Plan Alternativo for NAICM*

Operational Viability Assessment Towards Increased Global Capacity

Version 2, slightly edited (pages 12, 26, 36)

15 August 2018

* Nuevo Aeropuerto Internacional de la Ciudad de México

MITRE

Cautionary Notes

- **The intended direct receivers of this document (H560-B18-002) may freely use it. They are 1) Through Mexico SCT's Undersecretary of Transportation: the Undersecretary herself and SCT's Secretary, 2) SENEAM's Director-General, 3) Mexico SCT's Secretary-designate, and 4) the Undersecretary-designate of Transportation.**

- **This document was internally funded by MITRE through senior MITRE engineers, air traffic controllers, and experts in satellite navigation.**

- **This document is protected by copyright (The MITRE Corporation © 2018. All Rights Reserved). Any partial reproduction of these slides should show the source (preferably along with this slide) and should caution the reader that isolated slide(s) do not necessarily represent the full extent of the conclusions provided therein.**

- **The information contained in this document has been prepared to be used as an aid by experienced MITRE briefers as a part of an oral presentation. Therefore, exercise caution when reading this document, as use of its material by other than the original presenters may result in diminished comprehension or misunderstandings.**

- **If questions arise that require a response from MITRE, contact Dr. Bernardo Lisker, International Director at** bernard@mitre.org

MITRE y su Centro para el Desarrollo de Sistemas Avanzados de Aviación

- **Organización de investigación y desarrollo no comercial, sin fines de lucro, exclusivamente dedicada al interés público desde 1958**
  - Orígenes en el Instituto Tecnológico de Massachusetts (MIT)
  - Planta de MITRE: ~8000 profesionales en ingeniería, matemáticas y otras disciplinas
  - Laboratorio considerado como recurso nacional en EE.UU., en la misma categoría (“FFRDC”) de Los Alamos National Laboratory y el Jet Propulsion Laboratory (que trabaja para la NASA)

Presencia Internacional

- **Objetividad**
  - No mantiene vínculos comerciales
  - No desarrolla equipamientos o software comercial (sólo prototipos)
  - No proporciona servicios rutinarios
  - <u>MITRE ha colaborado con cerca de 60 gobiernos</u>

Introduction

- **This briefing provides a high-level summary of MITRE's aeronautical assessment of the Plan Alternativo issued by Mexico's MORENA party in late 2015**
  - The assessment is not an agreed-upon deliverable under the terms of any signed agreement between MITRE and another organization or group, and as such, it is informally provided to decision makers in Mexico on an "as is" basis
- **The briefing is intended for a general audience with some air navigation knowledge**

Background *(1 of 3)*

- **The Plan Alternativo's principal goals are to:**
  - Expand Santa Lucía Military Base (Santa Lucía) to permit civil commercial flights that will operate simultaneously with Aeropuerto Internacional de la Ciudad de México (AICM)
  - Provide additional capacity to meet anticipated growth in air traffic demand (AICM has been saturated for many years)

- **MITRE assessed the Plan Alternativo intensely, trying to make it work**

Background *(2 of 3)*

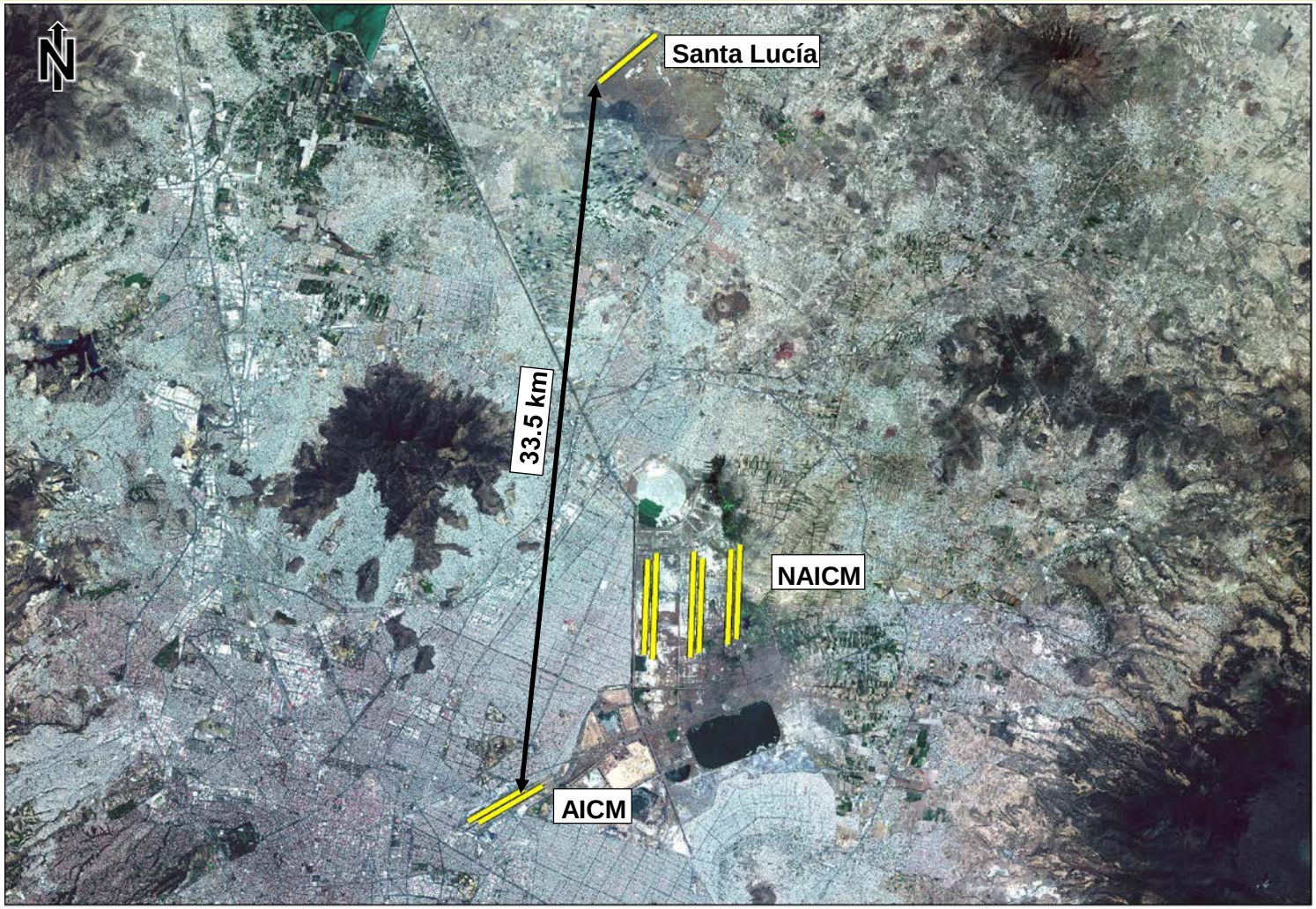
- **During the past 22 years MITRE has analyzed several sites, some of which were analyzed outside of the scope of SCT-MITRE agreements:**
  - AICM by itself: found ways to increase capacity, very slightly, in the year 2000
  - Area of “Rellenos Sanitarios”, close to AICM: found to be not feasible to operate multiple approach procedures, due to orography nearby
  - Texcoco “1”, close to Atenco: feasible, but rejected for social and political reasons (Atenco’s conflict)
  - Santa Lucía by itself: determined unfeasible due to its limited space, requiring demolition of the Base, land need to be acquired just after the Atenco issues, and, importantly, severe noise exposure to surrounding communities (out of scope)

Background *(3 of 3)*

- Zapotlán de Juárez, ~20 km north of Tizayuca to operate along with AICM: very limited space; found orography issues leading to high approach minimums; driving distance of ~77 km to passenger epicenter at Fuente de Petróleos
- Texcoco “2” (Nuevo Aeropuerto Internacional de la Ciudad de México—NAICM): now under construction; found feasible and capacity-expandable for many decades

