

POTENTIALITIES IDENTIFIED BY THE MEXICAN SPACE AGENCY FOR THE USE OF GNSS APPLICATIONS IN AVIATION, AGRICULTURE AND OTHER SECTORS IN MEXICO

United Nations/Finland Workshop on the Applications of Global Navigation Satellite Systems

Helsinki, Finland
23 – 26 October 2023

SERRANO ARELLANO, Antonio
Development and Promotion Manager
Mexican Space Agency
October 25, 2023

AEM
AGENCIA ESPACIAL
MEXICANA



UNITED NATIONS
Office for Outer Space Affairs



NLS
NATIONAL
LAND SURVEY
OF FINLAND



2023
AÑO DE
Francisco
VILLA
EL REVOLUCIONARIO DEL PUEBLO

1. Mexico background - General

Area:
~2M km²



Population:
~117 M people

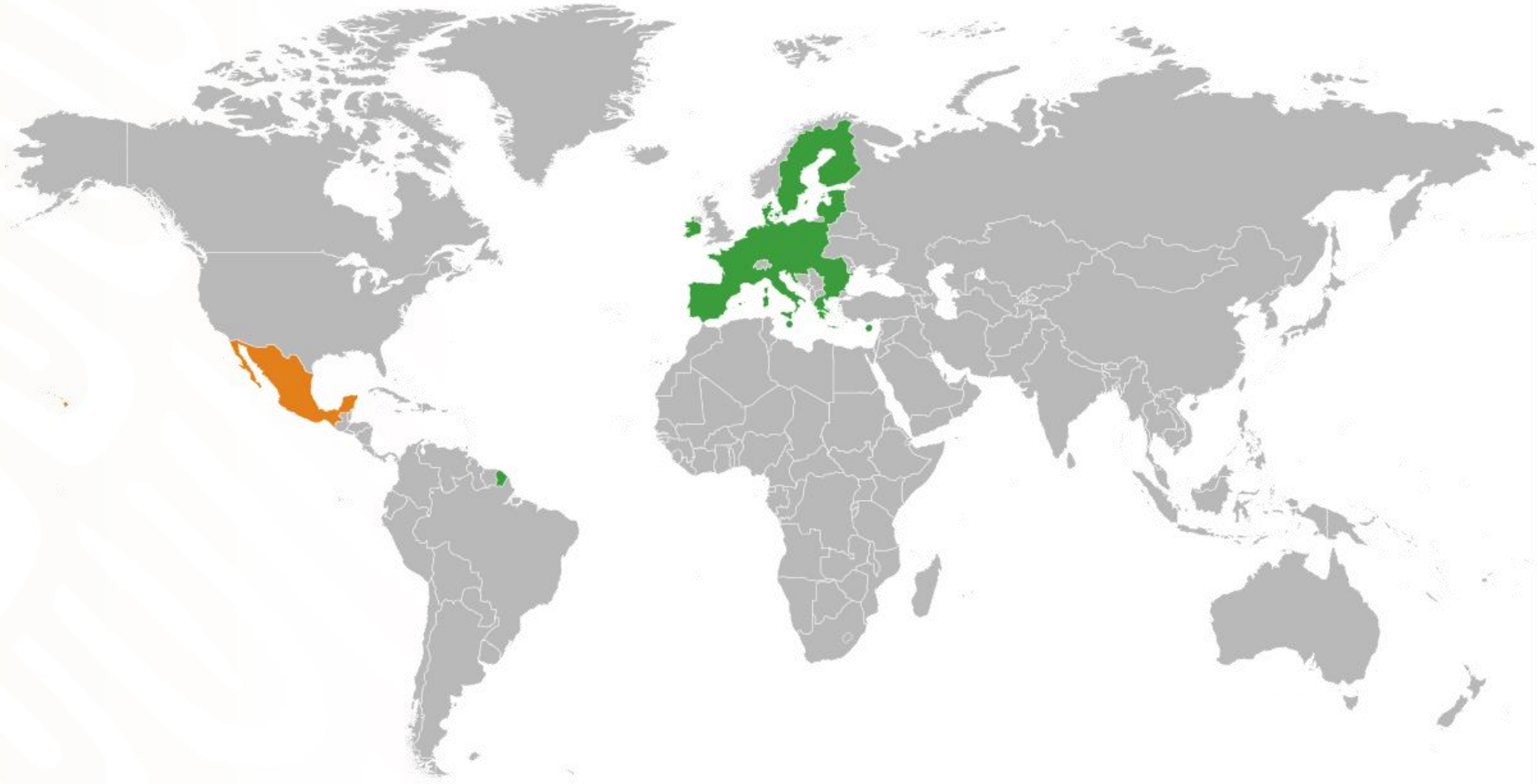


GDP:
~1,400 billion USD



Currency:
Mexican peso (MXN)
1 USD~18MXN
1 €~19MXN

Capital:
Mexico City (15% GDP)



1. Mexico background - General

Area:
~2M km²



Population:
~117 M people



GDP:
~1,400 billion USD



Currency:
Mexican peso (MXN)
1 USD~18MXN
1 €~19MXN

Capital:
Mexico City (15% GDP)



1. Mexico background - General

Main Economic Activities:

Agriculture



Livestock



Fishery

Mining



Oil production

Manufacturing

Water, electricity, gas



Railways:

26,000 km



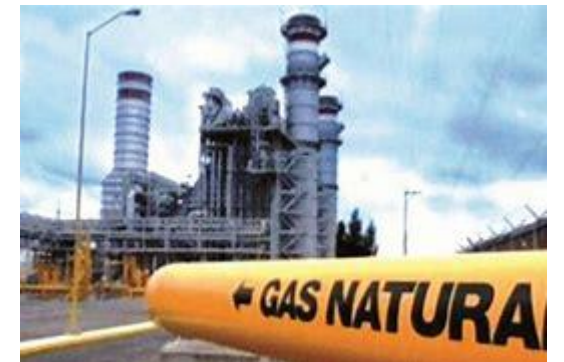
Roads:

400,000 km



International Airports:

CAT 1 → 26



1. Mexico background - General

Main Economic Activities:

Agriculture



Livestock



Fishery

Mining



Oil production

Manufacturing

Water, electricity, gas



Railways:

26,000 km



Roads:

400,000 km



International Airports:

CAT 1 → 26



1. Mexico background - General

Main Economic Activities:

Agriculture

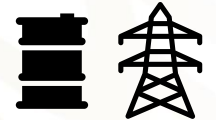


Livestock



Fishery

Mining



Oil production

Manufacturing

Water, electricity, gas



Railways:

26,000 km



Roads:

400,000 km



International Airports:

CAT 1 → 26



1. Mexico background - General

Biodiversity:

10+ Ecosystems

100k+ species

~12% global biodiversity



Coastline:

9,000km+



Rivers and lakes:

~240 rivers

~40 lakes



Natural Hazards:

48 active volcanoes

4,200 earthquakes/yr

(magnitude 4.5 or more)

Tropical storms and hurricanes



1. Mexico background - General

Biodiversity:

10+ Ecosystems

100k+ species

~12% global biodiversity



Coastline:

9,000km+

Rivers and lakes:

~240 rivers

~40 lakes

Natural Hazards:

48 active volcanoes

4,200 earthquakes/yr

(magnitude 4.5 or more)

Tropical storms and hurricanes



1. Mexico background - General

Biodiversity:

10+ Ecosystems

100k+ species

~12% global biodiversity



Coastline:

9,000km+



Rivers and lakes:

