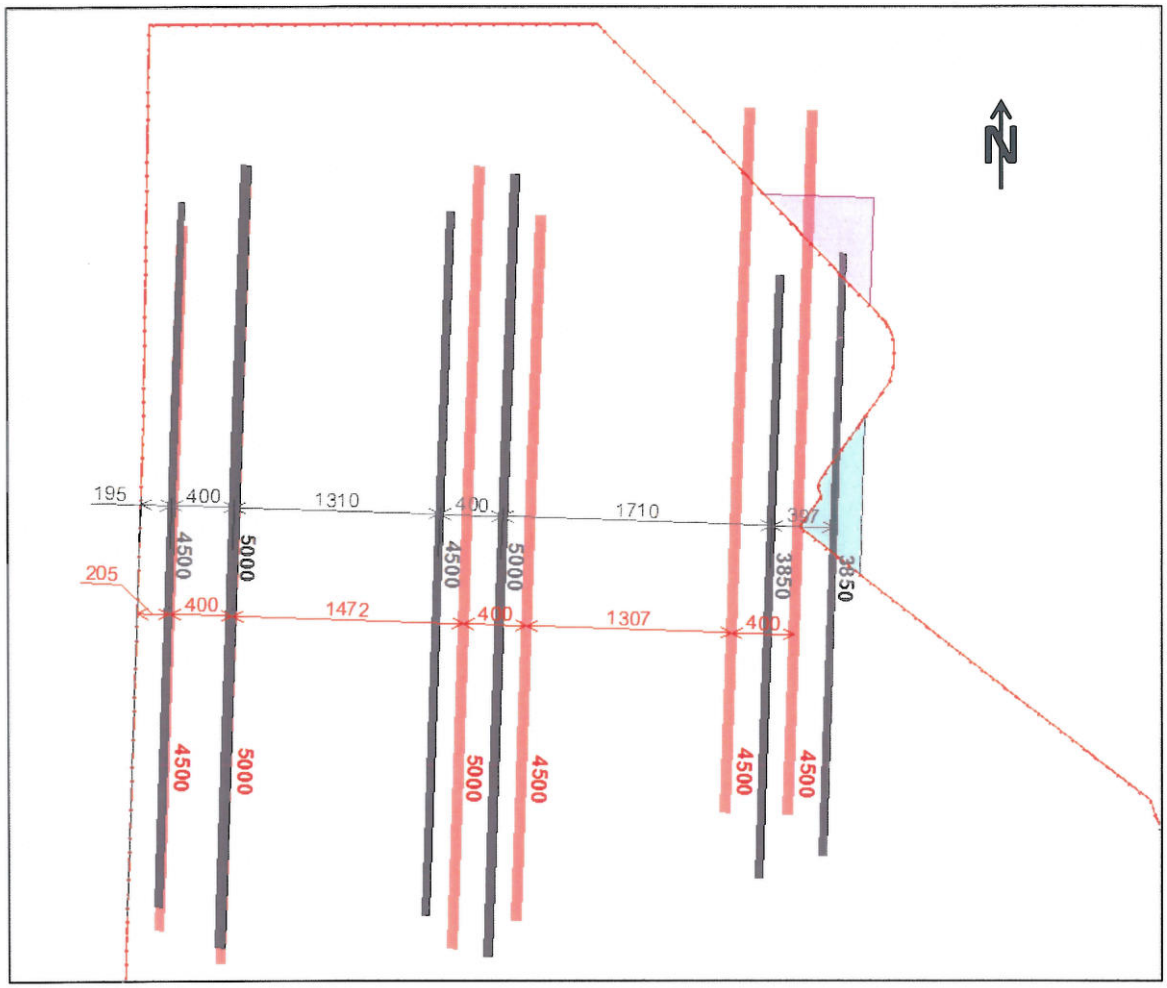


Figure 5. Comparison of the NAICM Alternative 2 Runway Configuration, Shown in Black to the NAICM Alternative 1 Runway Configuration, Shown in Red

Operational flexibility

The *NAICM Alternative 2 Runway Configuration* appears to support closure of any single runway, as follows:

- If Runway 1 is closed, then its arrivals are moved to Runway 2, which operates in mixed mode. Runways 3 and 4 are switched, with arrivals on Runway 4 (to give 1710 m separation from arrivals on Runway 2) and departures on Runway 3 (departures that require the full 5000 m runway length would be assigned to Runway 2). There will still be 1710 m separation between arrivals on Runways 4 and 5.

