

Enclosure 3

(Ref. Technical Letter F500-L15-007)



**Center for Advanced
Aviation System Development**

Independent Operations at Nuevo Aeropuerto Internacional de la Ciudad de México and Cancún Airport

*Air Traffic Control Equipment Requirements and
Key Elements to Consider*

Prepared for

Aeropuertos y Servicios Auxiliares

January 2015

Principal Acronyms and Abbreviations

ACC	Area Control Center
ATC	Air Traffic Control
FAA	U.S. Federal Aviation Administration
FMA	Final Monitor Aid
ft	Feet
HITL	Human-In-The-Loop
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
KATL	Hartsfield-Jackson Atlanta International Airport
MITRE	The MITRE Corporation
MMUN	Cancún International Airport
MSL	Mean Sea Level
NAICM	Nuevo Aeropuerto Internacional de la Ciudad de México
NM	nautical mile
NTZ	No-Transgression Zone
PANS-ATM	Procedures for Air Navigation Services – Air Traffic Management
PAOAS	Parallel Approach Obstacle Assessment Surface
RNAV	Area Navigation
RNP	Required Navigation Performance
SENEAM	Servicios a la Navegación en el Espacio Aéreo Mexicano
SOIR	Simultaneous Operations on Parallel or Near-Parallel Instrument Runways
SOP	Standard Operating Procedure
STAR	Standard Terminal Arrival Route
U.S.	United States

1. Introduction

The MITRE Corporation (MITRE) has been assisting the Mexican aviation authorities in the development of a new airport for Mexico City for a number of years. The new airport, Nuevo Aeropuerto Internacional de la Ciudad de México (NAICM), will be required to provide a significant capacity increase over the existing airport in order to fulfil the anticipated future traffic demand of the Mexico City basin. Accordingly, MITRE has recommended that NAICM have the capability to conduct independent approaches and departures to/from three parallel runways. Airports in Mexico do not currently conduct any independent operations (whether to/from two or three parallel runways). These types of specialized operations have a number of Air Traffic Control (ATC) equipment and procedural requirements that must be met to accomplish them successfully and safely. Other important ATC matters, such as the design of the airspace, controller positions, and training must be considered as well.

At Cancún International Airport (MMUN), Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM), with the assistance of MITRE, is planning to set-up dual independent approach and departure operations to/from the existing parallel runways to allow air traffic controllers develop the techniques and gain experience in conducting independent operations that can later be used at NAICM.

A team of MITRE engineers visited MMUN and Mexico City in December 2014 to discuss requirements for independent operations with officials from SENEAM and observe aircraft operations. The purpose of this document is to summarize the information presented in those meetings and provide additional information relevant to the planning of independent operations at MMUN and NAICM. This document covers the key elements associated with approach and departure control operations. Other elements associated with ATC operations, such as tower operations, including the number of operational positions, terminal, apron and taxiway layout as it relates to aircraft surface movements, as well as traffic flow management are also important considerations when planning for dual- and triple-independent operations.

The International Civil Aviation Organization (ICAO), in both the *Manual on Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR)* [ICAO, 2004] and *Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM)* [ICAO, 2007], allows independent parallel approaches to two runways. The United States (U.S.) Federal Aviation Administration (FAA) document *Air Traffic Control* [FAA, 2014] provides information on independent approaches to two and three runways. All of these documents provide regulations and minimum standards for the conduct of independent operations. This document amplifies and clarifies additional information that will be essential for the Mexican aviation authorities to approve the actual conduct of independent operations at MMUN and NAICM based on the above-mentioned ICAO and FAA documents. Also, refer to Enclosure 2 of MITRE Technical Letter F500-L15-007, dated 12 January 2015 for information on Terminal Maneuvering Area implementation planning.

Additionally, MITRE has provided the Mexican authorities with a number of reports on independent approaches for both MMUN and NAICM in the past. This document amplifies prior analyses performed for MMUN and NAICM, as well as information on surveillance, display, and communications-override equipment required to manage the runway separation

standards in [ICAO, 2004; ICAO, 2007] and [FAA, 2014a]. Refer to [MITRE, 2009; MITRE, 2014] for additional information.

Section 2 of this document contains information on general requirements for independent approaches at MMUN and NAICM, including equipment and procedural matters. Section 3 identifies key elements to be considered in preparing for dual (MMUN) and triple (NAICM) independent approach and departure procedures, including best practices for independent approaches and departures. Section 4 provides a summary of the document, including next steps.

2. General Requirements for Independent Approaches at MMUN and NAICM

The general requirements for independent approaches are contained in [ICAO, 2004; ICAO, 2007]. Additional requirements for triple independent approaches from [FAA, 2014a] are noted as appropriate. Runway spacing requirements for MMUN and NAICM were provided in [MITRE, 2009; MITRE, 2014] and are not discussed in this document. The requirements below are relevant for independent approaches, but are amplified with additional best practices contained in Section 3 of this paper.

- Airspace design must permit controllers to provide at least 1000 feet (ft) vertical separation between aircraft on adjacent approach courses until the aircraft are established on their respective localizer courses. Minimum distance criteria for turns onto final approach must also be met, and a maximum intercept angle of 20 degrees must be used for localizer turn on for approaches to three runways and a maximum of 30 degrees for two runways. One nautical mile (NM) of straight flight prior to localizer intercept is also required. Figure 1 shows some of the intercept rules for independent approaches.

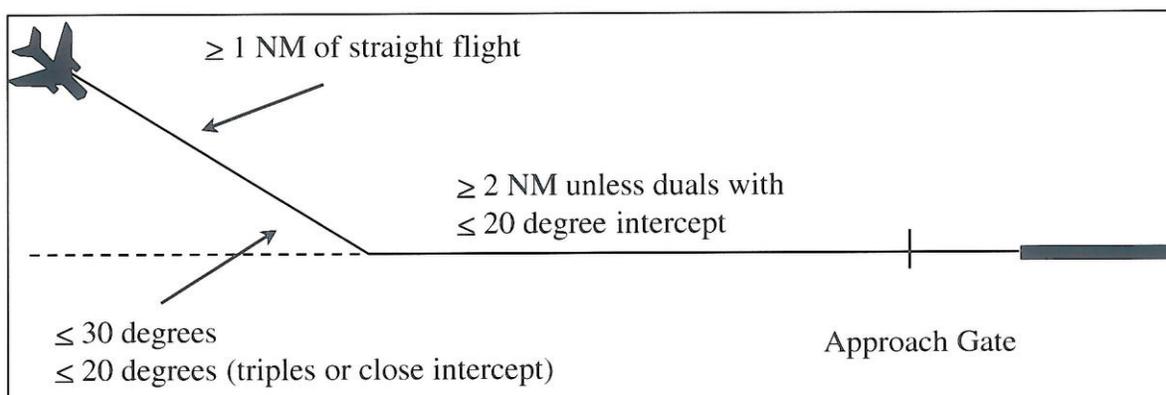


Figure 1. Turn on Rules for Independent Approaches

- A No-Transgression Zone (NTZ) at least 610 m (2000 ft) wide must be established centered between the approach courses, starting at the point where the aircraft lose 1000 ft of vertical separation between aircraft on adjacent final approach courses. The NTZ should extend from this point until at least one NM before the furthest runway threshold along the final approach course(s).