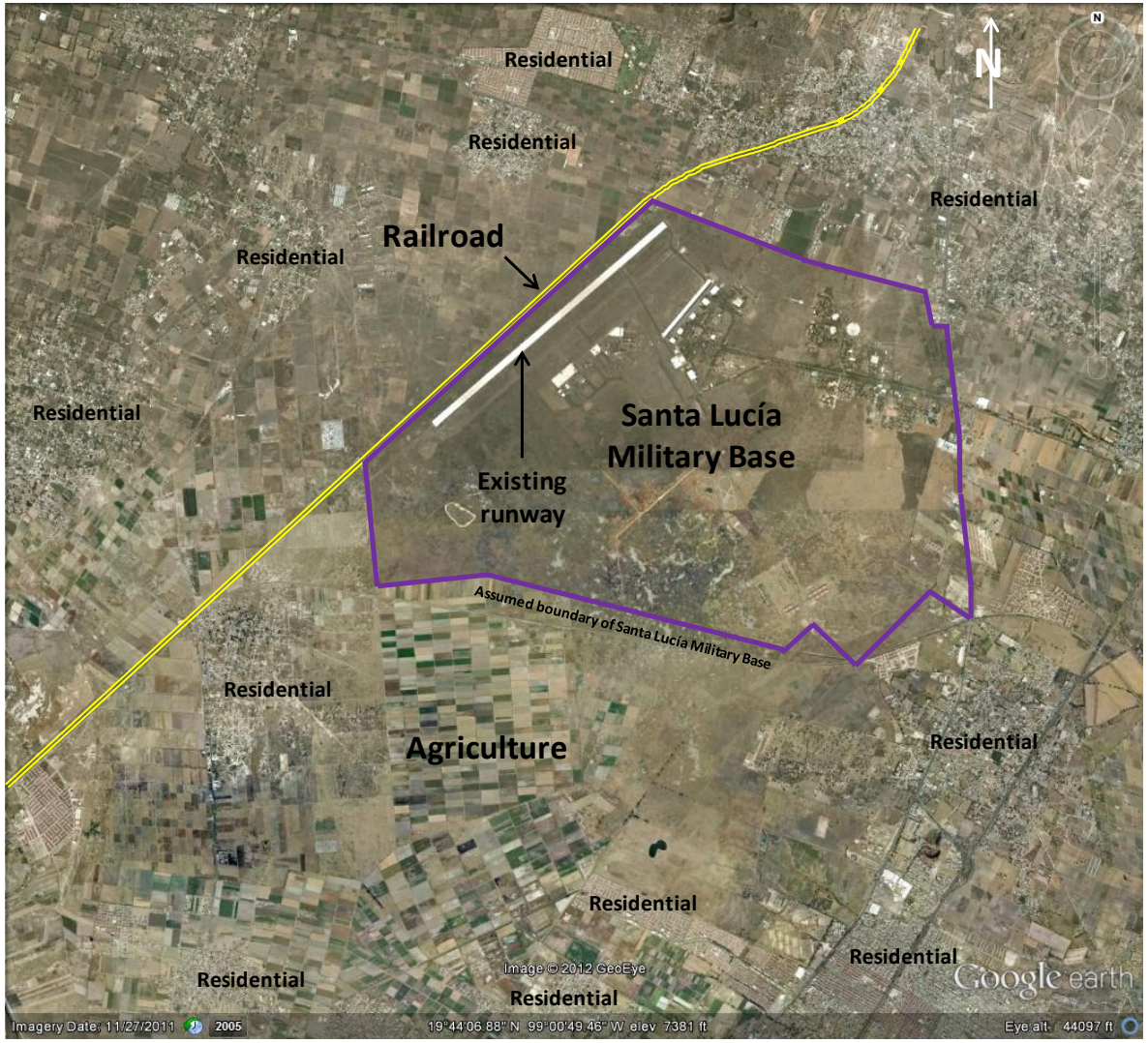
- **MITRE met MORENA Party representatives in late 2015**
  - MORENA representatives described a land plan to replace NAICM; MITRE described preliminary aeronautical findings concerning their plan, now called *Plan Alternativo (out of scope)*

Location of NAICM, AICM, and Santa Lucía



0 2 4 8 Nautical Miles

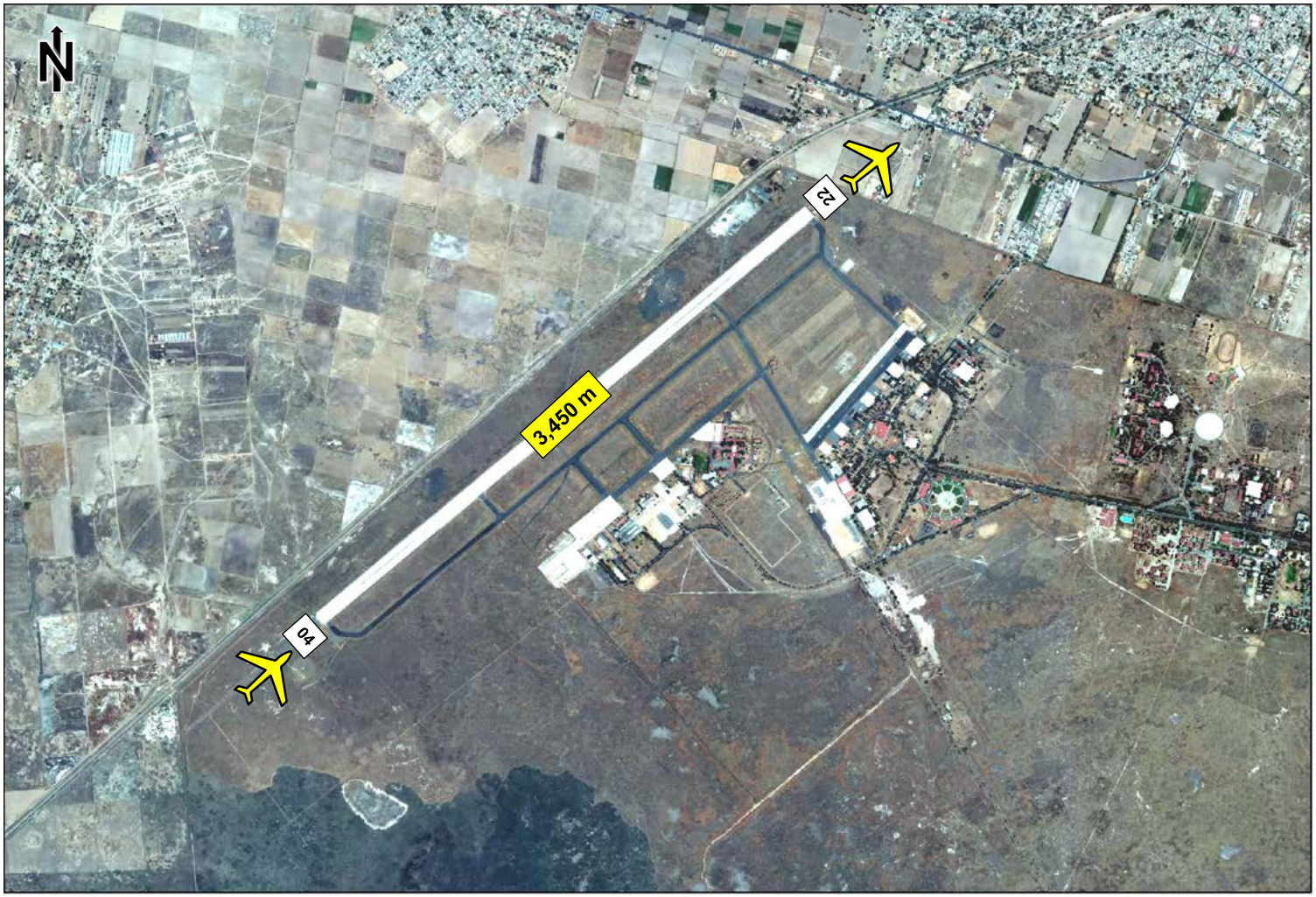
Approximate Boundary of Santa Lucía



Background Source: Google Earth

Current Santa Lucía (Only Military Use)