- If Runway 2 is closed, departures from that runway are shifted to Runway 1, which operates in mixed mode. Departures requiring the full 5000 m runway length would be assigned to Runway 4.

- If Runway 3 is closed, those arrivals are shifted to Runway 4 (operating in mixed mode) and there is still a 1710 m separation between arrivals on Runways 4 and 5.
- If Runway 4 is closed, departures from that runway are shifted to Runway 3, which operates in mixed mode. Departures requiring the full 5000 m runway length would be assigned to Runway 2.
- If Runway 6 is built, then either Runway 5 or 6 can be closed, with the other runway serving both arrivals and departures in mixed mode. There will be sufficient separation to have triple independent parallel approaches.
    - Clearly, if Runway 6 is not constructed and Runway 5 is closed, the airport will be reduced to operating two arrival streams and two departure streams, which would result in a significant reduction of runway capacity.

The operational flexibility of the *NAICM Alternative 2 Runway Configuration* is therefore equivalent to that of the *NAICM Alternative 1 Runway Configuration*, but clearly less flexible than the *MITRE-Recommended Runway Configuration (July 2012)*.

Terminal Location

The design of the *NAICM Alternative 2 Runway Configuration* appears to plan for the east midfield terminal to be the main passenger facility (with an east-west dimension of 1020 m); the smaller west midfield terminal (with an east-west dimension of 620 m) would serve a supporting role. MITRE had always planned on locating the main terminal between the western and center pairs of runways.

Additional information provided to MITRE by ASA after 26 November 2013 indicates that the rationale for locating the main terminal between the center and eastern pairs of runways is due to soil drainage issues on the western part of the site. However, the MITRE team feels that, regardless of where the main terminal is built, these issues need to be resolved in order to construct the western pair of runways and other airport related facilities and components. Otherwise, triple approach capacity will not take place and overall capacity will lead to an airport saturated relatively soon. Furthermore, MITRE recommends that the most extreme runways, i.e., Runways 1 and 6 be constructed first, in order to "stake claim" on that land.

Note that if the terminal building were to be constructed in the area to the east of the center pair of runways and Runway 6 were never built, then the operation of the airport would be significantly less efficient compared to if the main terminal were placed to the west of the center pair (the most efficient operation is when the terminal is located between the main runways or runway pairs). Moreover, aircraft requiring the longer 5000 m runway (i.e., Runway 2) would need to taxi a much longer distance.

Distance to Boundaries, Infrastructure, and Wildlife Attractants

The design of the *NAICM Alternative 2 Runway Configuration* appears to provide sufficient distance from boundaries and other nearby infrastructure, such as the major drain (*dren*). There are at least 3 km from all runway ends to Lago Nabor Carrillo.

It is worthwhile mentioning that ASA reported to MITRE an intention by the Comisión Federal de Electricidad (CFE) of installing a power line in the proximity of the NAICM site. Preliminary information indicates that the proposed power line would be very close to the *NAICM Alternative 2 Runway Configuration* (as well as the *NAICM Alternative 1 Runway Configuration).*

Taxiway Separation

The design of the *NAICM Alternative 2 Runway Configuration* provides only 190 m of separation between the parallel taxiway and Runways 2 and 3 and Runways 4 and 5 (on the side of those runways adjacent to the terminal buildings). MITRE recommends, however, 200 m of separation between runways and parallel taxiways. This may not be a significant issue, however, as the dual parallel taxiways utilized in the design may provide more flexibility for aircraft maneuvering. Nevertheless, MITRE recommends that the maneuvering of very large aircraft (such as the Airbus A380) be further evaluated.

Airspace Ramifications

As mentioned above, the relatively short 3850 m length of the eastern runway or runway pair could result in a significant proportion of aircraft requiring one of the other runways (particularly for takeoff), depending on how NAICM and its fleet mix evolve in the future. This will increase the need to vector traffic within the terminal area such that an aircraft that is using one of the longer runways can exit the terminal area in the east. The conceptual airspace design developed by MITRE for use with NAICM would need to be modified for this purpose, and this need to vector aircraft around the terminal area may add to the complexity of operations and controller workload.