- A dedicated Final Monitor controller must be assigned for each approach course. The controller must monitor aircraft during the entire final approach. Monitoring should continue until at least one NM before the approach end of the runway. If an aircraft blunders towards the other approach course, the monitor controller should instruct the aircraft to return to its course. The Final Monitor controller(s) for adjacent course(s) should break out the aircraft approaching the adjacent runway if endangered by the blundering aircraft. Appropriate airspace to accommodate aircraft broken out from the approach(es) should be available to enable pilots to climb to the minimum vectoring altitude and be merged back into the approach pattern.
- Each runway should have a vertically-guided approach. These can be Instrument Landing System (ILS), Area Navigation (RNAV), or Required Navigation Performance (RNP) approaches. The U.S. permits mixed ILS, RNAV, and RNP approaches during independent operations, but ICAO does not. Mexican authorities should decide if mixed approaches can be performed, similar to the U.S., since RNAV or RNP approaches may be required at NAICM.
- A Parallel Approach Obstacle Assessment Surface (PAOAS) off-centerline study should be conducted to ensure that aircraft broken out from an approach do not collide with any obstacles or terrain. This is necessary since aircraft being broken out from an approach will no longer be protected by the obstacle surfaces for that approach and may not be following the missed approach course. A detailed description of the PAOAS can be found in [FAA 2014b; ICAO, 2006].
- The surveillance radar and associated displays should have equivalent performance to a monopulse Secondary Surveillance Radar with an update rate of 5.0 seconds or faster and an accuracy of equal to or better than 0.06 degrees/1 milliradian (one sigma). Information on surveillance requirements was provided in [MITRE, 2009; MITRE, 2014].
- The surveillance radar should be located at or near the airport and should provide surveillance coverage along the final and missed approach courses in all areas where monitoring is required. Sufficient surveillance coverage should also be available to allow radar control of inbound, outbound, and missed-approach aircraft.
- Each Final Monitor controller should have a dedicated Final Monitor Aid (FMA) display.¹ The FMA functionality will likely have to be incorporated into the Mexican terminal surveillance automation systems. The specifications for the FMA and additional details are contained in [MITRE, 2014]. Figure 2 shows a schematic of the FMA.
- Each Final Monitor controller should have a dedicated frequency for monitoring or, if the monitor frequency is shared with another controller (e.g., the local controller in the tower), then transmissions from the Final Monitor controller should override the other controller.

¹ A separate display for each monitor controller is not explicitly required, however it is an important practice. In case of an outage of one display, air traffic controllers may share displays on a temporary basis.

- Missed approach paths must diverge by at least 45 degrees for independent approaches to three runways.²
- Controller and pilot training and information must be conducted to promote awareness of the procedures necessary to conduct independent approaches.
- Pilots must be advised that independent approaches are in progress. This advisory may be accomplished using the Automatic Terminal Information Service broadcast.
- Weather and other factors should be considered prior to the conduct of independent approaches. For example, excessive crosswinds and turbulence may make the tracking of ILS courses difficult, increasing path-following errors and causing higher workload for monitor controllers. Similarly, thunderstorms near the airport could interfere with the path following of the aircraft. ATC should evaluate adverse conditions and suspend independent approaches if deemed necessary.

The above requirements are mandatory, but are not, in general, sufficient for the safe and successful conduct of independent approaches. Appropriate airspace design is essential to ensure that airport capacity can be maintained. See Section 3 for additional discussions.

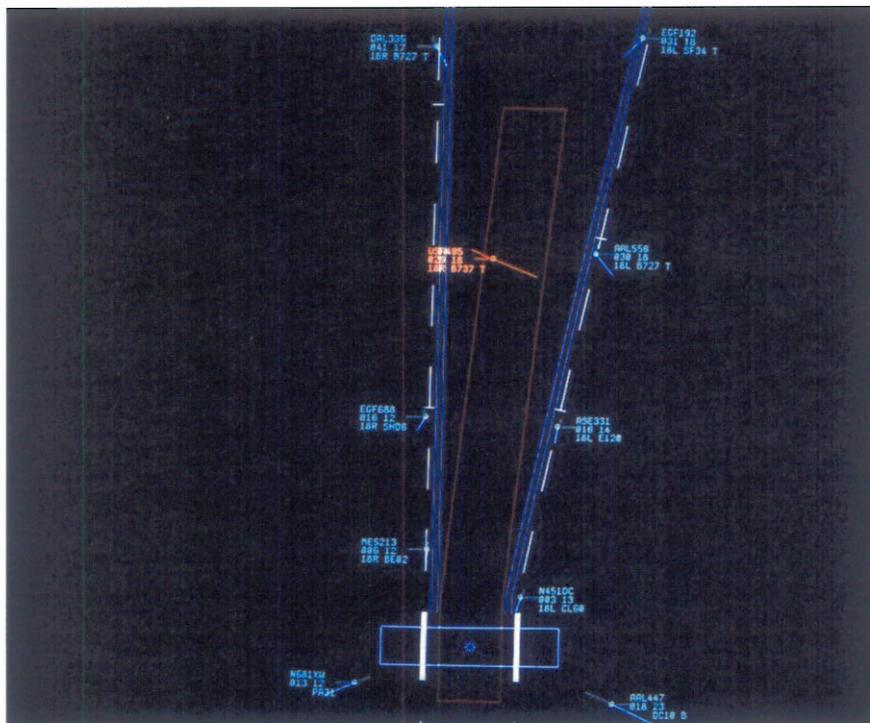


Figure 2. Example of an FMA Display (With an Offset Localizer)

² The U.S. requires at least 45-degree divergence for missed approaches for independent approaches to two and three runways. ICAO requires at least 30-degree divergence for approaches to two runways. For NAICM, MITRE assumed that Mexico will use 45-degree divergence for approaches to either two or three runways. (This allows the use of the same missed approach path when conducting dual or triple approaches.)

