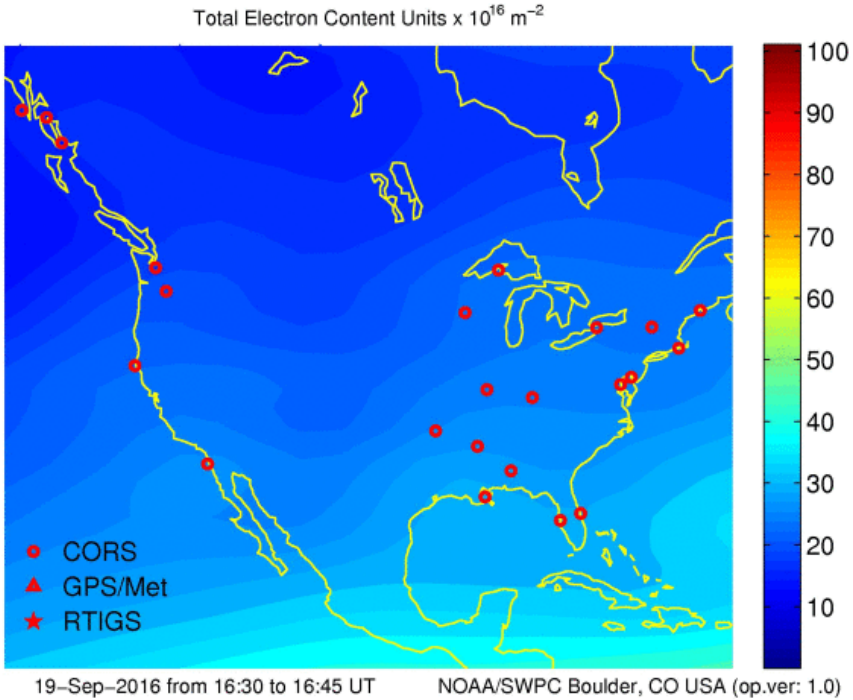
Development of a Ionospheric Electron Content and Weather Measurement System in a CubeSat nanosatellite mission

Background & Inspiration



TEC Maps Development

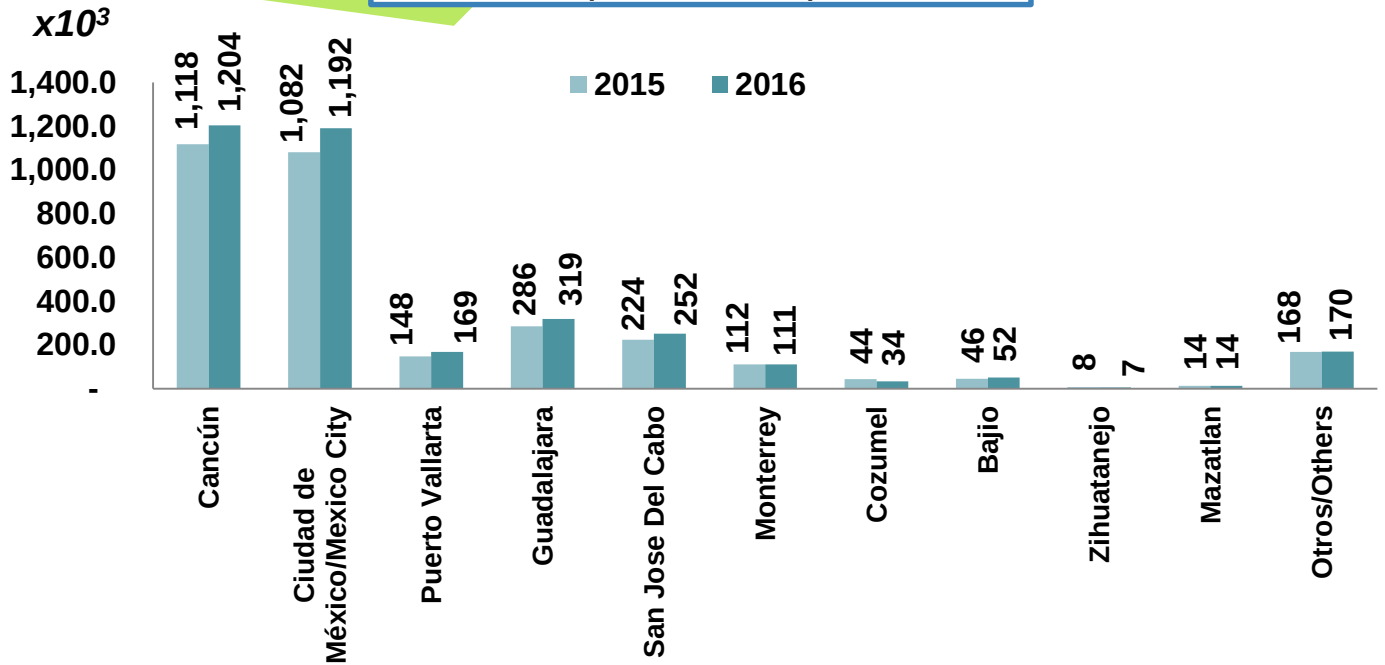
- **How do they work?**
- **Why are those important?**
- **How can we generate this data?**