Arrivals and Departures on the Existing 3,450 m Runway

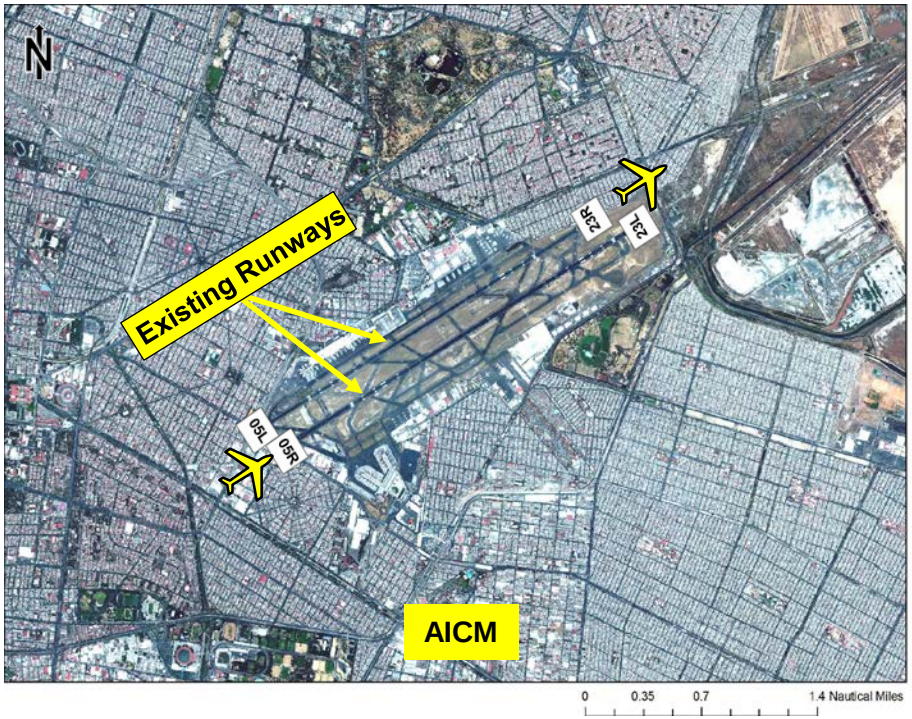


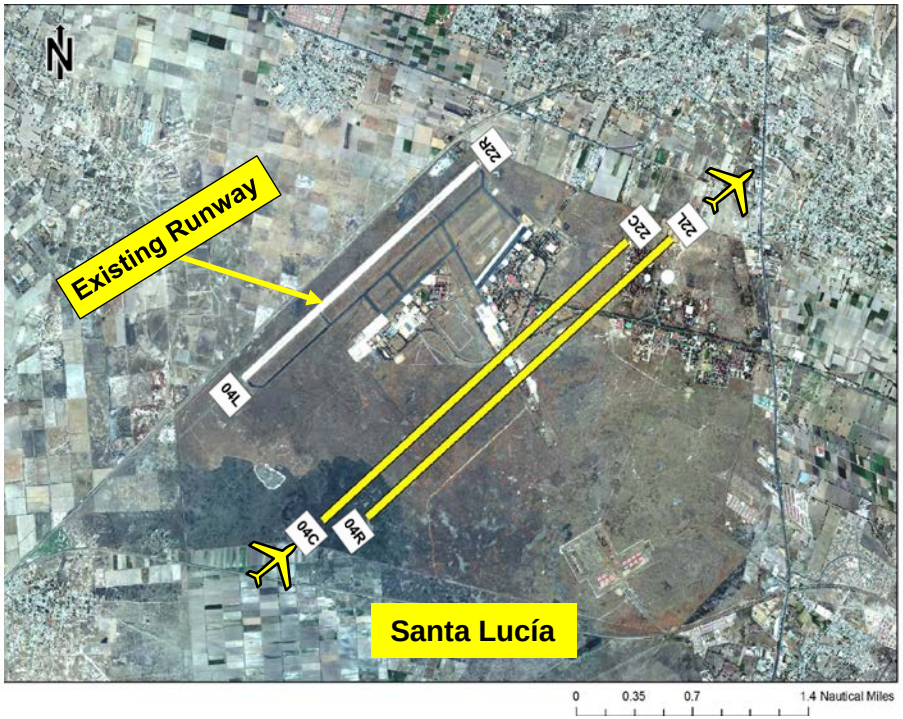
Background Source: Includes copyrighted material of DigitalGlobe, Inc., All Rights Reserved

0 0.25 0.5 1 Nautical Miles

Plan Alternativo

Near-Term

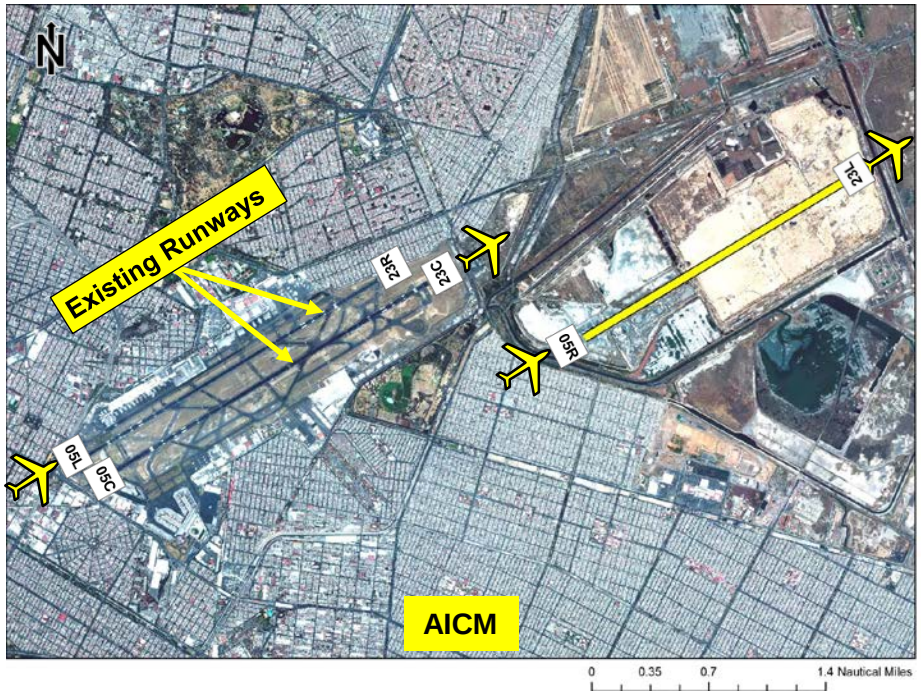


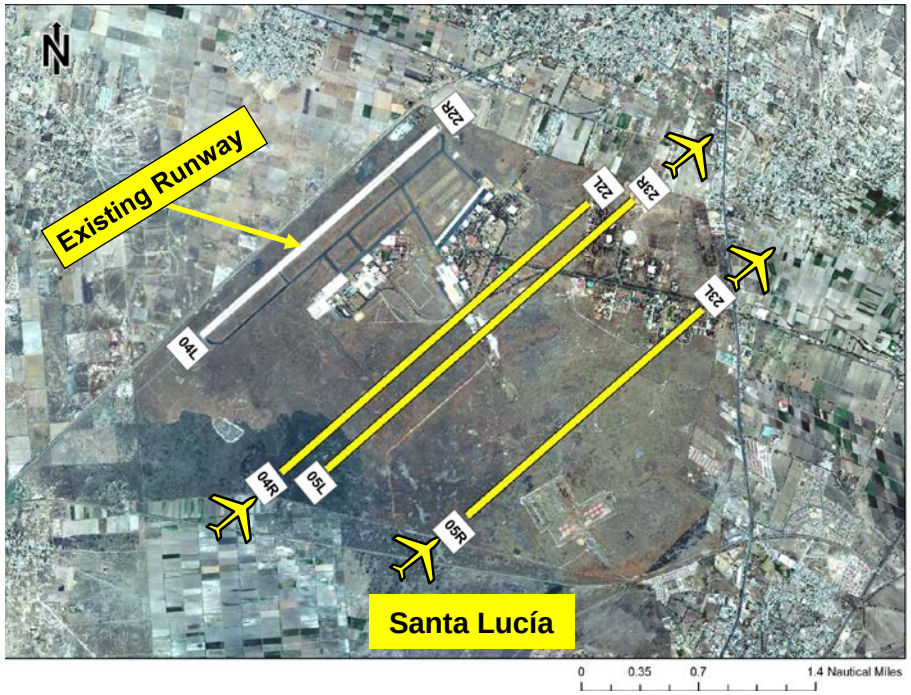


As the 2015 Plan Alternativo did not show parallel runways, MITRE modified them (to ensure parallel runways) to simplify procedure design and air navigation.