3. Preparing for Dual- and Triple-Independent Approach and Departure Operations: Key Considerations

Dual independent approach and departure operations are authorized at more than 30 airports worldwide. Triple independent operations are authorized at eight airports, all of which are in the U.S. This section reviews the key elements to be considered in preparing for dual- and triple-independent approach and departure operations at MMUN and NAICM.

A key consideration when preparing for dual- and triple-independent operations is airspace and route design. Generally, the purpose of dual- and triple-independent operations is to increase arrival and departure capacity. Airspace and Standard Terminal Arrival Routes (STARs) should be designed to support efficiencies gained by Continuous Descent Operations, to permit the balancing of traffic demand to the arrival runways, to ensure maximum utilization of all the runways, and to allow equitable distribution of controller workload. It is essential that air traffic controllers have the flexibility to move aircraft from busy arrival routes to less busy arrival routes in order to balance the runway demand. Additionally, departure procedures should be designed to allow for unrestricted climb-outs to the extent possible.

Most U.S. airports that conduct dual- and triple-independent operations are designed with a four “cornerpost” design. Arrival aircraft are routed over the cornerposts and departure aircraft exit the airspace between the cornerposts. Figure 3 depicts West Flow Dual Approach Radar Tracks at The Hartsfield-Jackson Atlanta International Airport (KATL). Aircraft over the ERLIN and WOMAC arrival fixes are typically the responsibility of one controller, and aircraft over the HONIE and CANUK arrival fixes are the responsibility of a second controller. This design allows aircraft from the northwest and southwest cornerposts to be assigned either the north or south downwind in order to balance the demand on the two arrival runways.



Figure 3. Dual Approach Radar Tracks at KATL: West Flow

Arrival routes should be examined to ensure that sufficient airspace capacity exists to meet the increased arrival capacity created by additional arrival runways. Normally, Area Control Centers (ACCs) can deliver enough aircraft to meet the increased capacity of the airport. However, this traffic may not be spread evenly among all arrival routes, and therefore there may be a need to create additional arrival capacity in certain sectors to accommodate heavier traffic flows. The primary airline may provide valuable input in this area regarding future schedule plans. Delay information, if appropriate, should also be reviewed to determine arrival sectors where delays are occurring. Sectors where aircraft are currently routinely rerouted to avoid delay should also be identified. This review will help determine if STARs must be redesigned in those sectors.

Flexibility is key to the design. STARs should be designed to meet the changing needs of ATC. Whenever possible, STARs should be designed to feed multiple runways, but each STAR should have a primary runway associated with it. Issues such as weather, airline schedule changes, airport construction, traffic demand, and unexpected emergencies at the airport can impact runway use at the airport. Figure 4 depicts the multiple options that are available to Atlanta Approach Control when delivering aircraft to three arrival runways (north, middle, and south complexes) on a west flow. Other combinations may be assigned through coordination, but the key factors are the standardization and flexibility of the design. Controllers will be delivering aircraft to NAICM on three arrival runways and while the overall design may not be similar to KATL, the concepts of flexibility and standardization to permit balancing of runway demand, maximizing runway usage, and equitable controller workload must be considered.

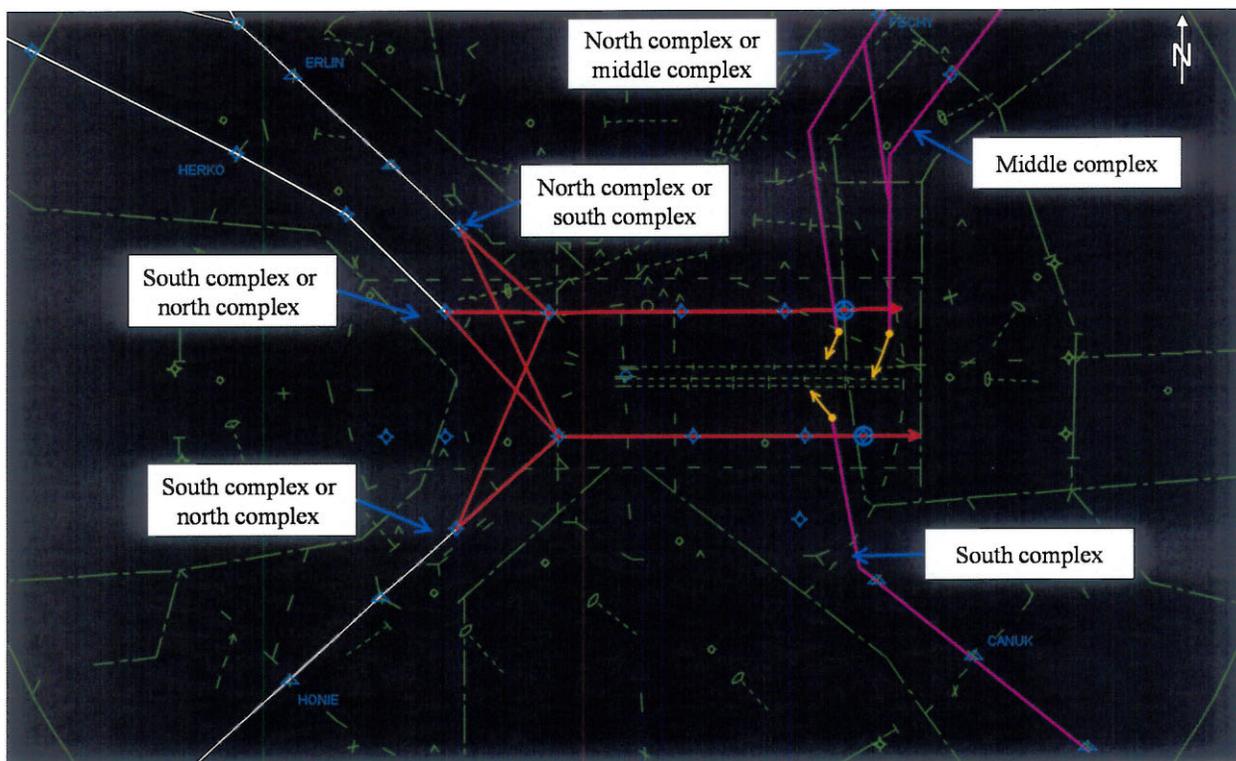


Figure 4. KATL STARs and Runway Options for Triple Arrivals: West Flow

Additional arrival and departure runways generally equate to additional controller operational positions, which often requires control room expansion and additional controller staffing. Typical operational positions and responsibilities for dual- and triple-independent approaches and departures in U.S. facilities are shown in Table 1. Additional information on controller positions and responsibilities is provided below the table.