Monthly Passenger Traffic

1,118,000
CANCUN

1,082,000
CDMX

Top ten airports by dometic air passenger traffic Jun 2015 vs Jun 2016/ Jun 2015 vs Jun 20166 (miles /thousand)

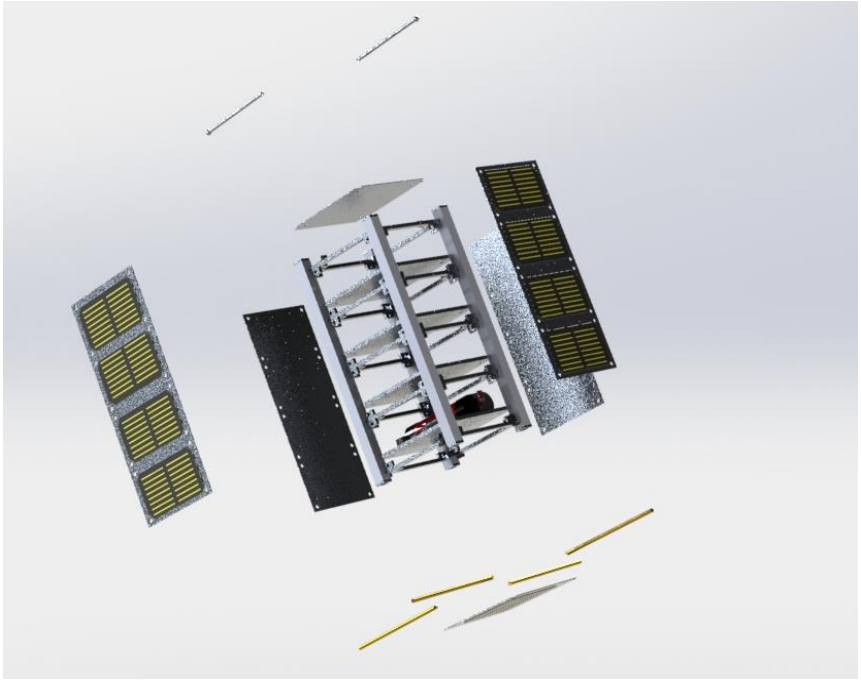


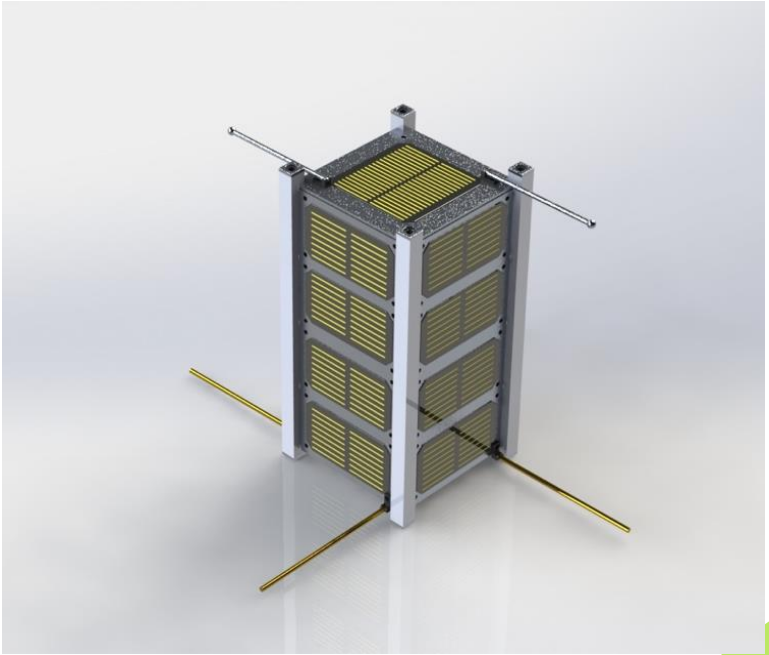
https://www.sct.gob.mx/transporte-y-medicina-preventiva/aeronautica-civil/5-estadisticas/55-estadistica-operacional-de-aeropuertos-airports-operational-statistics/