~240 rivers

~40 lakes



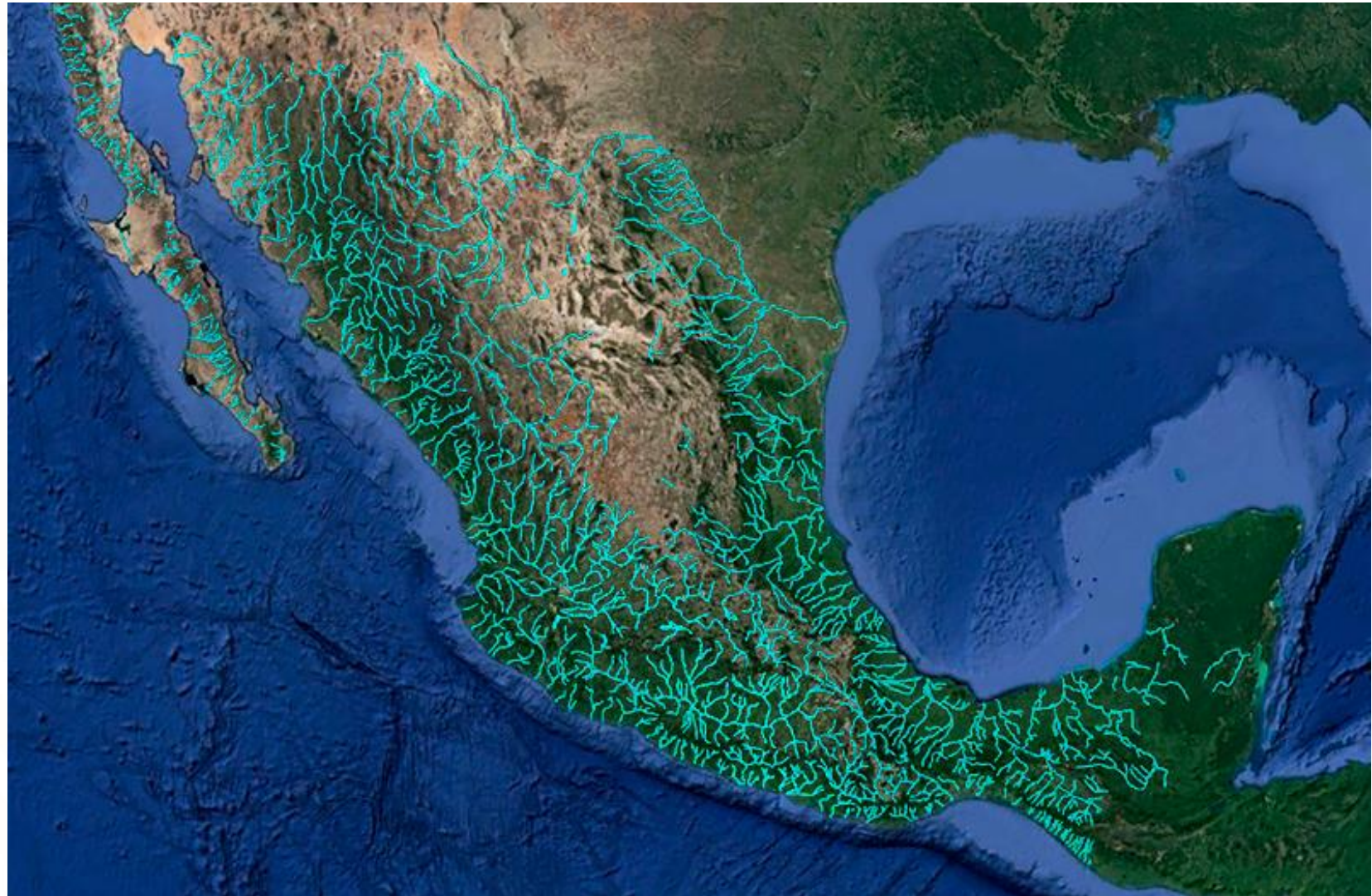
Natural Hazards:

48 active volcanoes

4,200 earthquakes/yr

(magnitude 4.5 or more)

Tropical storms and hurricanes



1. Mexico background - General

Biodiversity:

10+ Ecosystems

100k+ species

~12% global biodiversity



Coastline:

9,000km+



Rivers and lakes:

~240 rivers

~40 lakes



Natural Hazards:

48 active volcanoes

4,200 earthquakes/yr
(magnitude 4.5 or more)

Tropical storms and hurricanes



2. Mexico background - Aerospace

Aerospace industry:
~10 billions USD exports
(2022)

Aeronautical companies:
~300 companies

Aerospace Clusters:
5 Clusters
Mexican Federation
Aerospace Industry

Mexico Aerospace Fair:
Since 2015

Software/Technologies
Clusters:
38 (2,000 companies)



AEM
AGENCIA ESPACIAL
MEXICANA

BAJA
AEROSPACE
CLUSTER

Chihuahua's
AEROSPACE
CLUSTER



Monterrey
Aerocluster

AEROCÚSTER
QUERÉTARO

FEMIA
FEDERACION MEXICANA DE LA INDUSTRIA AEROSPAIAL, A.C.

2. Mexico background - Aerospace

Aerospace industry:
~10 billions USD exports
(2022)

Aeronautical companies:
~300 companies

Aerospace Clusters:
5 Clusters
Mexican Federation
Aerospace Industry

Mexico Aerospace Fair:
Since 2015

**Software/Technologies
Clusters:**
38 (2,000 companies)



650 companies
40 countries
50,000 visitors

AEM
AGENCIA ESPACIAL
MEXICANA

BAJA
AEROSPACE
CLUSTER

Chihuahua's
AEROSPACE
CLUSTER



Monterrey
Aerocluster

AEROCÚSTER
QUERÉTARO

FEMIA
FEDERACION MEXICANA DE LA INDUSTRIA AEROSPAICIAL, A.C.

2. Mexico background - Aerospace

1st Mexican satellite: 1985
(Telecommunications)

Mexico satellites:

- 6 government (COMM)
- 5 university (nanosatellites)
- 2 private sector (Earth Observation)*