Plan Alternativo

Long-Term

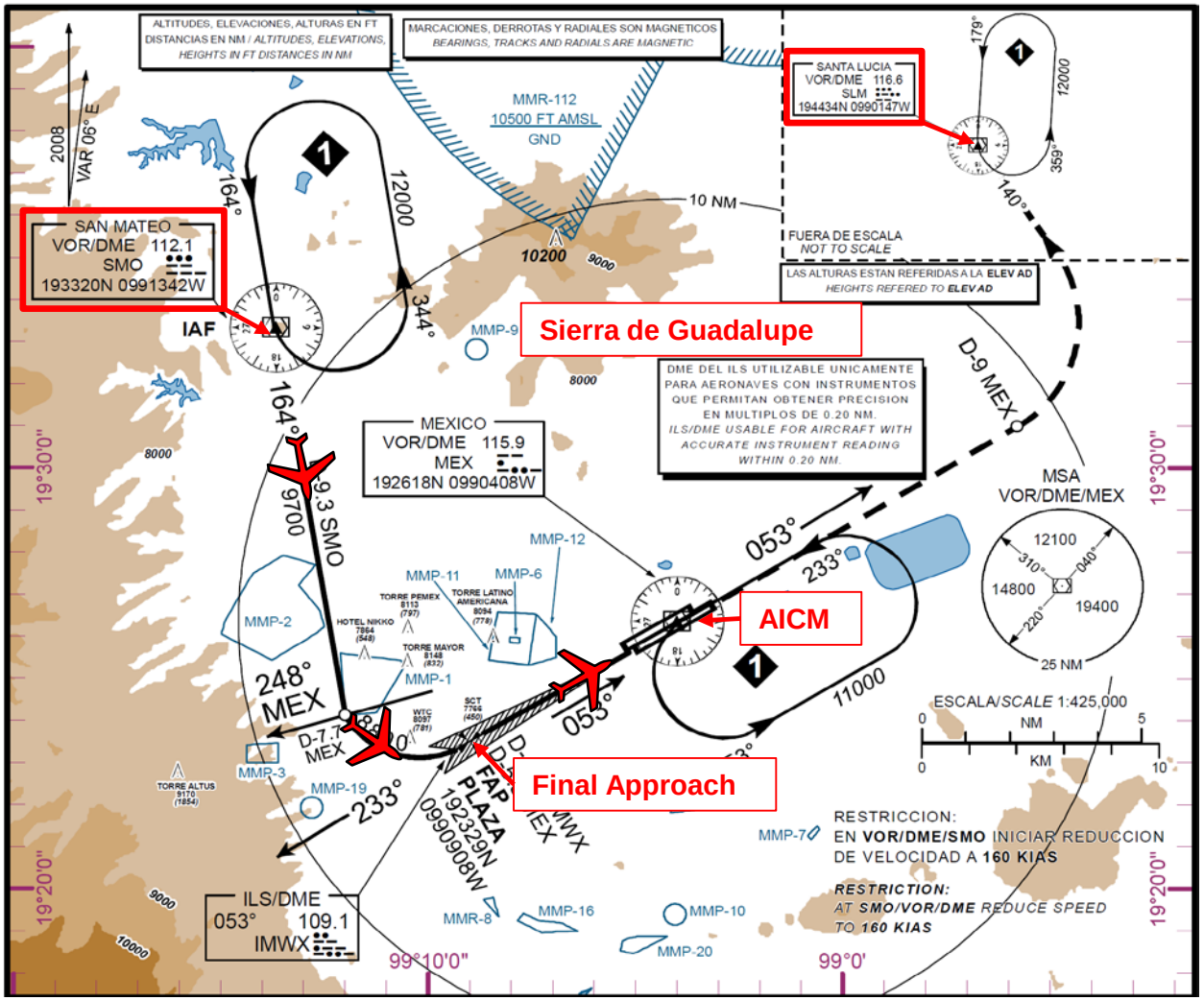




Notice an additional runway in the "Rellenos Sanitarios" area, located far from AICM's terminals. As mentioned before, MITRE analyzed that area in the year 2000 and found it to be unfeasible.

The runways are deemed by MITRE too short (approach lights require, *each direction,* 900 m., i.e., 1.8 km), to achieve maximum payload and reach many long-range destinations. While less so, AICM is <u>also limited</u>. Thus, Santa Lucía and AICM would remain limited.

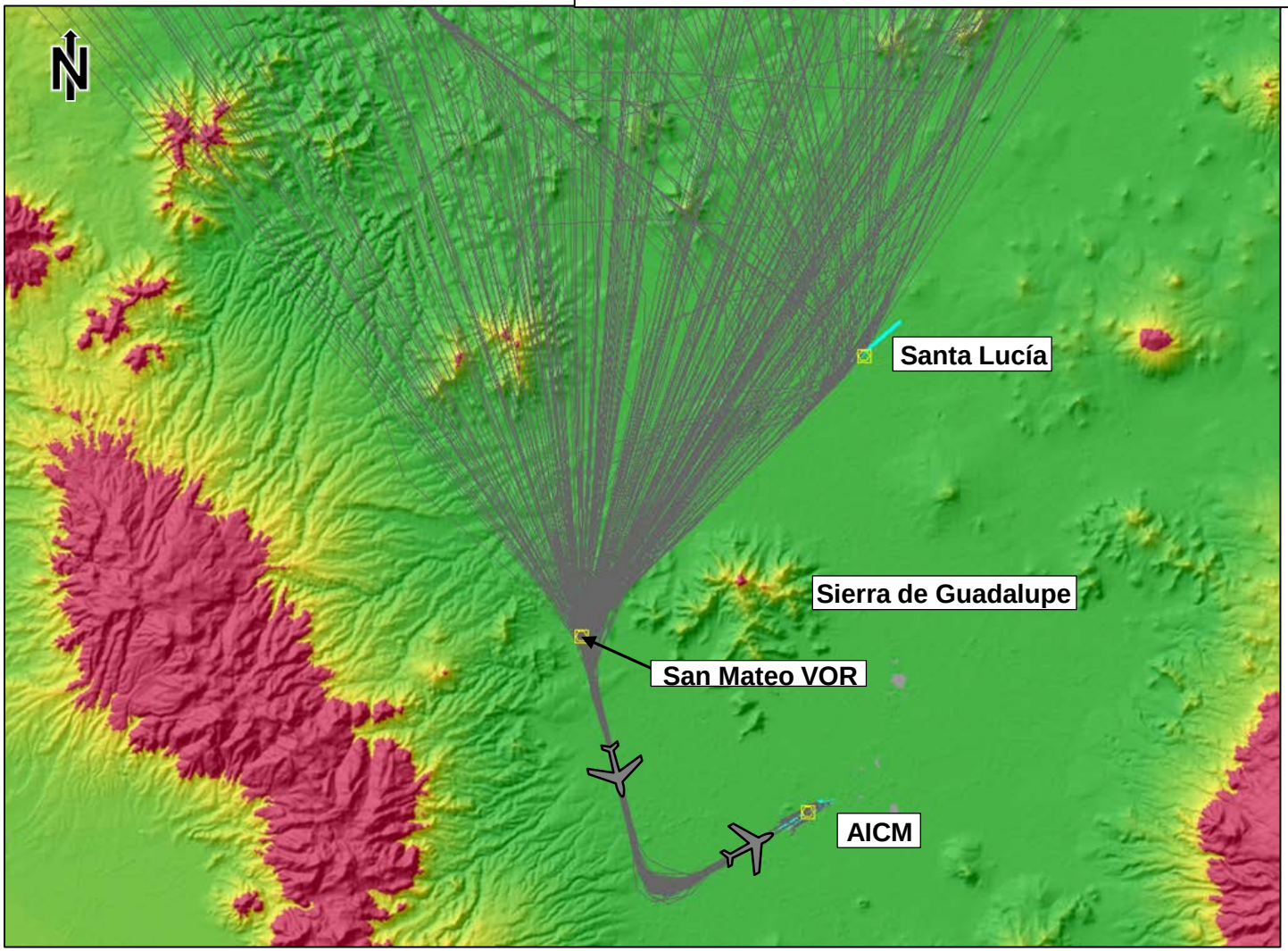
Current Approach to AICM (over the San Mateo VOR)



Source: Aeronautical Information Publication (AIP) of Mexico (18 August 2016 AMDT AIRAC 09/16)

Radar Tracks Showing Typical Arrival Paths to AICM Today

This large flight concentration, through the San Mateo VOR, is an unintended consequence of the traffic volume at AICM. NAICM procedures would eliminate such a concentration of traffic.