Finally, note that an aeronautical feasibility analysis of the *NAICM Alternative 2 Runway Configuration* has not been conducted.

5. NAICM Alternative 3 Runway Configuration

As previously mentioned, MITRE has always planned on locating the main terminal between the western and center pairs of runways. However, if there were some advantage of locating the main terminal facility between the center and eastern runway pairs, one alternative could be to modify the *MITRE-Recommended Runway Configuration (2012)* described in Section 2 by shifting the center pair of runways to the west. The advantage of this approach is that aeronautical feasibility would only need to be reestablished for the center pair of runways, as the other four runways are at locations previously analyzed. Moreover, since the center runway pair would be shifted 400 m to the west and the arrival and departure assignments of this pair are being switched (i.e., Runway 3 would be used for departures and would be 5000 m in length, while Runway 4 would service arrivals and would be 4500 m in length), the new Runway 4 would be located in exactly the same position as the original Runway 3. Therefore, only the new Runway 3 would need to be aeronautically re-evaluated. Note also that noise impact would need to be re-examined. A conceptual depiction of this runway

configuration, referred to as the *NAICM Alternative 3 Runway Configuration*, is shown in Figure 6. Runway lengths are unchanged from those given in Table 1, except that the lengths of Runways 36L/18R and 36R/18L are reversed.

It is important to reiterate, however, that a relatively small non-federal area to the north and east must still be acquired in order to construct the easternmost pair of runways. Also, if the terminal building were constructed in the area to the east of the center pair of runways, it is critical that enough land be obtained to build both of the easternmost pair of runways to ensure an efficient operation.