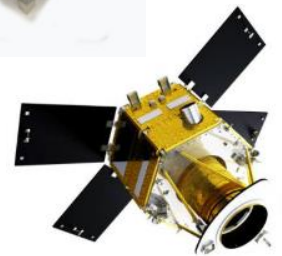
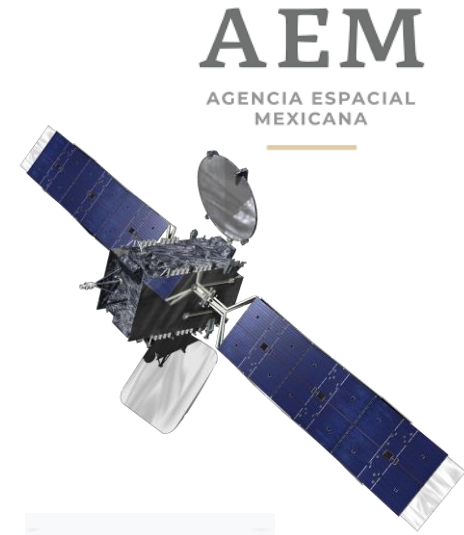
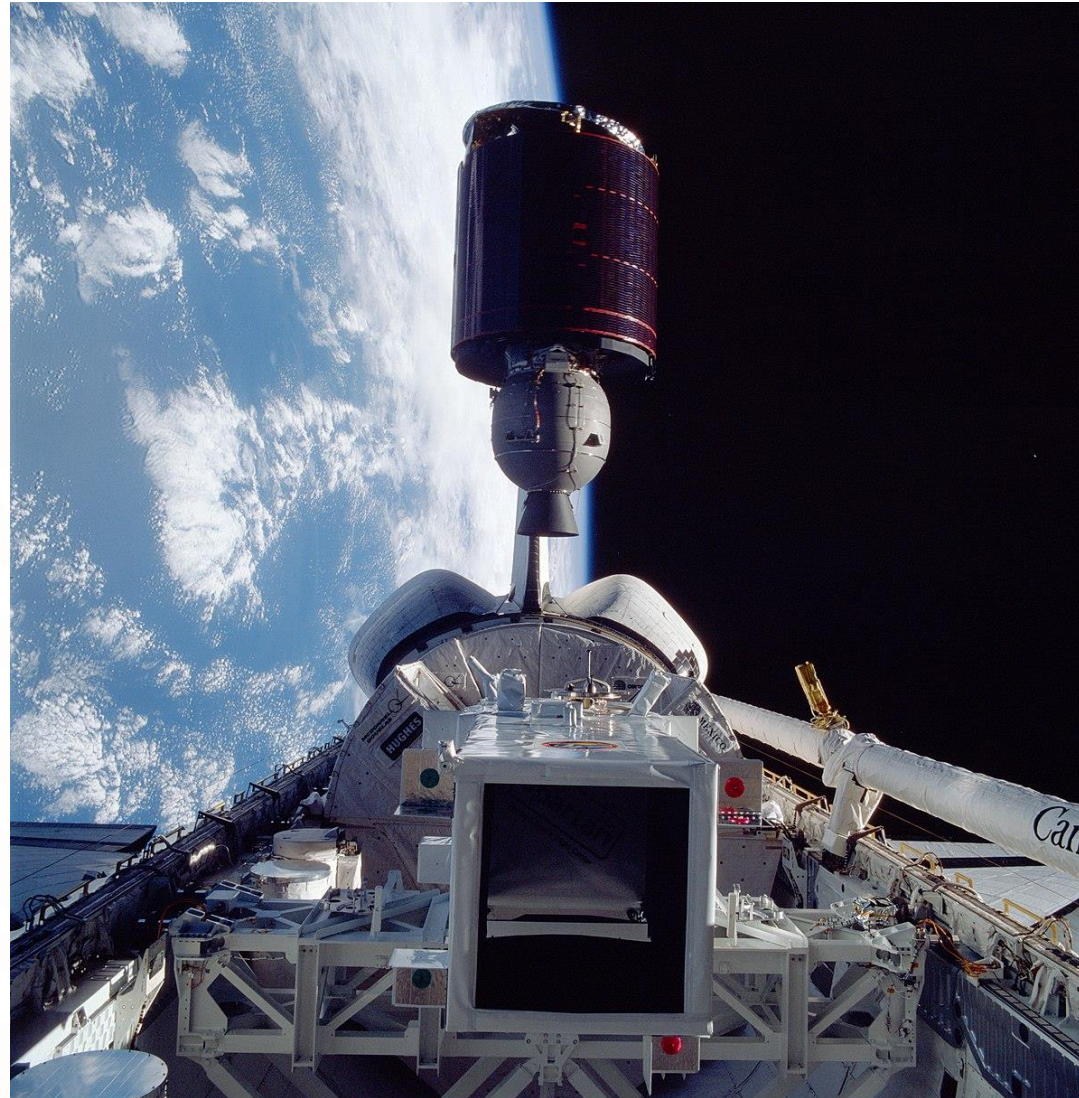
Astronauts: 1 (1986)

Space Policy@2011

Satellite Policy@2018

Mexican Space Agency

Creation: 2010
Size: 60 people
Annual budget: 4M USD



2. Mexico background - Aerospace

1st Mexican satellite: 1985
(Telecommunications)

Mexico satellites:

6 government (COMM)
5 university (nanosatellites)
2 private sector (Earth Observation)*

Astronauts: 1 (1986)

Space Policy@2011

Satellite Policy@2018

Mexican Space Agency

Creation: 2010
Size: 60 people
Annual budget: 4M USD

Ministry of Infrastructure, Communications and Transport

AEM
AGENCIA ESPACIAL
MEXICANA

MEXICAN SPACE AGENCY

National Space Activities Program 2020-2024

Priority Objective 1 - Identify prospects and promote the development of space infrastructure for telecommunications, navigation, global positioning and their applications, which favor digital transformation and the supply of services to contribute to well-being, social inclusion and economic development.

2. Mexico background - Aerospace

1st Mexican satellite: 1985
(Telecommunications)

Mexico satellites:

6 government (COMM)
5 university (nanosatellites)
2 private sector (Earth Observation)*

Astronauts: 1 (1986)

Space Policy@2011

Satellite Policy@2018

Mexican Space Agency

Creation: 2010
Size: 60 people
Annual budget: 4M USD

Ministry of Infrastructure, Communications and Transport

AEM
AGENCIA ESPACIAL
MEXICANA

MEXICAN SPACE AGENCY

National Space Activities Program 2020-2024

Priority Objectives:

1. Telecommunications, navigation and global positioning
2. Earth observation
3. Space exploration

3. Mexico background - GPS

150+ GPS stations from 1985 to 2015:

Land registry/cadastral (1985)

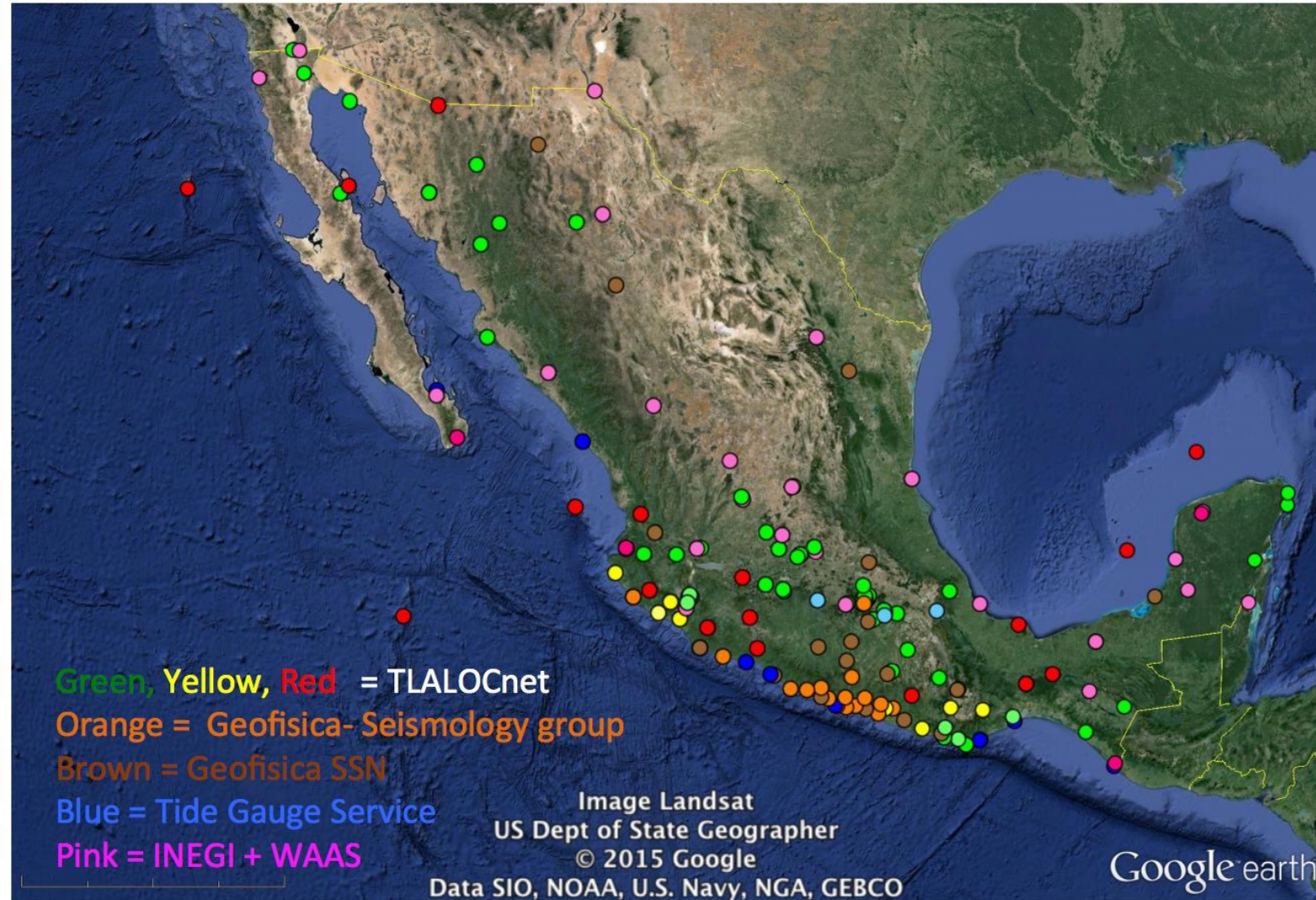
Volcanoes monitoring (1996)