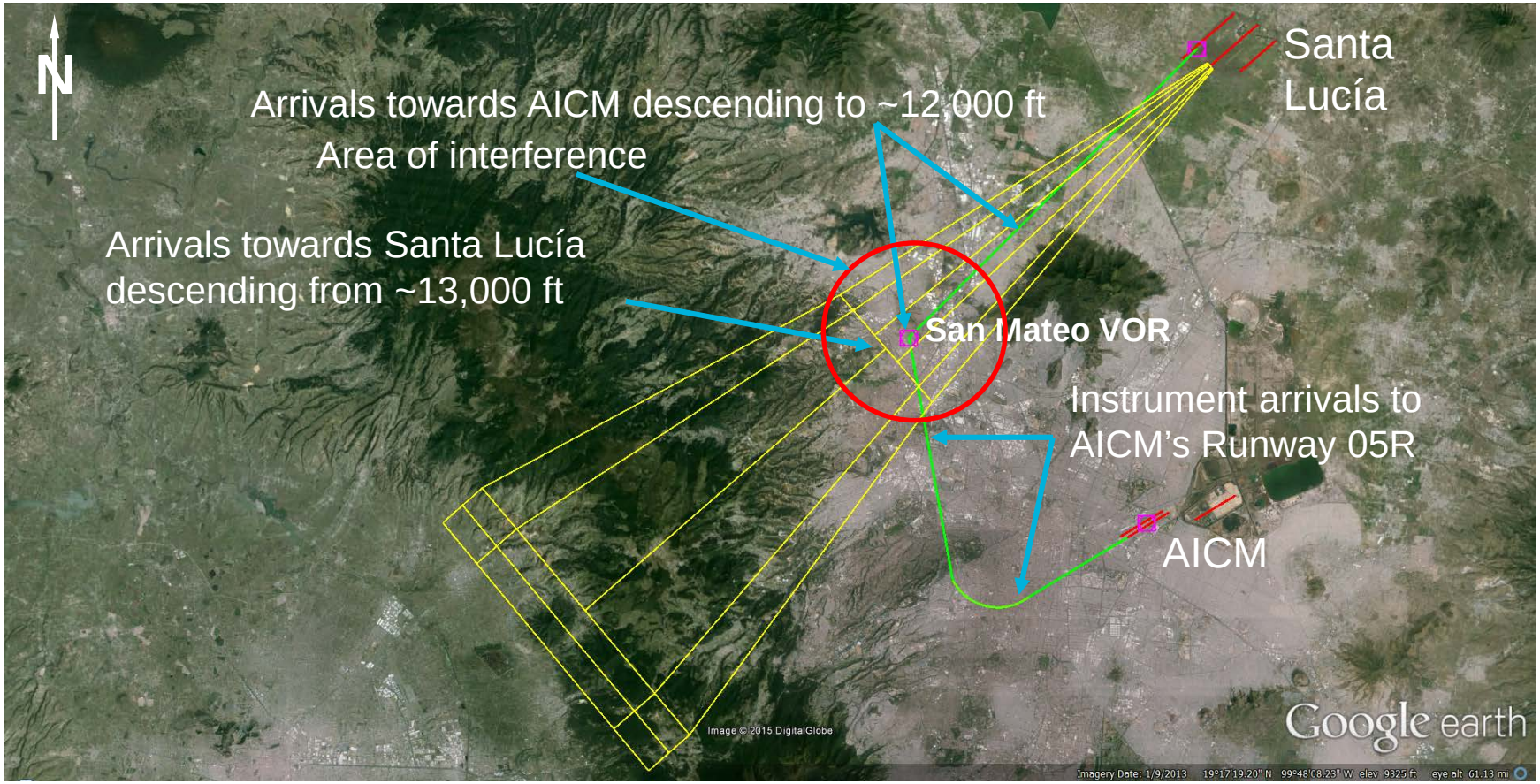


Source (in Spanish): La información relativa a aeronavegación en esta lámina se basa en datos del Global Flight Informatics (MGFI) de MITRE, que incluye el Sistema Threaded Track de MITRE (sistema de síntesis de trayectorias de vigilancia de aeronavegación en base a la fusión de diversos datos, tales como datos radar, Automatic Dependent Surveillance – Broadcast [ADS-B] y otros datos relevantes al sistema). Ello puede incluir (en inglés): MITRE-owned ADS-B receivers, Aircraft Communications Addressing and Reporting System (ACARS), Aircraft Meteorological Data Reporting (AMDAR), Innovata, Official Airline Guide (OAG), FlightRadar24, Jeppesen, Advanced Technologies and Oceanic Procedures (ATOP), International Civil Aviation Organization (ICAO) Global Flight Information Regions (FIRs), National Oceanic and Atmospheric Administration (NOAA), Global Forecast System (GFS), FlightAware, Meteorological Aviation Reports (METAR), and National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM).

MITRE

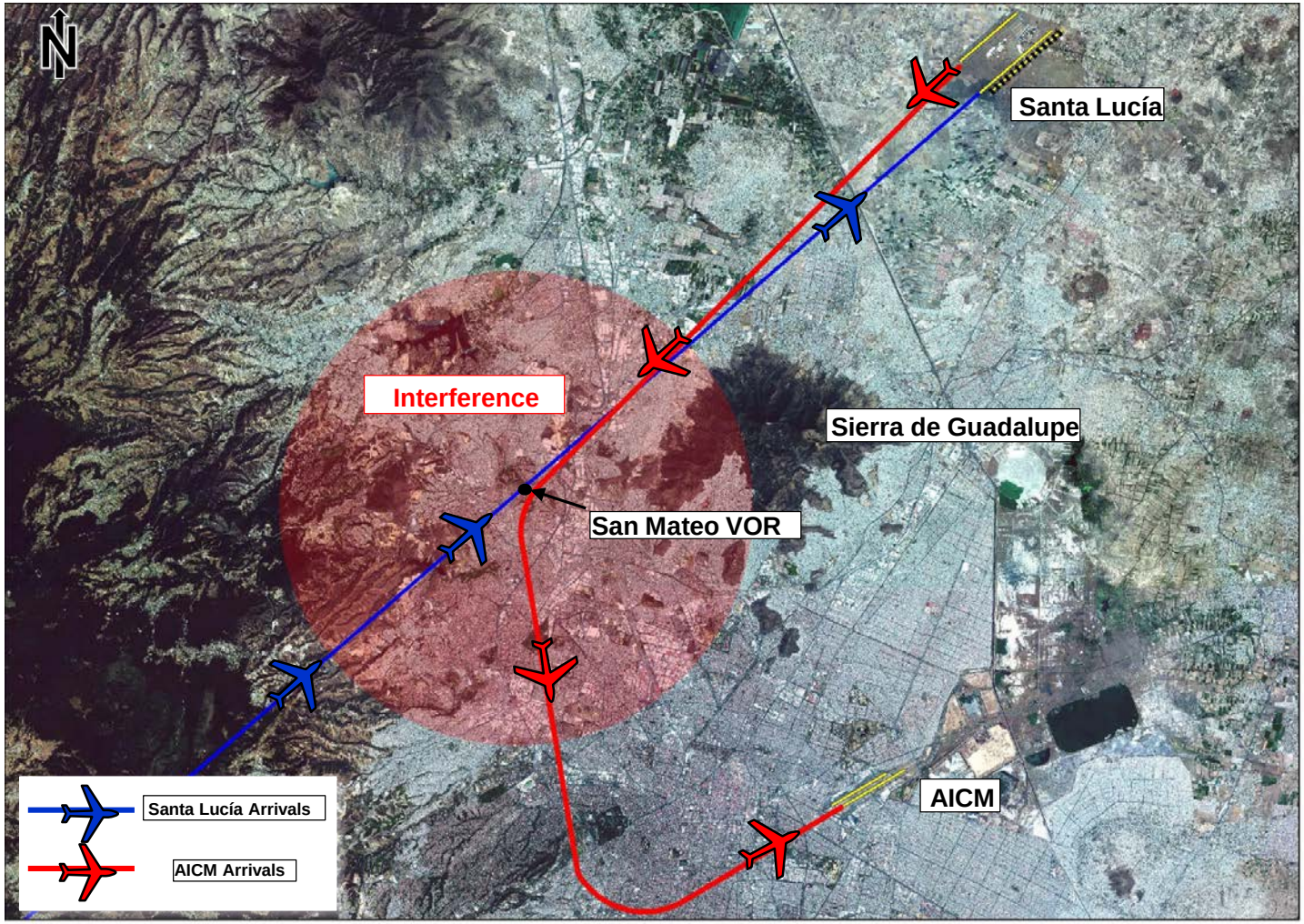
Simultaneous Arrivals to Santa Lucía and AICM