Table 1. Typical Operational Positions and Responsibilities for Dual- and Triple-Independent Approaches and Departures

Controller Operational Position	Responsibilities	# of Positions for Duals	# of Positions for Triples
“Feeder/Arrival”	Accepts handoffs from the ACC and delivers the aircraft to a “Final” controller	2 - one controller for each arrival runway	3 - one controller for each arrival runway
“Final”	Accepts handoffs from the “Feeder/Arrival” controller and establishes aircraft on the final approach course with appropriate separation and spacing	2 - one controller for each arrival runway	3 - one controller for each arrival runway
“Final Monitor”	During other than visual approaches/visual separation scenarios, ensures aircraft are on the monitor frequency prior to losing standard separation with aircraft on adjacent final approach course(s) Initiates action if those aircraft blunder into the NTZ, and ensures longitudinal separation (between aircraft landing on the same runway) on the final approach course	2 - one controller for each arrival runway	3 - one controller for each arrival runway
“Local/Tower”	Normally takes responsibility at one NM or less from touchdown	2 - one controller for each arrival runway	3 - one controller for each arrival runway
“Departure”	Accepts departures from the “Local/Tower” and delivers aircraft to the ACC	2 - one controller for each departure runway	3 - one controller for each departure runway

Currently, the Mexico City approach control function of the ATC facility (hereafter referred to as Centro México) that supports Mexico City International Airport staffs four controller

positions: Arrival³, Arrival Assistant⁴, Approach⁵, and Final⁶. The approach control function at MMUN staffs two positions: Arrival and Approach. Both Centro México and MMUN have two departure positions.

It is anticipated that Centro México will expand from its current four Approach control positions to a minimum of nine Approach control positions when conducting triple independent operations. These nine positions include Feeder/Arrival, Final, and Final Monitor positions for each of the three arrival runways. If an Arrival Assistant position is desired for each associated Feeder/Arrival position, a total of twelve Approach control positions will be required.

U.S. facilities that conduct dual- and triple-independent departure operations typically staff a departure controller for each departure runway. It is anticipated that an additional departure position will be required at Centro México to support a third departure runway.

It is anticipated that MMUN will expand from its current two Approach control positions to six Approach control positions. These positions include a Feeder/Arrival, Final, and Final Monitor position for each arrival runway.

It is important to mention that the actual number of controller positions required for both NAICM and MMUN depends on much more detailed analyses, such as airspace designs, ATC sectorization, Human-In-The-Loop (HITL) simulation activities, etc. Therefore, the information regarding the anticipated number controller positions provided above should not be considered as final.

The need for additional controller positions will require a reconfiguration of the ATC facility control room or, in the case of NAICM, potentially a totally new ATC facility. As part of planning these facilities it is important to consider the interaction of the different controller functions and responsibilities. Most U.S. facilities that conduct independent operations are similarly configured. Typically, the Final controllers are located next to each other. During the critical vectors to the final approach course phase of flight, it is important to have Final controllers located next to each other to enhance communication and coordination. Feeder/Arrival controllers are located adjacent to the Approach controller that they sequence aircraft for and hand-off aircraft to. This is not possible, however, during a triple independent approach operation since the three Final controllers are seated adjacent to each other. Since most facilities operate in a dual runway arrival operation when demand does not support three arrival runways, most U.S. facilities set up the Feeder/Arrival and Final functions for dual operations adjacent to each other and configure the third Feeder/Arrival controller next to the Feeder/Arrival controller that the third Feeder/Arrival controller would typically have the most interaction with. The three Final Monitor positions must be located adjacent to each other due to the need for immediate communication and coordination in the event aircraft must be vectored

³ Accepts handoffs from the ACC and provides appropriate separation and sequencing for the Approach controller. This function is somewhat similar to the “Feeder/Arrival” controller.

⁴ Assists the Arrival controller with hand-offs, coordination, and other duties as necessary.

⁵ Accepts handoffs from the Arrival controller and vectors aircraft to the final approach course. This function is somewhat similar to the “Final” controller.

⁶ Ensures longitudinal and lateral compliance along the final approach course. This function is somewhat similar to the “Final Monitor” controller.

off the final approach course. There is no requirement for the Final Monitor controllers to be located adjacent to or near the Feeder/Arrival and Final positions. It is recommended that the Departure controllers be located next to each other, however, they do not necessarily need to be located close to any of the Feeder/Arrival positions.

Figure 5 depicts the KATL Approach Control design. The KATL “Final Radar” position is equivalent to the “Final” position described in Table 1. Notice how these three positions (V), (O), (A) are adjacent to each other. The yellow “CI-APP” is an “overhead” coordinator position. The “Arrival Radar” position is equivalent to the “Feeder/Arrival” position described in Table 1. “Arrival Radar” (H) sequences for/hands-off to “Final Radar” (A) and “Arrival Radar” (D) sequences for/hands-off to “Final Radar” (V). These positions are adjacent to each other. The green “Hand Off” positions next to the “Arrival Radar” positions are equivalent to the Centro México Arrival Assistant position. The third “Arrival Radar” (L) position is adjacent to the Arrival Radar (D) position since this is the Arrival Radar position that “Arrival Radar” (L) typically interacts with.⁷ “Arrival Radar” (L) sequences for/hands-off to “Final Radar” (O), but it cannot be located next to “Final Radar” (O) due to the need for the three “Final Radar” controllers to be located adjacent to each other. The KATL “Precision Monitor” position is similar to the “Final Monitor” position described in Table 1. Also, the three “Departure” (N), (S), and (I) positions are grouped together and are located adjacent to the “Arrival Radar” controllers.