Objetives

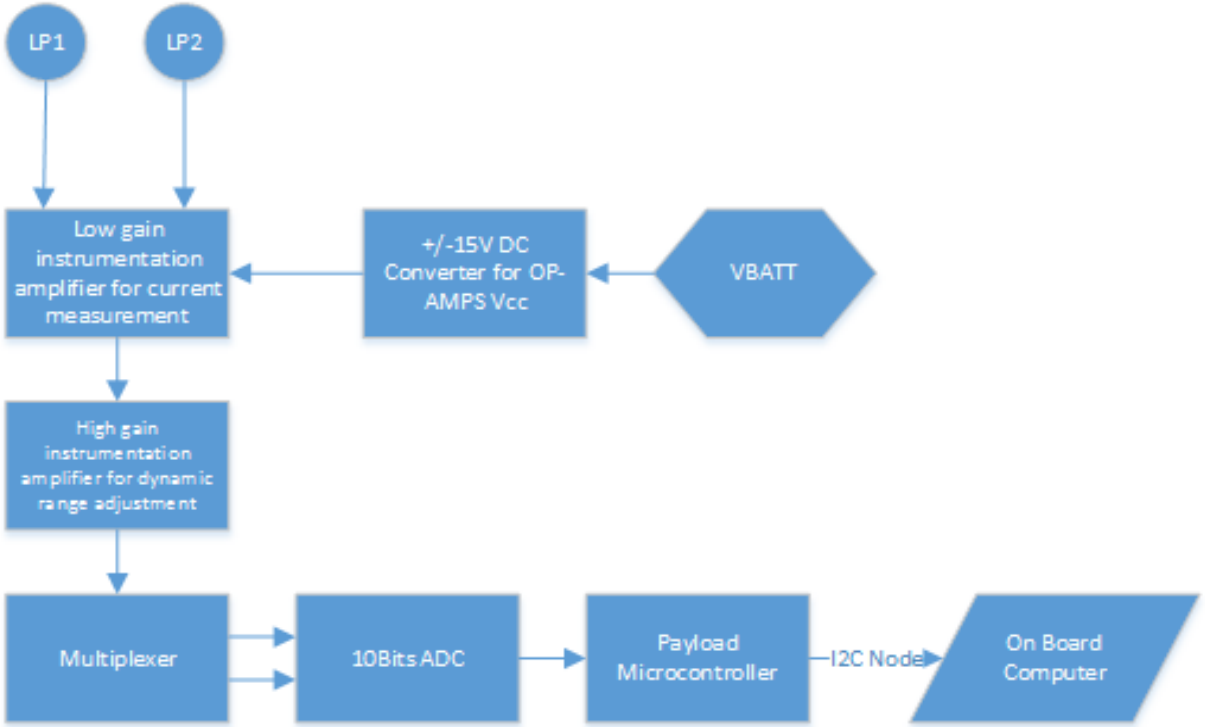
- Design of a CubeSat nanosatellite-based mission for the measurement and quantification of the Total Electron Content in a determined location of the ionosphere.
- Design of a proper array of ground stations enabled to receive and process the data obtained from the CubeSat measurements in order to generate regional TEC-Maps over Mexican territory.