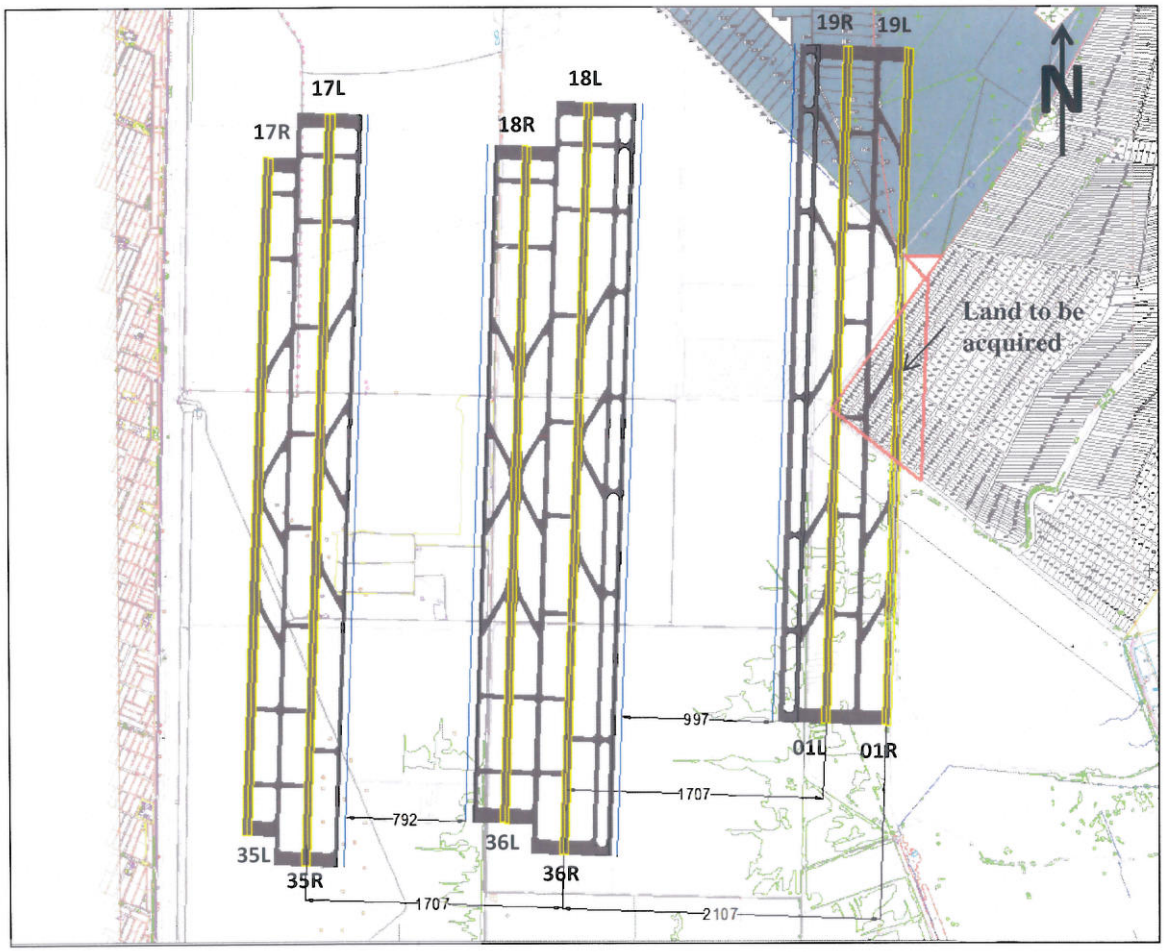


Figure 6. NAICM Alternative 3 Runway Configuration

6. Closing Remarks

MITRE has already established the aeronautical feasibility of the *MITRE-Recommended Runway Configuration (2012)*, which was proven during a previous project, and is in the process of examining the *NAICM Alternative 1 Runway Configuration*. Both of these configurations consider that the terminal building will be located between the western and center pairs of runways. Substantial amount of work, not just procedural but also relating to airspace vectoring has been completed.

The new *NAICM Alternative 2 Runway Configuration* being considered by ASA is based on the terminal building being located between the center and eastern pairs of runways. This configuration is less flexible than the *MITRE-Recommended Runway Configuration (2012)* and its aeronautical feasibility has not been proven. For example, the feasibility of triple independent approaches and departures would need to be re-examined. Additionally, the *NAICM Alternative 2 Runway Configuration* may introduce some airspace and operational issues that would need to be analyzed due to the reduced length of the easternmost runways. Analysis of this new configuration would require a significant amount of work spanning many months.

The *NAICM Alternative 3 Runway Configuration* is a modification of the *MITRE-Recommended Runway Configuration (2012),* as it shifts the center runway pair 400 m to the west to provide more room between the center and eastern pairs of runways for terminal building development. MITRE was able to shift the center pair of runways in a manner such that only the new Runway 3 would need to be re-analyzed in order to establish aeronautical feasibility. This would still take time, however less so than the effort required to analyze the *NAICM Alternative 2 Runway Configuration.*

It is important to highlight that if the terminal building is to be located between the center and eastern pairs of runways, it is critical that the appropriate amount of land to construct Runway 6 (i.e., the easternmost runway) be acquired before any final decisions are made to construct the airport. Constructing the terminal building between the center and eastern pairs of runways to later discover that Runway 6 could not be constructed because the appropriate amount of non-federally owned land could not be acquired would significantly impact the operational efficiency of the airport.

Appendix A. Runway End Coordinates

The coordinates of each of the runway ends, for the four configurations described above, are given in Tables A-1 through A-4.

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

Runway	Runway End and Displaced Threshold	WGS 84 Coordinates on Runway Centerline
17R/35L	17R Runway End	19 32 29.9N/99 00 27.8W
	35L Runway End	19 30 03.5N/99 00 33.2W
17L/35R	17L Runway End	19 32 39.3N/99 00 13.7W
	35R Runway End	19 29 56.7N/99 00 19.7W
18R/36L	18R Runway End	19 32 41.6N/98 59 15.0W
	36L Runway End	19 29 59.1N/98 59 21.0W
18L/36R	18L Runway End	19 32 31.3N/98 59 01.6W
	36R Runway End	19 30 05.0N/98 59 07.1W
19R/01L	19R Runway End	19 32 53.7N/98 58 15.9W
	19R Displaced Threshold (Tentative)	19 32 39.8N/98 58 16.4W
	01L Runway End	19 30 27.3N/98 58 21.4W
19L/01R	19L Runway End	19 32 53.2N/98 58 02.2W
	19L Displaced Threshold (Tentative)	19 32 39.3N/98 58 02.7W
	01R Runway End	19 30 26.9N/98 58 07.6W