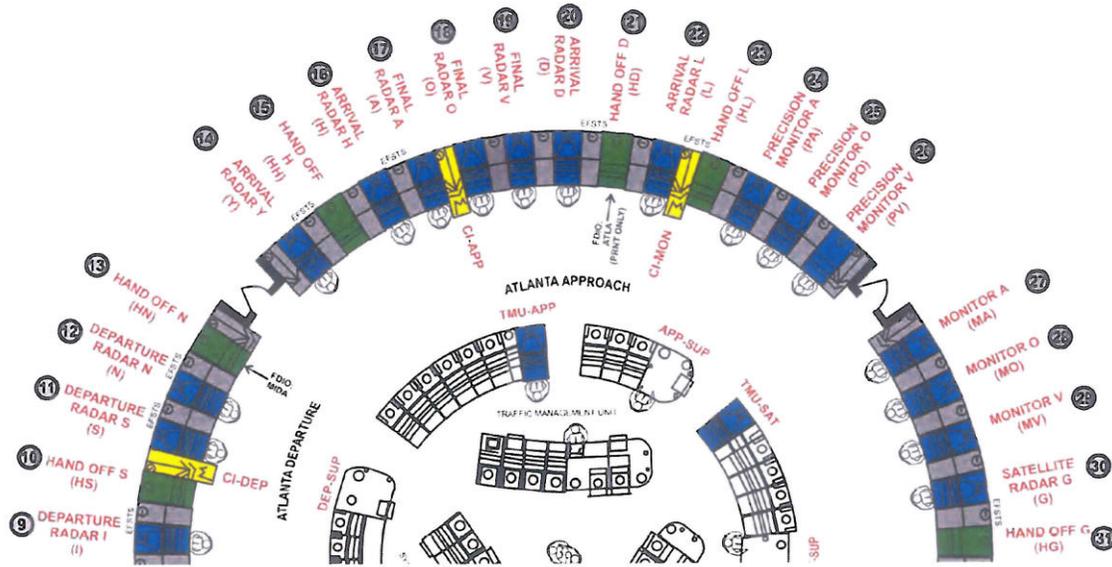


Figure 5. KATL Approach Control Operations Room Layout

Another important element to consider when preparing for dual- and triple-independent operations at MMUN and future NAICM is controller training. Based on the initial plan to use MMUN as a test-bed facility for dual independent operations, a comprehensive training plan must be developed for MMUN. Prior to the training plan being implemented, airspace and

⁷ Note that “Hand Off” (HD) position is located in between “Arrival Radar” (L) and “Arrival Radar” (D), but is rarely staffed.

procedure designs to support dual independent approaches and departures must be completed. Important training matters to consider and questions to address are as follows:

- Assemble a test group to serve as a “beta” group for the proposed training program prior to training being conducted. This allows additional issues to be identified, measures the relevance of training, verifies time allotment for training, and creates awareness amongst the workforce.
- Determine where simulator training (if required) will be conducted. This may be different from today. Does MMUN Approach Control have the resources (personnel, airspace laboratory, required equipment, etc.) to conduct simulator training or must the training be conducted at a different facility?
- Determine if joint ACC and MMUN Approach Control simulator training will be required. If there is not a significant change in delivery of aircraft to Approach Control, ACC simulator training may not be required.
- Determine how much simulator training will actually be required. Since airport constraints (e.g., the number of aircraft gates/parking stands, the lack of a full-length parallel taxiway on Runway 12L/30R) may limit the airport arrival and/or departure rate at MMUN, will major airspace redesign be required or will only minor modifications be required? Do air traffic controllers just need to be trained on independent arrival procedures? What type of training will be required for Final Monitor controllers?
- Determine how air traffic controllers will be certified on conducting independent approaches. Is this a separate certification or will it just be part of the Approach Control function? Can initial certifications be accomplished via simulator training?
- Determine how NAICM personnel will be cycled through MMUN if it serves as a training facility for NAICM independent operations.

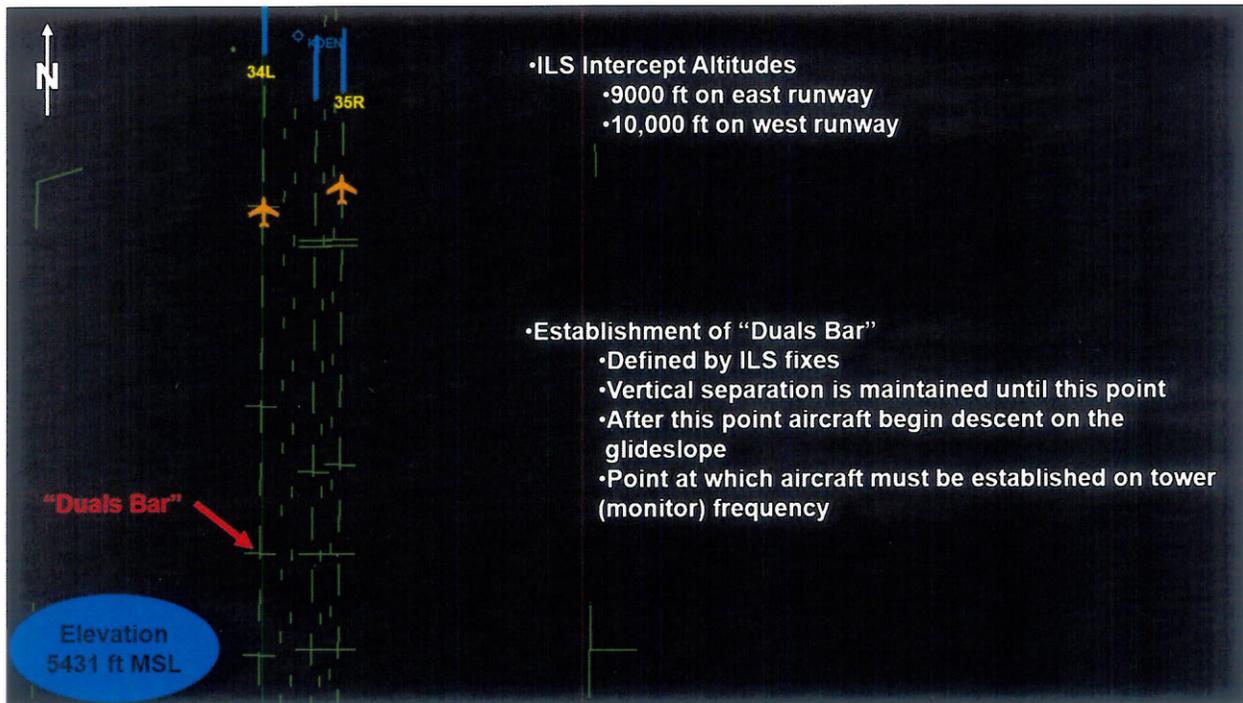
The opening of NAICM and the transition to triple independent operations will require training in addition to that received for MMUN dual independent operations. Important matters to consider for NAICM, in addition to those mentioned above for MMUN, are as follows:

- The opening of NAICM will require a total airspace redesign. Both ACC and approach controllers will need significant training on the new airspace and procedures.
- Airport arrival and departure rates at NAICM are expected to increase as soon as the airport opens. Air traffic controllers will need training on handling increased traffic volumes, unless the plan is to initially lower the airport arrival and departure rate and gradually allow them to increase over several years.
- Air traffic controllers that are certified on dual independent operations will still require triple independent operation training. At KATL, even though air traffic controllers had conducted dual independent operations for many years, classroom and simulator training was required for triple independent operations.
- Air traffic controllers must be trained on transitioning from dual independent approaches to triple independent approaches and vice-versa, since triple independent approaches will

not be required 24 hours per day. Dual independent approaches, or even segregated or single runway operations may be used during less busy times of the day (e.g., early hours of the morning).

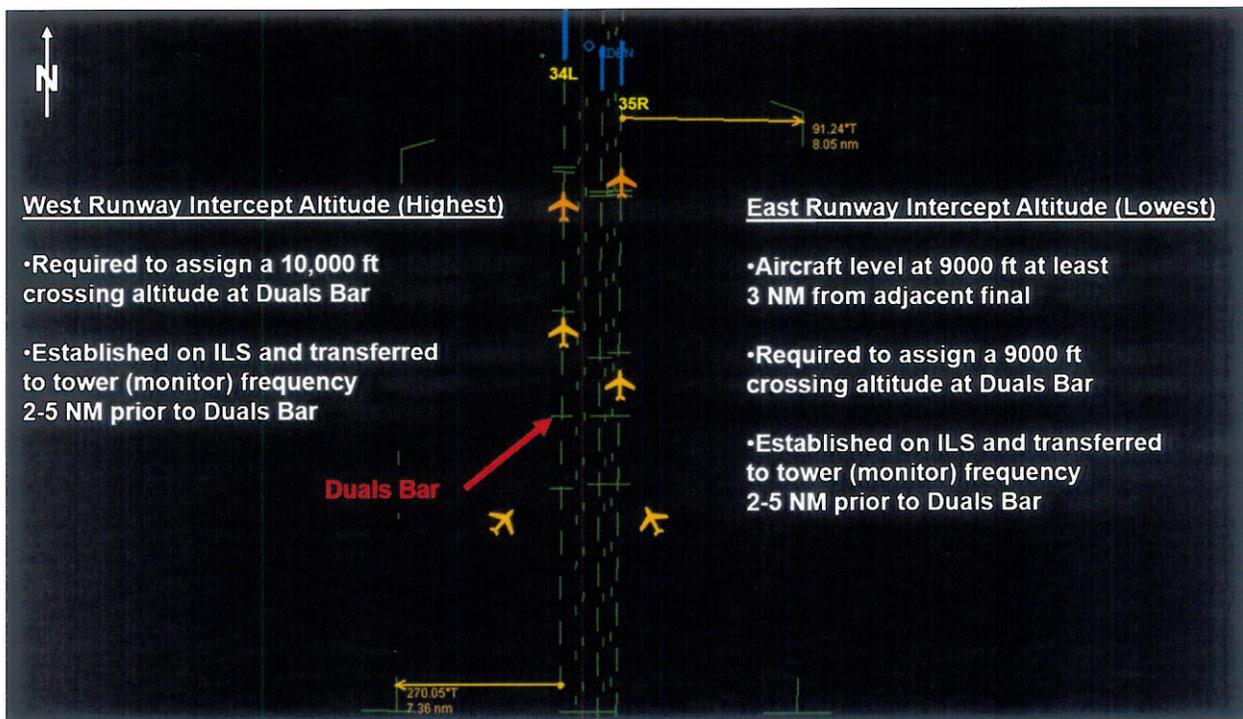
The general requirements for dual- and triple-independent approaches were discussed in Section 2. Each facility that conducts multiple runway independent approaches uses these requirements to tailor their specific Standard Operating Procedures (SOPs). MITRE recommends that MMUN and NAICM tailor their SOPs to reflect those used at Denver Approach Control. The following bullets refer to dual independent approaches on the Denver International Airport (KDEN) north-south parallel runways. Figures 6 and 7 depict the KDEN dual independent approach concept. It should be noted, when considering the intercept altitudes discussed below, that the KDEN airfield elevation is 5431 ft Mean Sea Level (MSL).

- When conducting dual independent approaches, the Denver Approach Control SOP requires air traffic controllers to establish aircraft on the final approach course and be changed to the Tower frequency (which is the same frequency as the Final Monitor) 2-5 NM outside a defined location known as the “Duals Bar”. The Duals Bar is defined by fixes on the ILS final approach courses. These fixes coincide with the point that aircraft leave 10,000 ft MSL on the ILS 34L glideslope. Other SOP requirements include:
 - When conducting dual independent approaches, the aircraft on the furthest east runway is assigned a 9000 ft MSL crossing restriction at the fix that defines the Duals Bar for that runway. The aircraft on the furthest west runway is assigned a crossing restriction at or above 10,000 ft MSL at the fix that defines the Duals Bar for that runway. This ensures 1000 ft vertical separation when aircraft are established on the ILS.
 - Aircraft assigned the 9000 ft MSL crossing restriction must be level at 9000 ft MSL 3 NM from the adjacent final approach course. While the crossing restriction at the Duals Bar ensures vertical separation when aircraft are established on the parallel approach courses, it does not establish vertical separation while aircraft are turning on to the final approach course. Requiring aircraft to be level at 9000 ft MSL 3 NM from the parallel final approach course ensures that aircraft will always be separated by 1000 ft or 3 NM until they are established on the final approach course and beginning their descent on the ILS.
 - Aircraft must be changed to the Tower/Final Monitor frequency for the appropriate runway at least 2-5 NM prior to the Duals Bar. Vertical separation will be lost once the higher aircraft begins descending on the ILS glideslope after passing the Duals Bar. Requiring aircraft to be established and changed to the Tower/Final Monitor frequency 2-5 NM prior to the Duals Bar is designed to allow pilots ample time to change frequency and establish communication with the Tower/Final Monitor prior to losing vertical separation with aircraft on the parallel approach course.