CAD & Renders ION CubeSat





Proposed Block Diagram for Payload



Power & Mass Budget

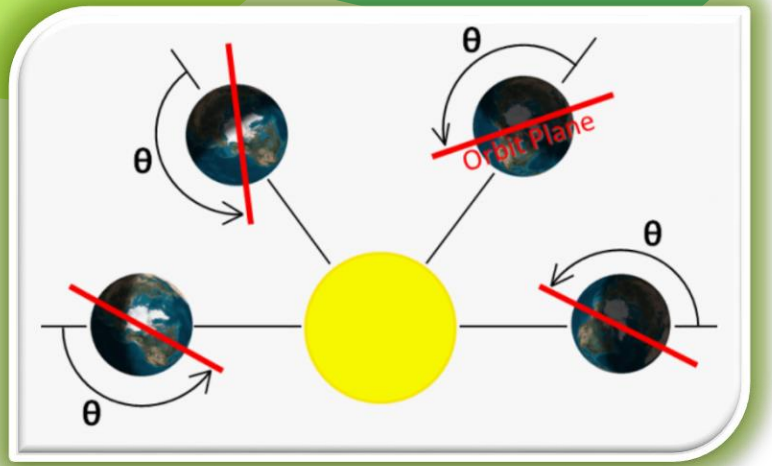
Subsystem	Mass Budget		Power Budget	
OnBoard CPU (C&DH)	70	g	0,2	W
Telemetry	75	g	4	W
Payload	150	g	1	W
EPS	176	g	0,15	W
ADCS	506	g	1	W
Antenna	100	g	2	W
Batteries	276	g	0	
Solar panels		g	0	W
Structure	454		0	
Total mass:	**1807**	**g**	0	
Total power:			**8,35**	**W**

Link Budget

Link budget payload	
Maximum payload frame size (bits):	40
Data rate dowlink of communication radio (bps):	115200
Time to download 1 Payload frame (in seconds):	0,0003472222222
Telemetry link budget (bits)	
EPS	170
C&DH	20
ADCS	60
Thermal	30
Total telemetry budget (bits):	280
Time to download 1 frame of telemetry (in seconds):	0,002430555556
TOTAL ime to donwload 1 Payload frame + telemetry frame (in seconds):	0,002777777778