Tide monitoring (1999)

Atmospheric monitoring/Tornadoes (2001)

Earthquakes monitoring (2001)

WAAS (2005-2007)



3. Mexico background - GPS

Some applications implemented already:

Fauna monitoring

Natural Protected Areas demarcation

Archeological zones demarcation



Whale shark at Baja California



3. Mexico background - GPS

Some applications implemented already:

Fauna monitoring

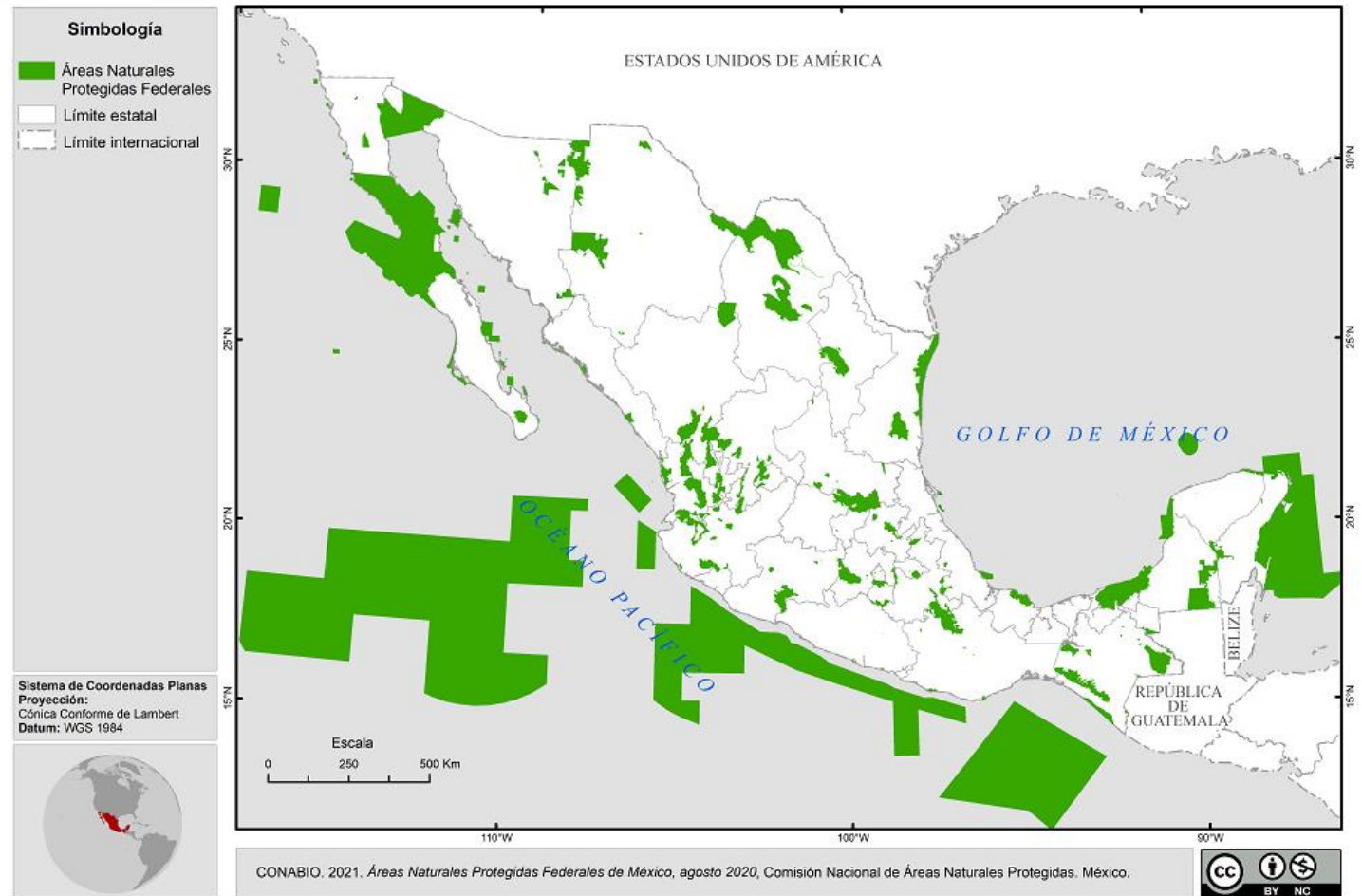
Natural Protected Areas demarcation

Archeological zones demarcation



CONABIO
COMISIÓN NACIONAL PARA
EL CONOCIMIENTO Y USO
DE LA BIODIVERSIDAD

National Commission for the
Knowledge and Use of Biodiversity



3. Mexico background - GPS

Some applications implemented already:

Fauna monitoring

Natural Protected Areas demarcation

Archeological zones demarcation



Anthropology and History National Institute



Sayil, Yucatan



4. GNSS demand world map



	European Union (EU27)			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	12.1	25.0	21.6	24.8
Services revenues (€ bn)	27.4	18.2	53.7	13.3

	Global	
	2021	2031
	Value	Value
Devices revenues (€ bn)	48.4	87.0
Services revenues (€ bn)	150.5	405.2

	Russia & Non-EU27 Europe (Non-EU27 Europe)			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	2.7	5.6	7.6	8.7
Services revenues (€ bn)	7.4	4.9	20.7	5.1