Area of Interference in the Proximity of the San Mateo VOR



Background Source: Google Earth

Single Approach to AICM and (simultaneously) Single Approach to Santa Lucía

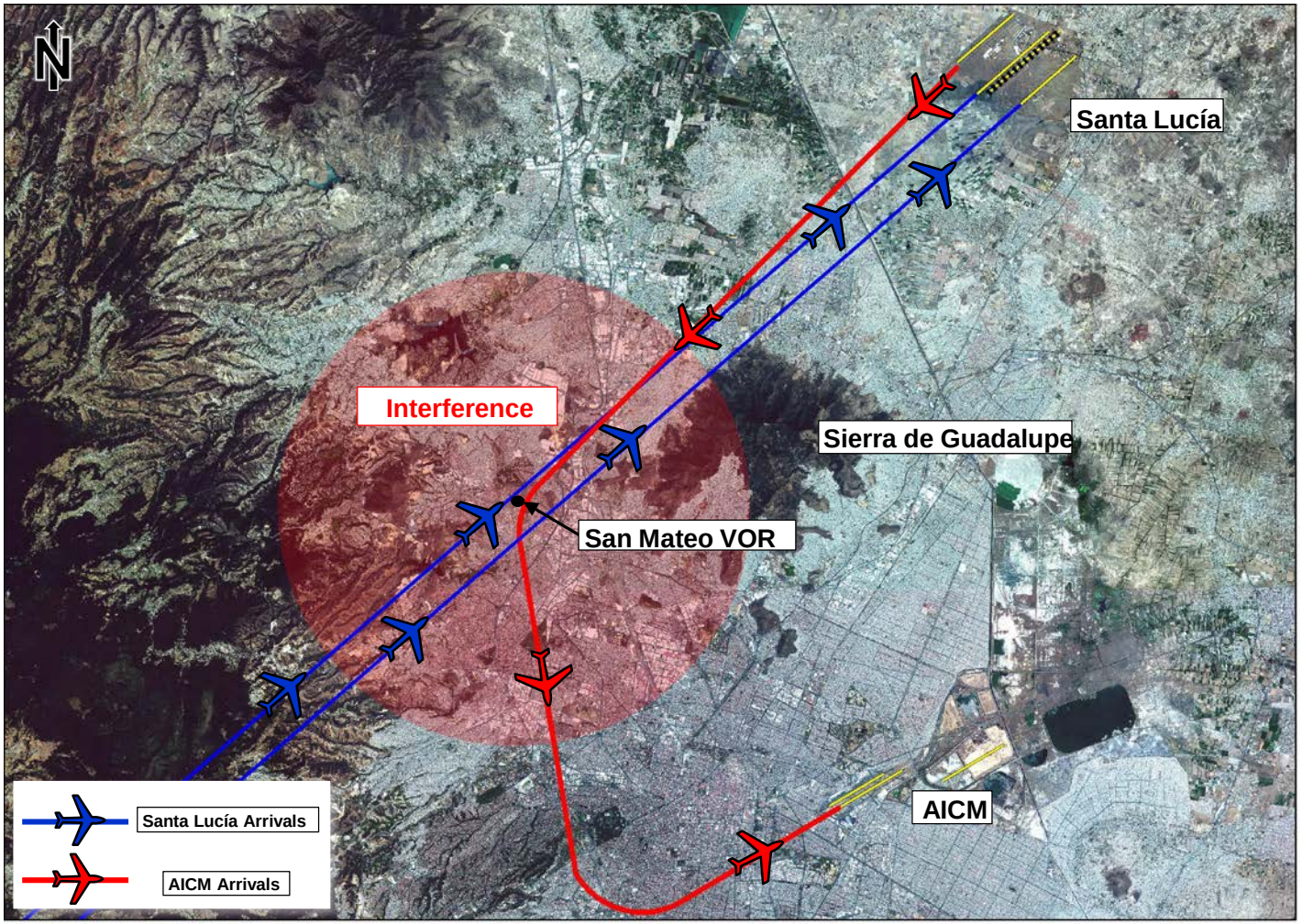


Background Source: Includes copyrighted material of DigitalGlobe, Inc., All Rights Reserved

0 2 4 8 Nautical Miles

While the red line represents the combined published arrival/approach to AICM, many flights are routed directly to the San Mateo VOR (as shown in a previous slide), from many other directions, mostly through radar vectoring.

Single Approach to AICM and (simultaneously) Dual Approaches to Santa Lucía



Background Source: Includes copyrighted material of DigitalGlobe, Inc., All Rights Reserved

0 2 4 8 Nautical Miles

While the red line represents the combined published arrival/approach to AICM, many flights are routed directly to the San Mateo VOR (as shown in a previous slide), from many other directions, mostly through radar vectoring.

The blue lines represents what a two-runway simultaneous approach to Santa Lucía might look like, with one track very close to Sierra de Guadalupe.

Approaches to Santa Lucía and (simultaneously) to AICM *(1 of 4)*

- **Single approach to each airport (<u>conventional procedures</u>)**
  - Creates an unacceptable area of interference at the San Mateo VOR
    - To ensure safety, long aircraft separations would be required and, as a result, global runway capacity in the area would not grow, leading to increasing delays, thus failing to resolve the enormous saturation levels at AICM

- **A single approach to AICM and dual approaches to Santa Lucía (<u>conventional procedures</u>)**
  - Creates an unacceptable area of interference at the San Mateo VOR
    - Dual approaches only exacerbates the problem
  - Due to the proximity of Sierra de Guadalupe, approaches to Santa Lucía "on the right" would be very complex when dealing with breakout maneuvers, weather avoidance, and other non-standard flight conditions such as unstable approaches
    - Increased airspace traffic complexity at both airports would likely lead to additional delays
    - To ensure safety, longer aircraft separations (than those mentioned in the top bullet) would be required and runway capacity would not only <u>not</u> grow, but, <u>paradoxically, airspace complexity may lead to larger delays</u>

Approaches to Santa Lucía and (simultaneously) to AICM *(2 of 4)*

- **Single approach to each airport (<u>RNAV-to-ILS procedures, a partially conventional procedure to Santa Lucía and a conventional procedure to AICM</u>) – *RNAV (Area Navigation) is a satellite-based procedure; ILS (Instrument Landing System) is a conventional approach procedure***
  - Minimizes interference at the San Mateo VOR
  - Controllers would have no flexibility to sequence aircraft appropriately behind other aircraft landing on the same runway using this procedure
  - Aircraft needing to discontinue their approach at certain points would have to climb to a new altitude that could conflict with AICM's traffic, causing disruptions at both airports
  - Accurate integration of multiple procedures from different directions cannot be accurately achieved without radar vectoring or advanced controller tools <u>that are not yet developed</u> (see more on this later)
  - <u>Dual</u> approaches to Santa Lucía under this procedure would exacerbate the above-mentioned issues; hence, a single approach to both airports would fail to resolve the saturation levels at AICM