Note: altitudes are in MSL

Figure 6. KDEN Dual Independent Approaches: North Flow (1 of 2)

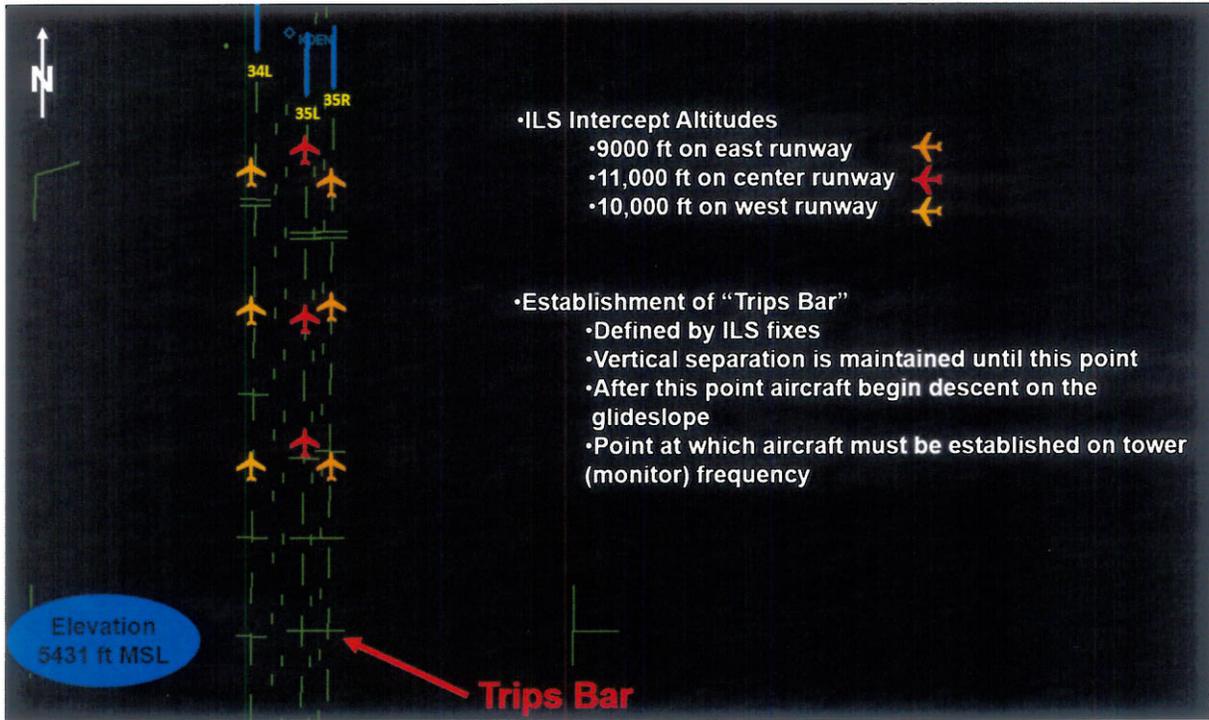


Note: altitudes are in MSL

Figure 7. KDEN Dual Independent Approaches: North Flow (2 of 2)

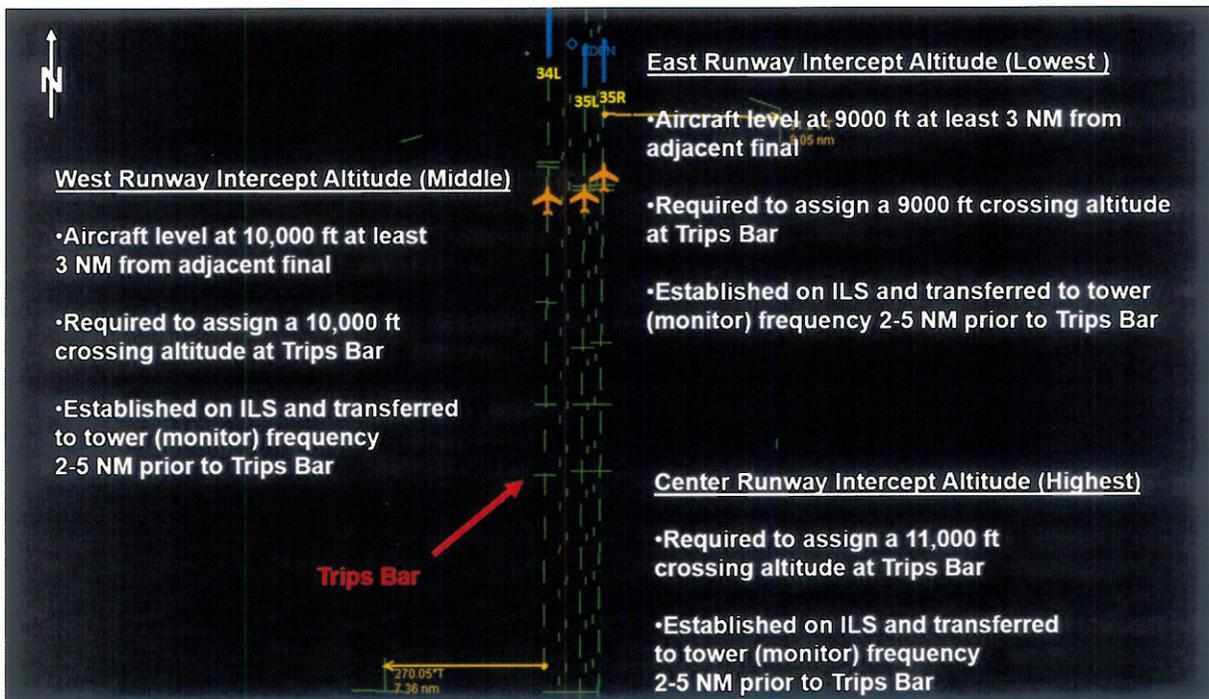
The following bullets refer to triple independent approaches on the KDEN north-south parallel runways. Figures 8 and 9 depict the KDEN triple independent approach concept.