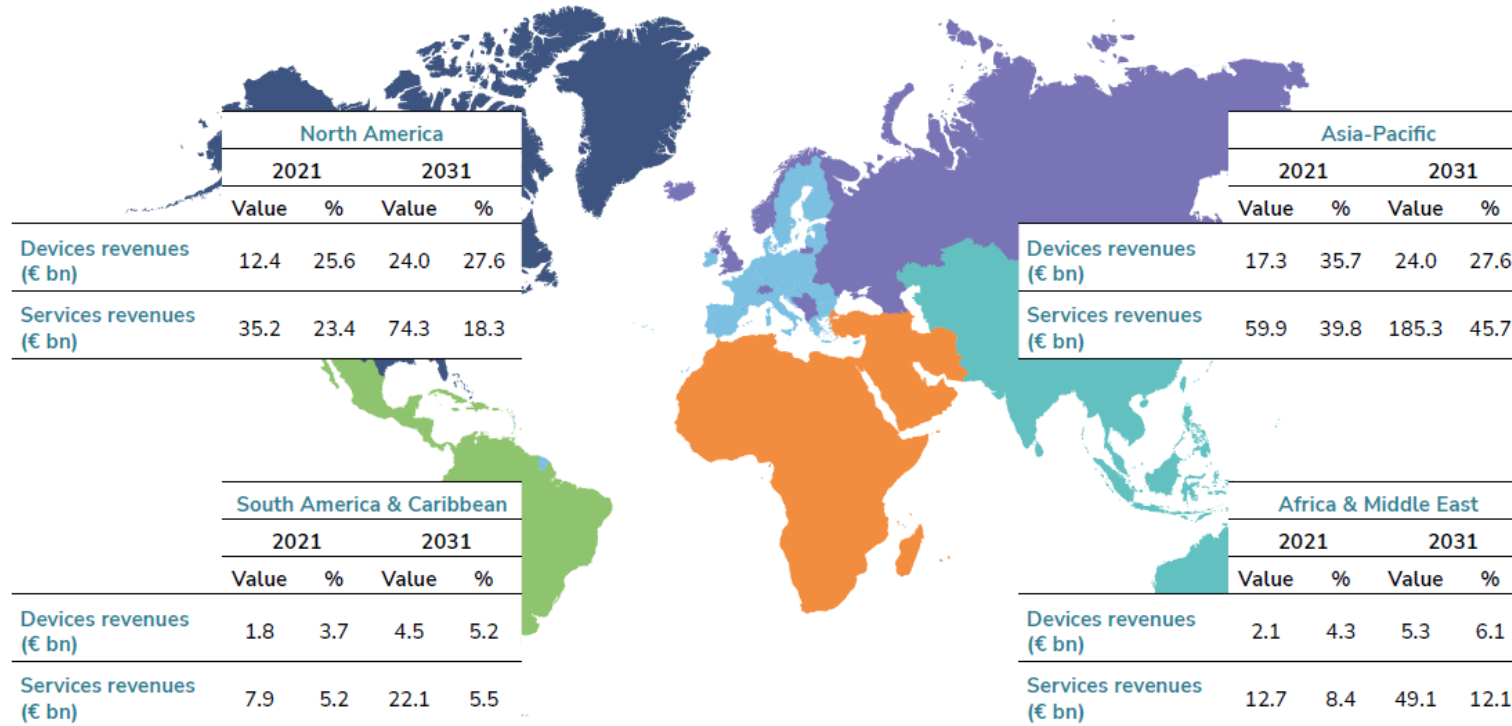
	North America			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	12.4	25.6	24.0	27.6
Services revenues (€ bn)	35.2	23.4	74.3	18.3

	Asia-Pacific			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	17.3	35.7	24.0	27.6
Services revenues (€ bn)	59.9	39.8	185.3	45.7



	South America & Caribbean			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	1.8	3.7	4.5	5.2
Services revenues (€ bn)	7.9	5.2	22.1	5.5

	Africa & Middle East			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	2.1	4.3	5.3	6.1
Services revenues (€ bn)	12.7	8.4	49.1	12.1



4. GNSS demand world map



	South America & Caribbean			
	2021		2031	
	Value	%	Value	%
Devices revenues (€ bn)	1.8	3.7	4.5	5.2
Services revenues (€ bn)	7.9	5.2	22.1	5.5

5. Galileo Information Center Collaboration



January 2021 – January 2024



5. Galileo Information Center Collaboration



January 2021 – January 2024



Mexican Space Agency is not part of the GIC consortium but we collaborate actively since 2022

5. Galileo Information Center Collaboration

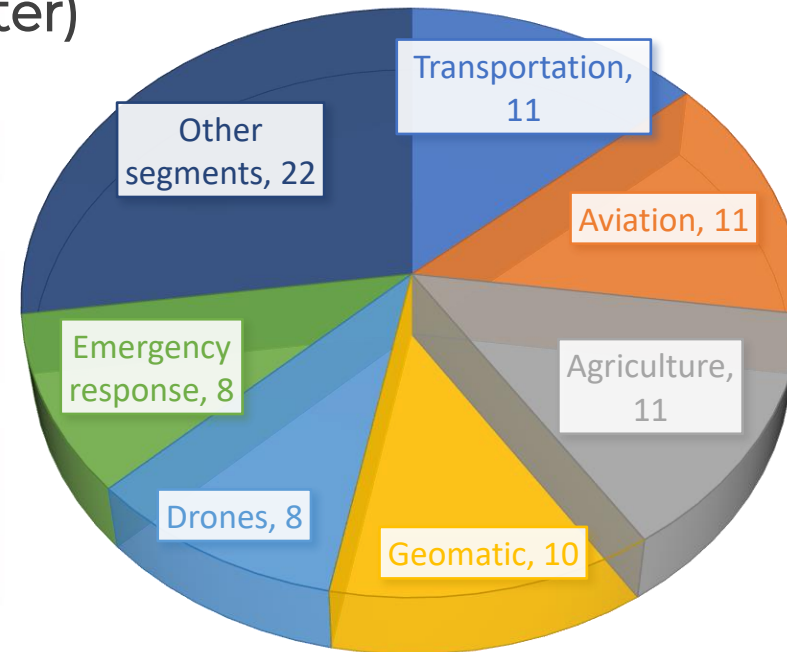


January 2021 – January 2024

Market study on key GNSS segments in Mexico and the region 2022 (Developed by Galileo Information Center)

Differentiators:

- Market importance and growth
- Innovation and GNSS initiatives
- Previous experience
- Other regulatory, political, social, economic barriers.



5. Galileo Information Center Collaboration



January 2021 – January 2024



6. Aviation



Navigation Service to the Mexican Airspace (SENEAM)



Federal Civil Aviation Agency



6. Aviation



WAAS

(2005-2007)

NavCANADA and SENEAM implemented 5 Wide Area Reference Stations in Mexico.

However, WAAS is not authorized for flight procedures due to technological (GNSS challenges) and regulatory limitations in Mexico.



6. Aviation



Currently, **Performance Based Navigation (PBN)** arrival, departure and approach procedures are in place for 25 airports in Mexico, as well as 172 PBN Routes in Mexican airspace, with the following Area Navigation (RNAV) specifications:

80 RNAV-2 Routes

63 RNAV-5 Routes

29 RNP-10 Routes



6. Aviation



According to the SENEAM:

The challenges in GNSS for aviation are:

- Radio frequency interference (spoofing/jamming)
- Signal propagation
- Space weather

Dual Frequency-Multiconstellation System (DFMC) could be an alternative for the future of the aviation in Mexico.

“DFMC GNSS permits the combined leveraging of dual frequency signals from up to four GNSS constellations simultaneously, including the GPS system (United States), Galileo (European Union), GLONASS (Russian Federation), and BeiDou (China).”



7. Drones

- Precision Farming
- Delivery of products
- Delivery of emergency items
- Location and search of people.
- Location of task force elements in operations
- Analysis of emergency situations such as fires or explosions
- Indoor navigation in tunnels, mines, shopping malls
- Emergency WiFi in areas affected by earthquakes