Sun Syncronous Orbit

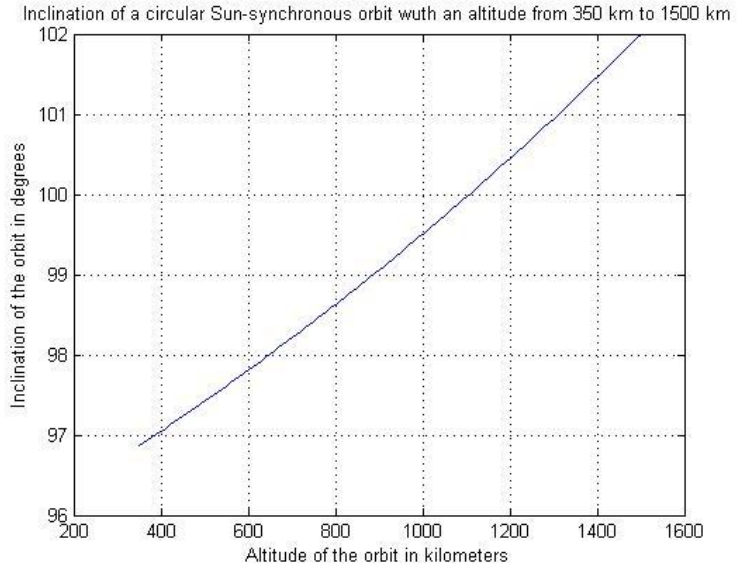
Orbits per day	Period (hrs)	Height above Earth's surface (km)	Maximum latitude
16	$1\frac{1}{2}$ = 1 hr 30 min	282	83.4°
15	$1\frac{3}{5}$ = 1 hr 36 min	574	82.3°
14	$1\frac{5}{7}$ ≈ 1 hr 43 min	901	81.0°
13	$1\frac{11}{13}$ ≈ 1 hr 51 min	1269	79.3°
12	2	1688	77.0°
11	$2\frac{2}{11}$ ≈ 2 hrs 11 min	2169	74.0°
10	$2\frac{2}{5}$ = 2 hrs 24 min	2730	69.9°
9	$2\frac{2}{3}$ = 2 hrs 40 min	3392	64.0°
8	3	4189	54.7°
7	$3\frac{3}{7}$ ≈ 3 hrs 26 min	5172	37.9°



Sun Syncronous Orbit

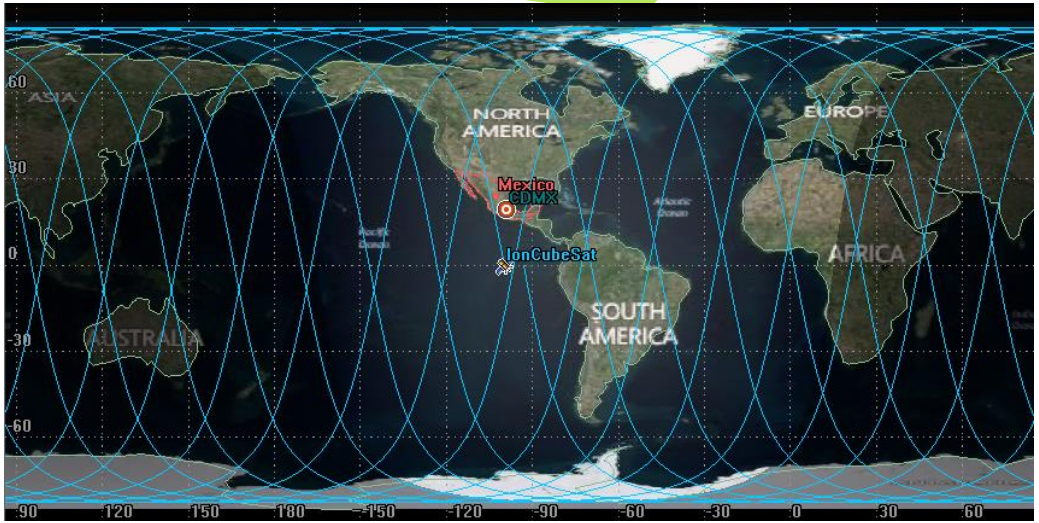
$$i = \frac{180 \arccos\left(-\frac{2\rho(R+h/\mu)^{\frac{7}{2}}}{3R^2 J_2}\right)}{\pi}$$

Orbit Description	
Semimayor axis	6852.2 km
Eccentricity	0 deg
Argument of perigee	0 deg
Inclination	97.3704 deg
RAAN	136.237 deg
Mean anomaly	0 deg
Perigee	6852.2 km
Apogee	6852.2 km
Period	1.31.50 h-m-s
Altitude	300 Km
Revs per day	15.886

