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
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)
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- Agriculture
- Livestock
- Fishery
- Mining
- Oil production
- Manufacturing
- Water, electricity, gas

Railways:
26,000 km

Roads:
400,000 km

International Airports:
CAT 1 → 26
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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
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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)
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Software/Technologies Clusters:
38 (2,000 companies)

650 companies
40 countries
50,000 visitors
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
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Ministry of Infrastructure, Communications and Transport

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.
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1st Mexican satellite: 1985 (Telecommunications)

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Ministry of Infrastructure, Communications and Transport

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/cadastre (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

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National Commission for the Knowledge and Use of Biodiversity
3. Mexico background - GPS

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Archeological zones demarcation

INAH

Instituto Nacional de Antropología e Historia

Anthropology and History National Institute

Sayil, Yucatan
4. GNSS demand world map

<table>
<thead>
<tr>
<th>Region</th>
<th>Devices revenues (€ bn)</th>
<th>Services revenues (€ bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>European Union (EU27)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021 Value</td>
<td>12.1</td>
<td>27.4</td>
</tr>
<tr>
<td>2021 % Value</td>
<td>20.0</td>
<td>18.2</td>
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<tr>
<td>2031 Value</td>
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</tr>
<tr>
<td>2031 % Value</td>
<td>24.8</td>
<td>13.3</td>
</tr>
<tr>
<td><strong>Global</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021 Value</td>
<td>48.4</td>
<td>150.5</td>
</tr>
<tr>
<td>2021 % Value</td>
<td>87.0</td>
<td>405.2</td>
</tr>
<tr>
<td><strong>Russia &amp; Non-EU27 Europe (Non-EU27 Europe)</strong></td>
<td></td>
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</tr>
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<td>2021 Value</td>
<td>2.7</td>
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<td>2021 % Value</td>
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<td>4.9</td>
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<td>5.1</td>
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<td><strong>North America</strong></td>
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Source: EUSPA EO and GNSS Market Report 2022
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Source: EUSPA EO and GNSS Market Report 2022
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
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

Thales Alenia Space
Thrusters Unlimited
Orolia- Safran Space
ANERPV & Webmaps
SEMTECH
6. Aviation

Navigation Service to the Mexican Airspace (SENEAM)

Federal Civil Aviation Agency
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.
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
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

Proof of concept on precision farming

- Internet of Things
- Geographic Information Systems
- Satellite Communications
- Earth Observation
- Global Navigation Satellite Systems
- Industrial and Commercial Development
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

Proof of concept on precision farming

Global Navigation Satellite Systems

Earth Observation

Satellite Communications

Internet of things

Industrial and Commercial Development

Geographic Information Systems

AEM

ACENCIA ESPACIAL MEXICANA

eutelsat

Remote Monitoring System

IoT Base Station

GEO Ku Band

IP/DVB-S2 @1Mbps

[IP SIM Return Link 27.5GHz@10-10Mbps]

Monitoring system

IoT FIRST

Estación Terrestre Eutelsat USA (Raleigh, NC)

Gateway Sigfox

Gateway Sigfox

Analytics & Web Service

IoT Infrastructure Cloud

Bloques

1 2 3 4 5 6 7

Mobile App
9. Water monitoring

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.
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

AEM
AGENCIA ESPACIAL MEXICANA

GALILEO
NAVIGATION MADE IN EUROPE

TELESPAZIO
a LEONARDO and THALES company

UNIVERSIDAD POLITÉCNICA DE MADRID

UAGro

BÁJAAEROSPACE CLUSTER

GALILEO INFORMATION CENTRE
Mexico

POLÍTÉCNICA

CDA

INDEP

CHIHUAHUA'S AEROSPACE CLUSTER

AQUIOSMIC

GEO TECNOLOGIAS

THRUSTERS UNLIMITED
powered by GEOSAT

GLOBAL EARTH OBSERVATION SATELLITES

INAF

MÉXICO

CENTRO NACIONAL DE METROLOGÍA

MONTERREY AERocluster

SEMTECH

CONAGUI

COMISION NACIONAL DEL AG

AEROClÚSTER QUERÉTARO

OROMIA

SAFRAN

FEMIA

MEXICO

DE AVIACIÓN CIVIL

THALESALenia Space

SENEAM

SERVICIOS A LA NAVEGACIÓN EN EL ESPACIO AÉREO MEXICANO

37
11. Latin American and Caribbean Space Agency (ALCE)

Ratified/Authorized
1. Antigua and Barbuda
2. Dominica
3. México
4. Nicaragua
5. Paraguay
7. Saint Lucía
8. Venezuela

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

Ratified process
9. Argentina
10. Bolivia
11. Costa Rica
12. Cuba
13. Ecuador
14. Guatemala
15. Haití
16. Honduras
17. Perú
19. St. Kitts

Working groups for the establishment 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.
Thank you

Antonio Serrano
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