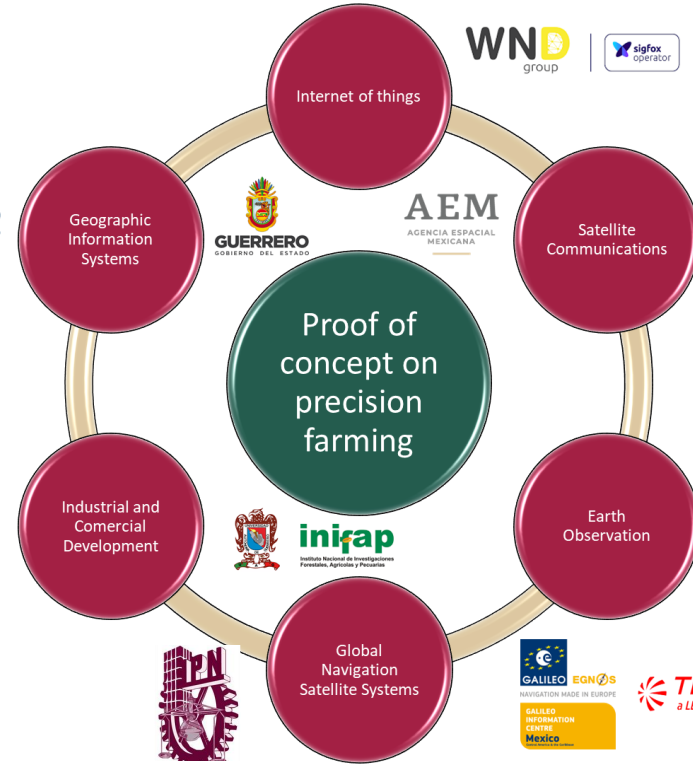
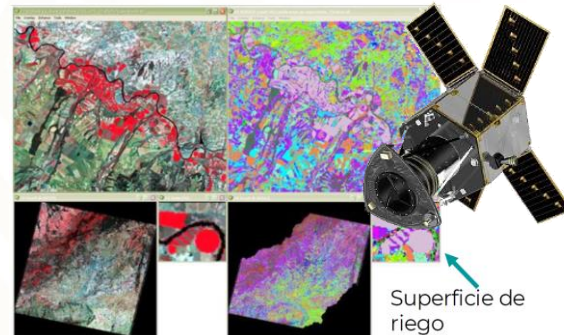
8. Agriculture



8. Agriculture

Objective

Implementation of a proof of concept focused on precision agriculture in the State of Guerrero considering the integral convergence of diverse technologies including GNSS.



- Predictive models for early pest control
- Optimal fertilization doses
- Disease control of various crops such as corn

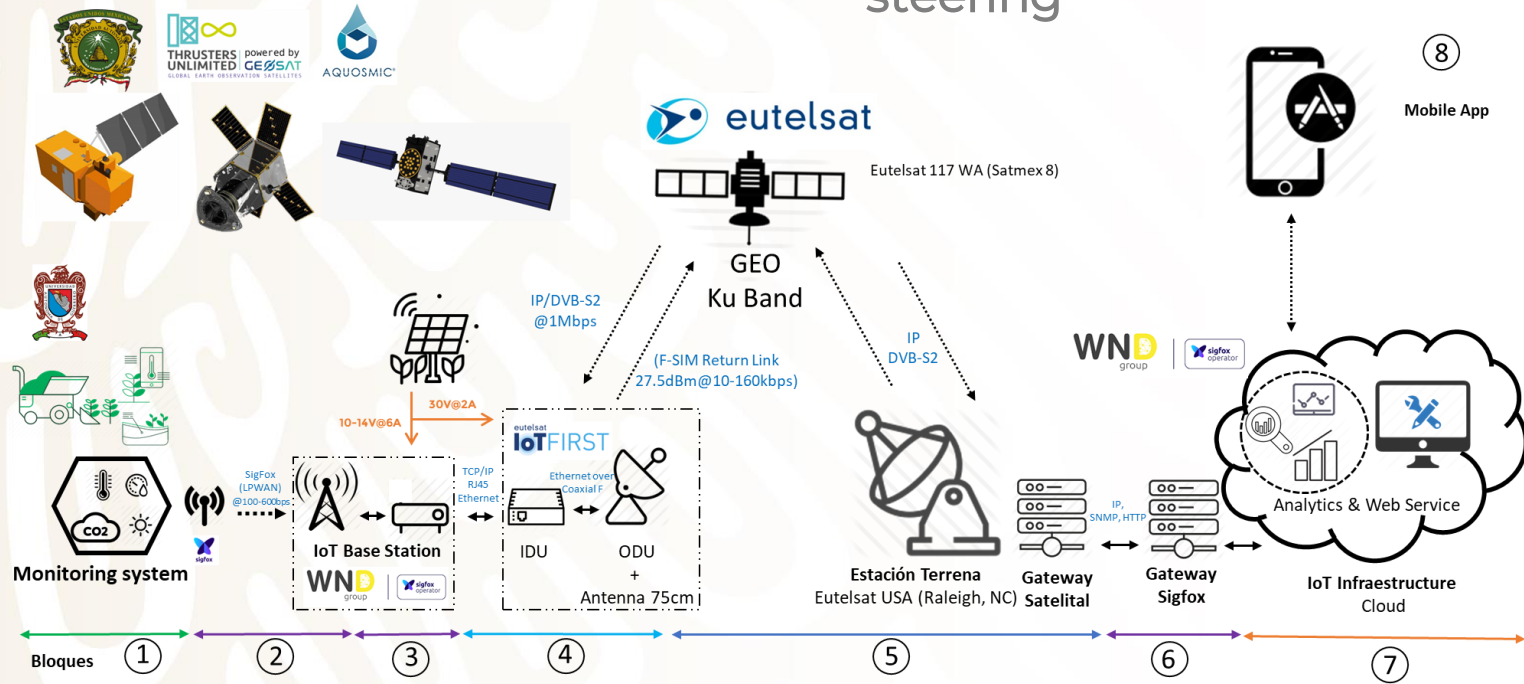
8. Agriculture



Drone Swarm



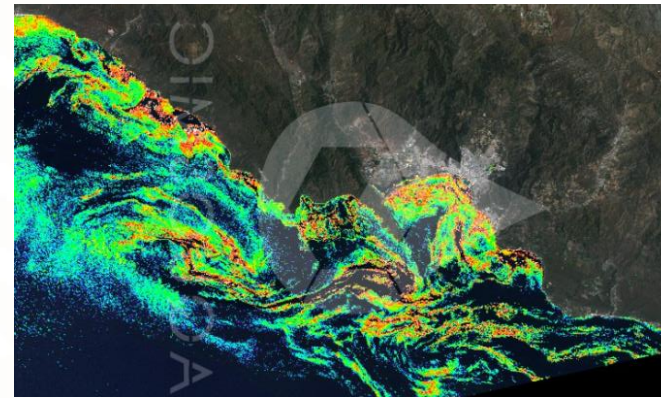
Agricultural equipment steering



9. Water monitoring

Images property of AQUOSMIC

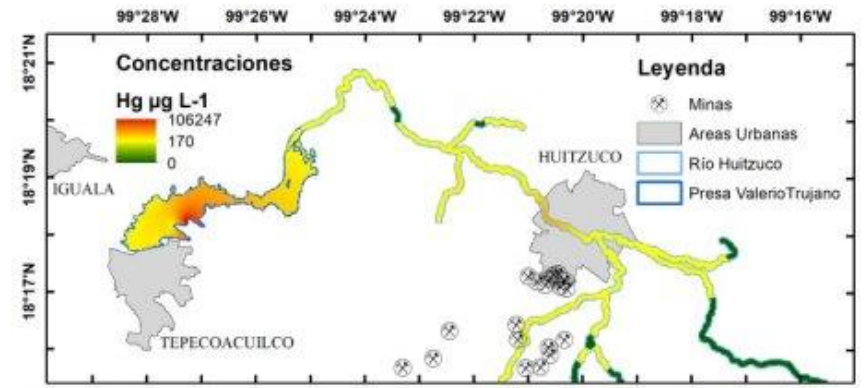
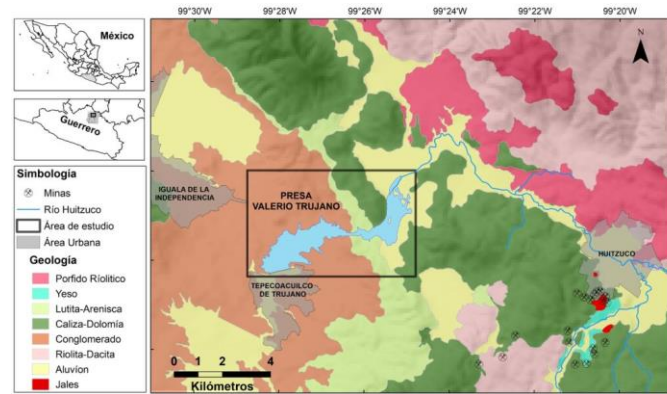
Harmful Algal Blooms