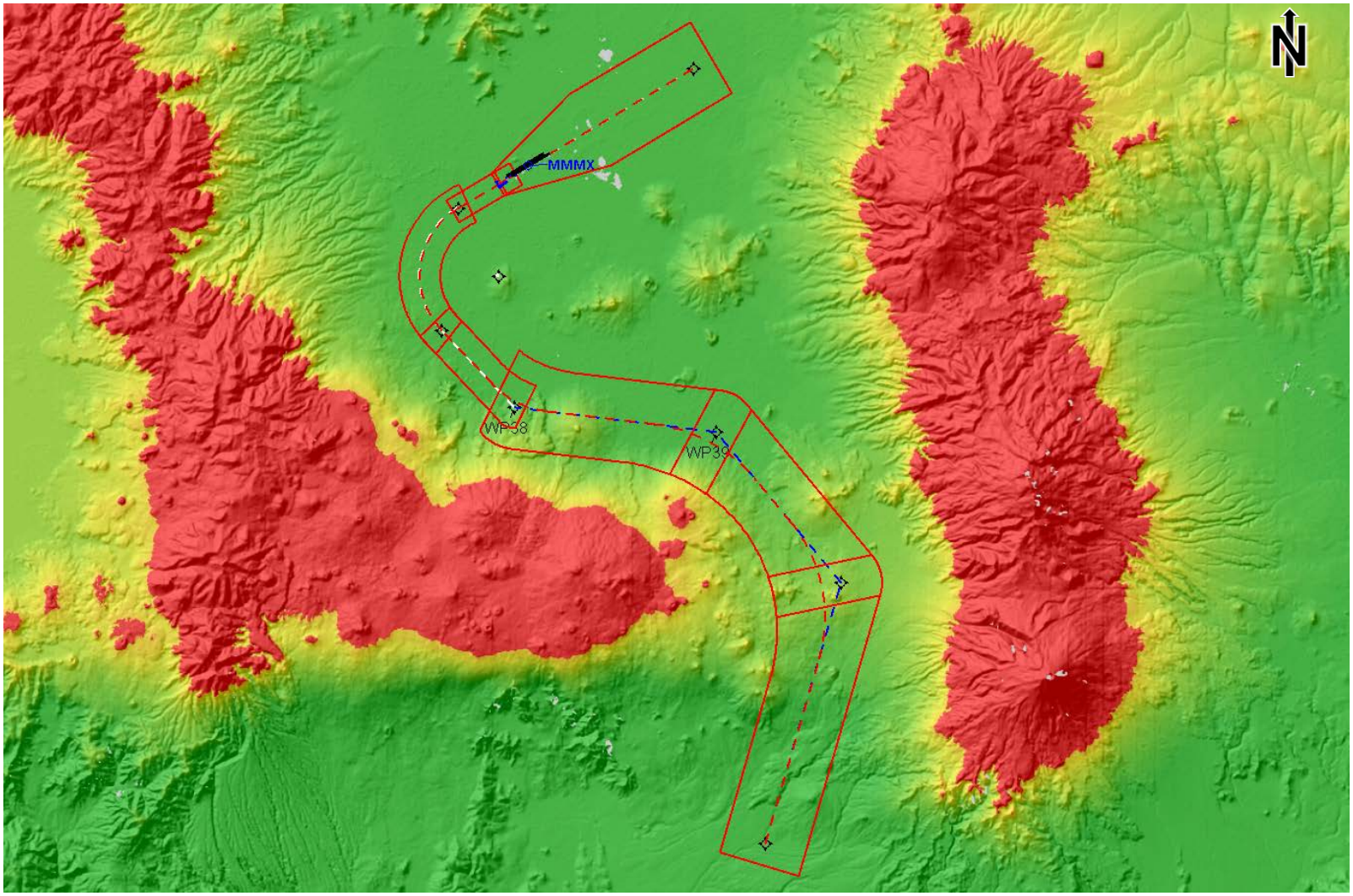
Approaches to Santa Lucía and (simultaneously) to AICM *(3 of 4)*

- **A single approach to AICM and single or dual approaches to Santa Lucía (<u>conventional procedures and clockwise runway rotation at Santa Lucía</u>)**
  - Reduces the impact of the interference at the San Mateo VOR
  - MITRE analyzed a rotation of up to 20+ degrees; however, high terrain to the north of the arrival path and to the north and south of the final approach may prevent, under a number of circumstances, the flexibility required to manage the procedure, <u>still a conventional procedure</u>, especially in the case of dual simultaneous approaches to Santa Lucía
    - As a result, a single approach to both airports would fail to resolve the saturation levels at AICM
  - At the critical phase of the approach, aircraft must fly at the correct speed, altitude, spacing behind previous aircraft, and correct flap setting, with undercarriage down. As mentioned before, aircraft needing to discontinue their approach would have to climb to a new altitude that could conflict with AICM's traffic, causing disruptions at both airports.

Approaches to Santa Lucía and (simultaneously) to AICM *(4 of 4)*

- **Single approach to AICM and single or dual approaches to Santa Lucía (<u>RNP AR procedure to AICM</u>) – *RNP AR (Required Navigation Performance Authorization Required) is a satellite-based approach procedure***
  - No interference at the San Mateo VOR by creating an RNP AR procedure from the south for AICM
  - MITRE investigated several possibilities of RNP AR procedures to AICM to avoid use of the San Mateo VOR (the following slides show a reasonable option)
  - The Height Above Touchdown (HAT) and visibility minimums would be far too high to be usable in bad weather, leading to closing of AICM during such periods, a very common event in winter time today that would only get worse as this procedure is implemented
  - RNP AR, as the sole approach procedure for a major airport, is highly problematic (see more on this later)

AICM – Runway 05R RNP AR Procedure



MMMX = AICM

AICM – Runway 05R RNP AR Procedure

Approach Specifics

- **RNP values:**
  - Final: 0.3
  - Intermediate: 0.3
  - Initial: 1.0
  - Missed Approach: 1.0

- **Minimums**
  - HAT: 419 ft
  - Ceiling: 500 ft
  - Visibility (with approach lights): ¾ Statute Miles
  - Visibility (without approach lights): 1-1/8 Statute Miles
  - Runway Visual Range (RVR): 4,000 feet

- **Unsatisfactory high HAT and visibility minimums (higher than at current AICM, operated today under conventional procedures)**

- **The fleet that could operate at AICM would be seriously restricted due to equipage and certification issues (see more on this later)**

Satellite Navigation (i.e., Performance-Based Navigation -- *PBN*) Procedures

- **PBN procedures (i.e., RNAV, RNP AR) tend to provide an accurate and repeatable path for aircraft to fly within the terminal airspace environment, however…**

- **PBN does not:**
  - Easily provide delay maneuvers when traffic demand exceeds available runway capacity
  - Integrate different traffic flows into one approach stream

- **PBN is a fixed-route system that <u>limits</u> a controllers' ability to achieve minimum separation between aircraft on final approach (to achieve high levels of arrival runway capacity)**
  - This limitation cannot be resolved merely <u>with additional air traffic controller training</u>. Advanced controller tools are needed.