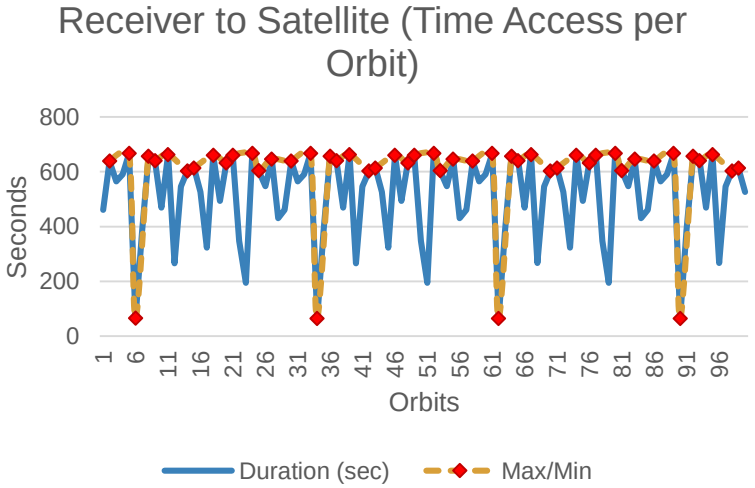


SSO Inclination for altitudes since 350 Km to 1500 Km

Orbit description



Sun-Synchronous Orbits per day



Proposed Ground Stations

Ground Station	Lattitude N	Longitude W
Ensenada	31°48'21.6"	116°35'24.4"
Sinaloa	24°47'19.0"	107°23'48.3"
Nuevo León	25°39'52.7"	100°14'40.1"
Chihuahua	28°39'18.8"	106°05'25.0"
Zacatecas	22°46'29.2"	102°37'33.7"
Puebla	19°02'53.3"	98°13'07.6"
Chiapas	16°45'25.4"	93°10'20.7"
Yucatan	21°00'43.6"	89°37'24.0"

Proposed Schedule

Phase	2017	2018	2019	2020	2021	2022
Funding						
Design, development, integration and testing						
Launching						
Operations of the mission, scientific data analysis and modeling						
Disposal.						

Launch Options

Possible Launching Commercial Carriers for the proposed mission, according to orbit's designed specifications:

- ULA Atlas V.
- Orbital STK Antares.
- Athena (Lockeed Martin).
- ISC Kosmotras (Rusia).
- Antrix PSL V (India).
- ESA Vega.

Booking: www.launchportal.org

Possible Risks

- **Funding.**
- **Delay of delivery parts from vendors.**
- **Success of mission operation in space.**
- **Regulations of small satellites.**
- **Launching opportunity lost.**

Conclusions

Development of multidisciplinary work
One of first developmentos of nanosats in Mexico
Mission succes criteria
Integration vs full development

Work Distribution

Name	Priority	Person in charge	Deadline
Objetives and Requirements	**A**	All	*8/7/2016*
Mission parameters and Orbit	**A**	Antonio	*8/7/2016*
Payload	**A**	Walter	*8/7/2016*
Ground Station (GS)	**A**	Antonio	*8/12/2016*
Budgets	**A**	All	*8/12/2016*
Electrical Power Subsystem (EPS)	**B**	Walter	*8/26/2016*
On Board Computer (OBC)	**A**	Antonio	*8/19/2016*
Telemetry and Commands (T&C)	**A**	Walter / Antonio	*8/12/2016*
Attitude Determination and Control Subsystem (ADCS)	**A**	Antonio	*8/19/2016*
Thermal Control (TC)	**C**	Carlos	*8/19/2016*
Structure	**C**	Carlos	*8/7/2016*

Carlos Leal

Mechatronics Engineering

UAM – Azcapotzalco

- ***Mechanical Design & Thermal Analysis***

Antonio Carmona

Communications and Electronics Engineering

ESIME - IPN

- ***Orbital Dynamics & Control Systems***

Walter Calles

Communications and Electronics Engineering

ESIME - IPN

- ***Payload Design & Electronic Systems***

¡Thanks for your attention!

ION CUBE SAT

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