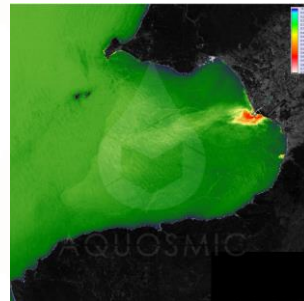
AQUOSMIC has the capability to measure a variety of parameters important for water quality verification, such as:

- Temperature
- Turbidity
- Chlorophyll-a
- Dissolved oxygen
- Dissolved organic matter
- Salinity
- Total nitrogen
- Total phosphorus
- Electrical conductivity
- Harmful Algal Blooms (HAB's)
- Heavy Metals (Mercury)*

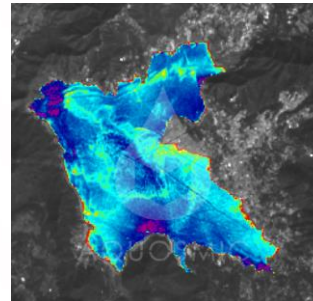
*Field tests are required to increase the list of metals and validate them.



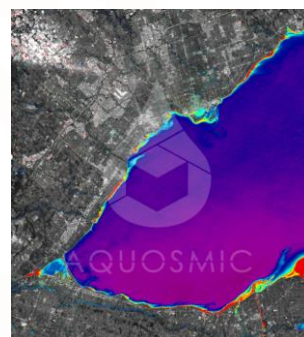
Dissolved matter



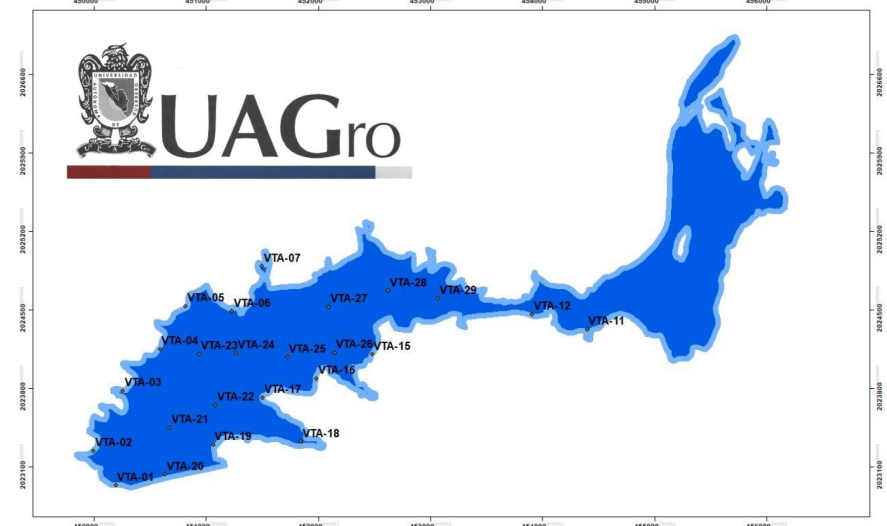
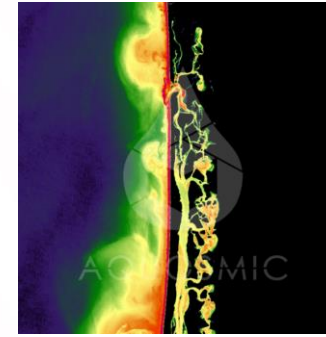
Total Nitrogen



Total Nitrogen



NDVI



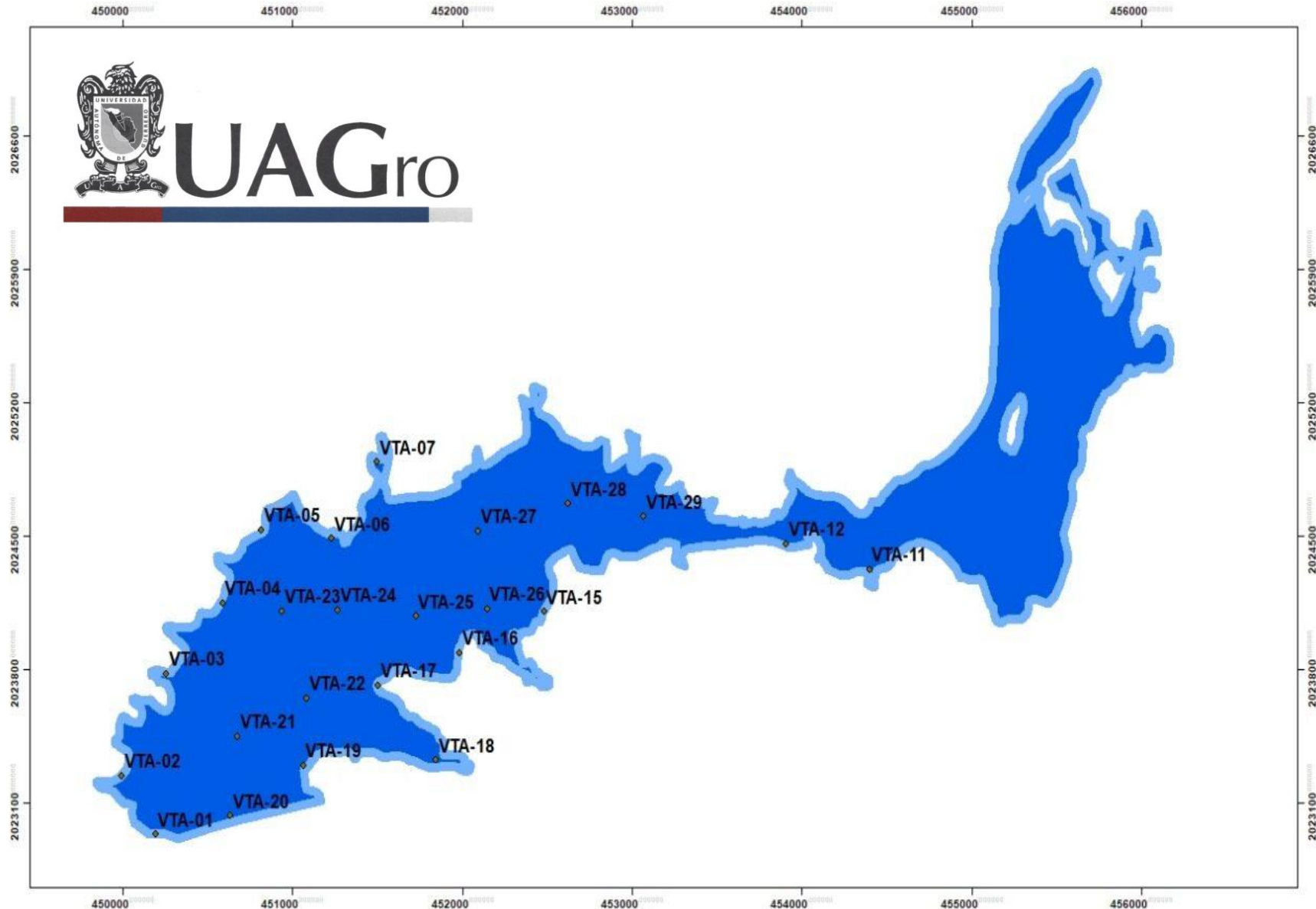
9. Water monitoring

GNSS for sensor stations positioning

Calibration of satellite images with parameters acquired on site once per year.