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

Table A-2. NAICM Alternative 1 Runway Configuration: Coordinates

Runway	Runway End and Displaced Threshold	WGS 84 Coordinates on Runway Centerline
17R/35L	17R Runway End	19 32 30.0N/99 00 40.5W
	35L Runway End	19 30 03.7N/99 00 45.9W
17L/35R	17L Runway End	19 32 39.4N/99 00 26.4W
	35R Runway End	19 29 56.8N/99 00 32.4W
18R/36L	18R Runway End	19 32 42.3N/98 59 35.7W
	36L Runway End	19 29 59.8N/98 59 41.8W
18L/36R	18L Runway End	19 32 32.0N/98 59 22.4W
	36R Runway End	19 30 05.7N/98 59 27.8W
19R/01L	19R Runway End	19 32 54.4N/98 58 36.7W
	19R Displaced Threshold (Tentative)	19 32 40.5N/98 58 37.2W
	01L Runway End	19 30 28.1N/98 58 42.1W
19L/01R	19L Runway End	19 32 53.9N/98 58 22.9W
	19L Displaced Threshold (Tentative)	19 32 40.0N/98 58 23.5W
	01R Runway End	19 30 27.6N/98 58 28.4W

Note: the runway coordinates contained in this table should not be considered final as MITRE is in the process of determining the aeronautical feasibility of this runway configuration.

Table A-3. NAICM Alternative 2 Runway Configuration: Coordinates

Runway	Runway End and Displaced Threshold	WGS 84 Coordinates on Runway Centerline
17R/35L	17R Runway End	19 32 34.9N/99 00 40.6W
	35L Runway End	19 30 08.6N/99 00 46.0W
17L/35R	17L Runway End	19 32 42.6N/99 00 26.6W
	35R Runway End	19 30 00.0N/99 00 32.6W
18R/36L	18R Runway End	19 32 33.0N/98 59 42.0W
	36L Runway End	19 30 06.7N/98 59 47.4W
18L/36R	18L Runway End	19 32 40.6N/98 59 28.0W
	36R Runway End	19 29 58.1N/98 59 34.0W
19R/01L	19R Runway End	19 32 19.6N/98 58 30.0W
	19R Displaced Threshold	19 32 02.1N/ 98 58 30.7W
	01L Runway End	19 30 14.4N/98 58 34.7W
19L/01R	19L Runway End	19 32 24.2N/98 58 16.2W
	19L Displaced Threshold	19 32 06.6N/98 58 16.9W
	01R Runway End	19 30 19.0N/98 58 20.9W

Note: the runway coordinates contained in this table are associated with a runway configuration that was neither developed nor analyzed for aeronautical feasibility by MITRE.

Table A-4. NAICM Alternative 3 Runway Configuration: Coordinates

Runway	Runway End and Displaced Threshold	WGS 84 Coordinates on Runway Centerline
17R/35L	17R Runway End	19 32 29.9N/99 00 27.8W
	35L Runway End	19 30 03.5N/99 00 33.2W
17L/35R	17L Runway End	19 32 39.3N/99 00 13.7W
	35R Runway End	19 29 56.7N/99 00 19.7W
18R/36L	18R Runway End	19 32 32.2N/98 59 29.1W
	36L Runway End	19 30 05.9N/98 59 34.5W
18L/36R	18L Runway End	19 32 41.6N/98 59 15.0W
	36R Runway End	19 29 59.1N/98 59 21.0W
19R/01L	19R Runway End	19 32 53.7N/98 58 15.9W
	19R Displaced Threshold (Tentative)	19 32 39.8N/98 58 16.4W
	01L Runway End	19 30 27.3N/98 58 21.4W
19L/01R	19L Runway End	19 32 53.2N/98 58 02.2W
	19L Displaced Threshold (Tentative)	19 32 39.3N/98 58 02.7W
	01R Runway End	19 30 26.9N/98 58 07.6W

Note: the runway coordinates contained in this table should not be considered final. MITRE prepared this runway configuration only for exploratory discussion purposes. Aeronautical feasibility has not been proven.