PBN: Additional Issues *(1 of 3)*

- **Where PBN routes allow descent below the Minimum Vectoring Altitude (MVA) within an airspace sector and prior to intercepting the ILS, consider that:**
  - Controllers cannot radar vector aircraft off the route due to terrain
  - Required minimum separation between successive aircraft must be provided from the start of the PBN procedure (potentially a much longer distance than occurs today from San Mateo)
    - Aircraft have to be configured for landing over extended distances with flaps and undercarriage down, which is extremely inefficient and burns large amounts of fuel
  - Bad weather, including turbulence, thunderstorms, and windshear, along the PBN route could close that route down for safety reasons, and potentially close the arrival runway if alternate routes are not available
  - During simultaneous (independent) approach operations at Santa Lucía (essential to meet increasing air traffic demand), in the event of a deviation towards the adjacent approach, break-out maneuvers would immediately climb and turn away which could severely disrupt the arrival flows to AICM

PBN: Additional Issues *(2 of 3)*

- **There are no major airports in the world, such as Mexico City's, whose approach procedures depend solely on RNP AR procedures, especially when one considers the need for RNP 0.3 for AICM. That is why approaches to NAICM have been designed to utilize, both conventional and PBN procedures.**
  - Many large airports use PBN for a high percentage of arrivals (STARs) and departures (SIDs), but not for the final approach
- **A very significant number of Regional Jet (RJ) aircraft, so important in the current marketplace, are not equipped for vertical navigation using barometric vertical navigation or Satellite-Based Augmentation Systems (SBASs), such as the U.S. Wide Area Augmentation System (WAAS)**
- **Only approximately 40% of the U.S. fleet is certified to operate under RNP AR**

PBN: Additional Issues *(3 of 3)*

- **Use of vertical guidance in the U.S. is an important safety issue: the U.S. does not permit independent approaches to parallel runways without vertical guidance on final approach**

- **While a PBN mandate can be issued, trying to implement it too soon (i.e., in under 10-12 years) at major airports would disincentivize many airlines from operating at specific airports, such as Mexico City, for being uneconomical.**
  - The U.S. plans to keep ILS approaches at major airports for the <u>indefinite future.</u>

PBN: Into the Future

- **Within the following 10 to 15 years advanced controller tools are expected to assist controllers to manage PBN arrivals in 4-dimensions (i.e., to allocate aircraft very accurate arrival times over waypoints)**
  - The features of these advanced tools, and success in implementing their use cannot be predicted accurately at this time
  - In a PBN-only environment, where no conventional procedures are used, aircraft time accuracy over a waypoint of <u>less than 15 seconds</u> is required. Less accuracy would create disruptions in arrival traffic flows and a loss of runway capacity.
    - This is an important reason why major airports around the world still rely on controllers to utilize conventional procedures (i.e., radar vectoring) to achieve large volumes of arrival runway capacity

Summary of MITRE Attempts to Make the Plan Alternativo Work in the Near Term

MITRE made intense attempts to separate traffic flows to avoid interference at the San Mateo VOR due to the Plan Alternativo

- **Alternative approach procedures attempted for Santa Lucía:**
  - Lower altitudes on approach
  - Shorter final approach procedures
  - Satellite-based navigation (RNAV-to-ILS) procedure
- **Alternative approach procedures attempted for AICM**
  - Satellite-based navigation (RNP AR) procedures with an Radius-to-Fix (RF) turn

Other Considerations *(1 of 2)*

- **Global capacity**
  - Texcoco “2” (NAICM) offers significant more air traffic capacity at a single airport, than does the combined potential capacities (“global capacity”) of a combined AICM with an expanded Santa Lucía
- **Noise exposure in accordance to international standards**
  - If AICM does not close, significant noise exposure to residential areas will continue unabated in the long term
  - Adding runways at Santa Lucía would cause significant new noise exposure to nearby communities located in a very quiet area
- **MITRE understands that there is concern about construction delays and missed cost targets and there are questions on whether the case of Berlin Brandenburg International Airport (hereinafter, Berlin) could be repeated at NAICM**
  - Berlin is truly an exceptional case, one where a very rare set of circumstances has caused construction delays

Other Considerations *(2 of 2)*

- The major technical issue causing the delay in opening Berlin is within the terminal building, specifically due to an overengineered fire detection system
- The aeronautical components of Berlin (runways, taxiways, instrument procedures) were ready on time

- **Nevertheless, Berlin does offer some lessons-learned**
  - It is essential that expert project managers be used for such a large and technically complex project
    - Over-complexity of technical systems can lead to failure; do not use overly “modern” systems not yet tested sufficiently
  - Change of management teams and technical experts should be minimized; institutional knowledge over a project lifetime is invaluable to the smooth integration of multiple systems

General Conclusions *(1 of 6)*

- **Air traffic safety is paramount, it cannot be compromised under any circumstances. At the same time, as with anything in engineering, there exist elements of risk, which when it comes to air traffic, are vastly minimized.**
  - The reader should consider that air traffic risk in the context of this document is not always about safety; there is also an element of feasibility and implementation risk
  - Throughout the previous pages operational safety has been discussed in the context of airspace complexity and its mitigation, as under no conditions would MITRE compromise safety.
  - The remainder of this document primarily discusses implementation risk. All MITRE can do is present the Mexican authorities its serious and most responsible opinion.

General Conclusions *(2 of 6)*

- **The Plan Alternativo is not considered viable by MITRE from an aeronautical perspective under current standards, technology, and design methodologies**
  - There are no obvious solutions that have not been explored and, therefore, there is a clear and present risk that the goal of expanding global operational capacity for Mexico City will not be achieved under one of the initiatives depicted on pages 18 through 21 of this document

- **The Plan Alternativo would result in the creation of a severely congested and complicated airspace system that would very likely increase already important air traffic delays and operational problems, that would prevent meeting future aviation demand in the Mexico City metropolitan area**

General Conclusions *(3 of 6)*

- **MITRE would like to state that in an effort to consider "out-of-the-box" ideas, senior members of the MITRE "Mexico Team" decided to consider a theoretical concept (a "thought experiment") of a kind, consisting of *"and what if the NAICM site did not exist?",* that is, "*what alternatives would have been available in that case to meet the future aviation demand in the Mexico City metropolitan area?"***
  - As problematic as the Texcoco soil is, it is increasingly rare to find in the world an airport site opportunity as that in Texcoco; therefore, it was not without a strong effort that this thought experiment took place

- **The conclusions of a situation without Texcoco are as follows:**
  - A site for an airport other than NAICM can be found. However, the site should most assuredly have to avoid an air traffic conflict with AICM, something very difficult to achieve except at a great distance from AICM. Airports at a great distance from the centers they serve are discouraged: major airports have even gone bankrupt.

General Conclusions *(4 of 6)*

- Hence, MITRE engineers concluded that only relatively close sites would be acceptable. However, as with Santa Lucía, given the rapid growth of air traffic in Mexico City, demolition of a broad area would be required (there are no empty areas in the proximity of Mexico City).
- Even if the above were acceptable, orography and terrain need to be considered to avoid the risk of declaring feasible an area that in reality is not. Therefore, highly accurate photogrammetric surveys would need to be performed as a pre-requisite to initiate sophisticated procedural development (the photogrammetric work would take up to one year; less if the rainy season has not ensued).
- A very accurate weather analysis, utilizing advanced equipage (similar to the one that has been utilized for several years at the NAICM site) would be required.

General Conclusions *(5 of 6)*

- After completion of the photogrammetric surveys, preliminary aeronautical analyses may start (as conventional instrument procedures need to be designed “top-down”, except for airports surrounded by relatively flat areas, sometimes as far as 50 km).
- Designing instrument approach procedures is only one part in the development of a workable design to manage air traffic arriving and departing in and out of a metropolitan area; therefore, terminal area design work would be the next step: a redesign of the entire terminal area airspace where the new airport would operate.
  - A complete reorganization of the airspace would be required; doing so can take two or more years of highly specialized analyses in addition to Human-In-The-Loop (HITL) simulations
    - Even if the site happened to be Santa Lucía itself, no detailed procedures, as well as airspace design (much less HITL simulations) have been developed by SENEAM or MITRE for other sites.
- The items above refer to aeronautical work. Master planning, civil engineering, and architectural design are not being considered.

General Conclusions *(6 of 6)*

- **In conclusion, whether an entirely new site or other initiatives are considered, planning and building a new airport operating safe procedures can easily exceed 10 years; this is a typical minimal period for projects that start from a "clean-slate".**
  - In the meantime, lack of operational capacity would continue to grow into a bottleneck that would affect many sectors of the economy

- **Costs and time delays gone awry are unacceptable risks. It is important to state that aeronautical risks are as unacceptable as aeronautical errors often cannot be reversed or remedied. MITRE encourages the Mexican authorities to consider this fact.**

- **It is unfortunate that successive authorities delayed so long the airport project that the Administration of President-Elect Andrés Manuel López Obrador faces today; the previous items would have not been an issue were it not for nearly 20 years of delay.**