Spatial resolution: 1m-30m/px

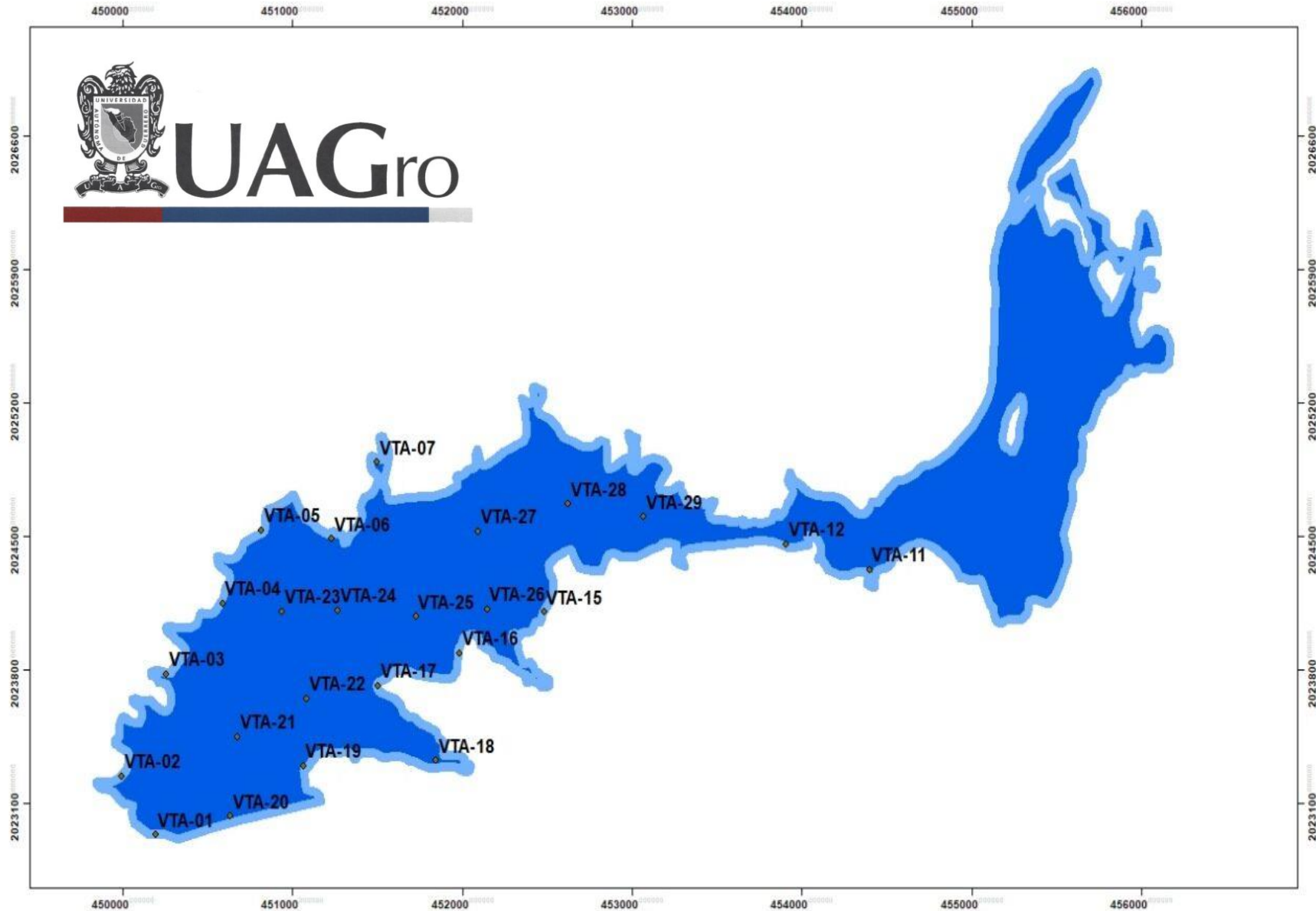
Accuracy of measurements: 96%



9. Water monitoring

Potential use in Mexico:

Water National Commission
5,000+ water bodies
25,000+ measurements/yr
50 M USD/yr



10. Stakeholders and institutions related



UNIVERSIDAD POLITÉCNICA DE MADRID



SENEAM
SERVICIOS A LA NAVEGACIÓN EN EL ESPACIO AÉREO MEXICANO



11. Latin American and Caribbean Space Agency (ALCE)



Ratified/Authorized

1. Antigua and Barbuda
2. Dominica
3. México
4. Nicaragua
5. Paraguay
6. St. Vincent and the Granadines
7. Saint Lucía
8. Venezuela



Ratified process

9. Argentina
10. Bolivia
11. Costa Rica
12. Cuba
13. Ecuador
14. Guatemala
15. Haiti
16. Honduras
17. Perú
18. Dominican Rep.
19. St. Kitts



Before Ratified process

20. Belize
21. Brasil
22. Chile
23. Colombia
24. El salvador
25. Uruguay

**Working groups for the stablishment of the ALCE agenda
Q4 2023 – Q1 2024**

Conclusions

- Mexico is a highly diverse country with a technology base centered on the aeronautics, manufacturing and software sectors.
- Its space field is a developing sector. It has no space infrastructure developments of its own.
- The Mexican Space Agency is relatively young, with low funding, but with a great capacity for linkage and coordination between actors of the triple helix and the Mexican government.
- A great synergy has been generated with the Galileo Information Center. The sectors with the greatest potential for GNSS applications are agriculture, transportation, aviation, geomatics, drones and emergency response.
- The approach to the use of GNSS systems should be focused on applications and services (downstream).
- One of the technological developments to be made in the field of aviation in Mexico is the adoption of an SBAS system.
- The Latin American and Caribbean Space Agency is potentially one of the great space catalysts in the region.

Conclusions

The Mexican Space Agency is open to collaborate and link with international governmental, academic and private actors focused on the development or use of GNSS applications and services.

AEM

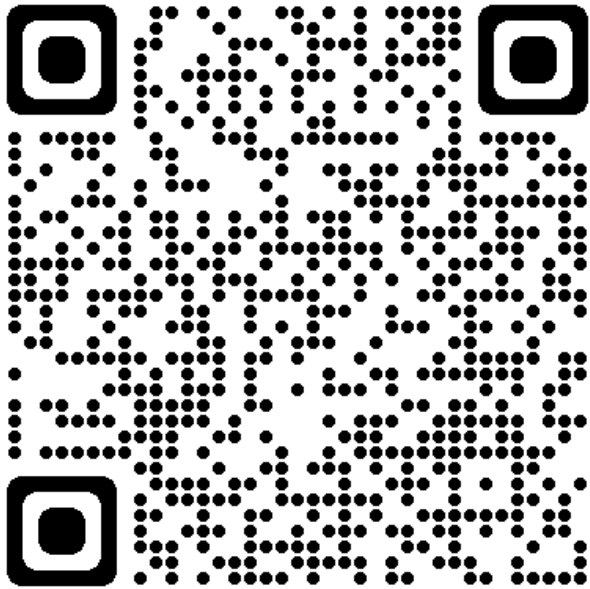
AGENCIA ESPACIAL
MEXICANA

Thank you

Antonio Serrano

Industrial Development and Promotion Manager

serrano.antonio@aem.gob.mx



 antonioserrano-as/



COMUNICACIONES
SECRETARÍA DE INFRAESTRUCTURA, COMUNICACIONES Y TRANSPORTES

AEM
AGENCIA ESPACIAL
MEXICANA