- When conducting triple independent approaches, the Denver Approach Control SOP requires air traffic controllers to establish aircraft on the final approach course and be changed to the Tower/Final Monitor frequency 2-5 NM outside a defined location known as the “Trips Bar”. The Trips Bar is defined by fixes on the ILS final approach courses. These fixes coincide with the point that aircraft leave 11,000 ft MSL on the ILS 35L glideslope. Other SOP requirements include:
 - When conducting triple independent approaches, the aircraft on the furthest east runway is assigned a 9000 ft MSL crossing restriction at the fix that defines the Trips Bar for that runway. The aircraft on the furthest west runway is assigned a 10,000 ft MSL crossing restriction at the fix that defines the Trips Bar for that runway. The aircraft on the center runway is assigned a crossing restriction at or above 11,000 ft MSL at the fix that defines the Trips Bar for that runway. This ensures 1000 ft vertical separation when aircraft are established on the ILS.
 - Aircraft assigned the 9000 ft MSL crossing restriction must be level at 9000 ft MSL 3 NM from the adjacent final approach course. Aircraft assigned the 10,000 ft MSL crossing restriction must be level at 10,000 ft MSL 3 NM from the adjacent final approach course. While the crossing restriction at the Trips Bar ensures vertical separation when aircraft are established on the parallel approach courses, it does not establish vertical separation while aircraft are turning on to the final approach course. Requiring aircraft to be level at 9,000 ft MSL and 10,000 ft MSL 3 NM miles from the parallel final approach courses ensures that aircraft will always be separated by 1000 ft or 3 NM until they are established on the final approach course and beginning their descent on the ILS.
 - Aircraft must be changed to the Tower/Final Monitor frequency for the appropriate runway at least 2-5 NM prior to the Trips Bar. Vertical separation will be lost once the highest aircraft begins descending on the ILS glideslope after passing the Trips Bar. Requiring aircraft to be established and changed to the Tower/Final Monitor frequency 2-5 NM prior to the Trips Bar is designed to allow pilots ample time to change frequency and establish communication with the Tower/Final Monitor prior to losing vertical separation with aircraft on the parallel approach course.



Note: altitudes are in MSL

Figure 8. KDEN Triple Independent Approaches: North Flow (1 of 2)



Note: altitudes are in MSL

Figure 9. KDEN Triple Independent Approaches: North Flow (2 of 2)

Independent departure operations are also anticipated at MMUN and NAICM. Departure runways at both airports are spaced appropriately to allow independent departure operations. Fifteen degrees divergence with aircraft departing parallel runways must be established immediately after departure in order to conduct independent parallel departure operations [ICAO, 2007; FAA, 2014a]. Figure 10 depicts triple independent departures on an east flow operation at KATL.

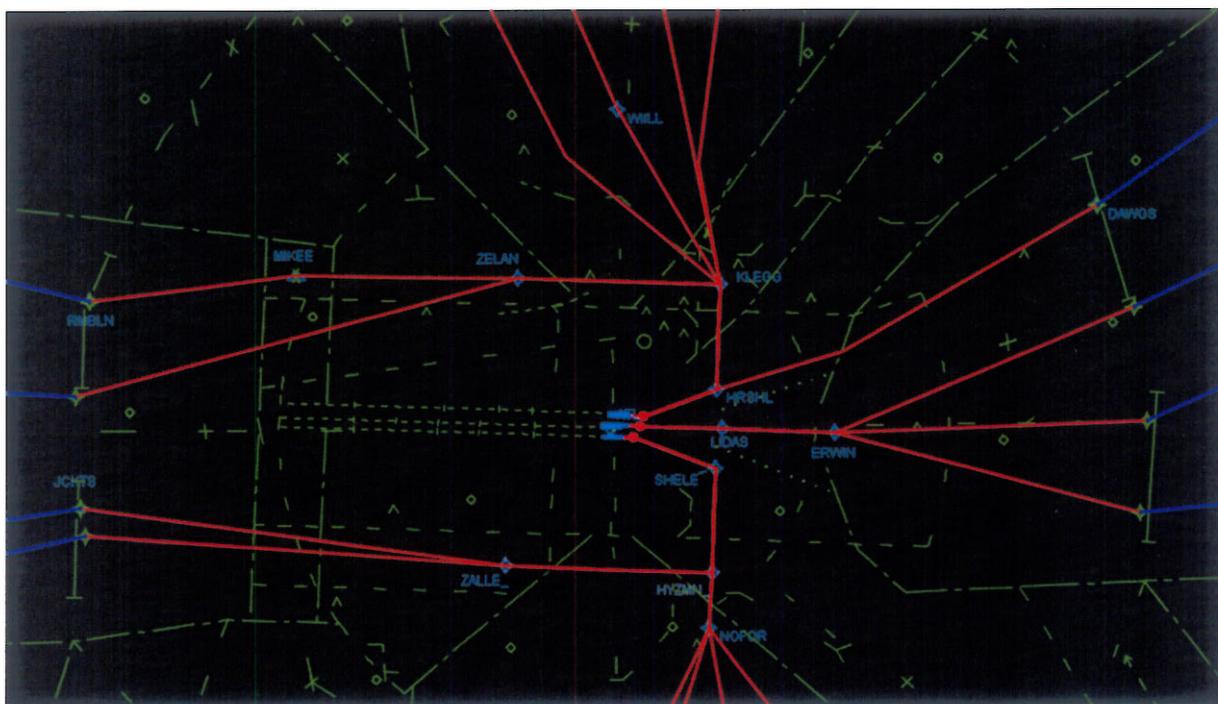


Figure 10. KATL Triple Independent Departures: East Flow

4. Summary

The proposed runway spacing at NAICM and the existing runway spacing at MMUN support independent operations. This document provides information regarding ATC equipment that the Mexican authorities will need to acquire for both airports in order to support dual- and triple-independent operations. It also identifies the key elements related to approach and departure control to be considered in preparing for dual- and triple-independent approach and departure procedures.

Numerous elements must be considered prior to implementation of independent operations, such as:

- Appropriate ATC equipment acquisition
 - The FMA display may need to be specially developed for the surveillance automation system
- Airspace and procedure design

- HITL simulation activities
- Additional operational positions and staffing
- Controller training
- Control room and tower configuration planning and development
- Tower operations
- Development of SOPs
- Terminal, apron and taxiway layout
- Aircraft surface movements
- Traffic flow management

The MITRE team will conduct airspace and procedure design work to support dual independent approach and departure operations at MMUN since it is intended to serve as a test-bed to allow air traffic controllers to gain experience for future NAICM operations. MITRE will start with conventional dual independent instrument approach and departure procedures for MMUN, to be validated by SENEAM. This work will be of a preliminary nature, as it will primarily be utilized to support HITL simulations, which will assist in providing additional information concerning workforce planning, radar controller positions, and other operational requirements needed to conduct independent approach and departure operations. Along with this work, MITRE will provide general support to SENEAM regarding airspace design concepts for MMUN.

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