Title: South American Seismic Sensing Constellation

Primary Point of Contact & Email: Sánchez Olivera Francisco Javier (javiersanchez1204@gmail.com)
Co-authors: Benítez Vargas Osvaldo, López Sánchez Sebastián and Ramírez Alcántara Moisés
Organization: Instituto Politécnico Nacional (MEX)

(X) We apply for Student Prize.

(X) Please keep our idea confidential if we are not selected as finalist/semi-finalist.

- Sustainable cities and communities

Need

The region of Central and South America is a region with high seismic activity, in the last decade there have been strong earthquakes leaving thousands of death people. That is why it is significant to have an effective and fast warning system that allows people to be prepared for these natural disasters.

The current situation in earthquake space research indicates a phenomenon related with earthquakes: Thermal radiation emissivity of Earth's surface. There are numerous observations of surface and near surface temperature growth during an Earth's crust earthquakes due to a process of energy transformation.

While conventional seismographs depend on the transmission of the movement through the ground, the possibility of measuring the thermal infrared radiances (TIR) from Earth's surface via satellite could serve as a more efficient and faster way to detect this event and save thousands of lives.

Mission Objectives

1. Design, build and launch a constellation of CubeSats.
2. Cover the Central & South America region with a constellation of CubeSats that can warn of seismic activity (two ground stations: ERIS (Mexico) and Santiago Station AGO (Chile)).
3. Cover the desired regions 24h per day using the least amount of CubeSats possible.
4. CubeSat standards.
5. The construction of each CubeSat must be under $200,000.

Concepts of Operation

Mission concept:

1. The system is launched in a rocket to reach the orbit of operation.
2. When the space vehicle reaches the desired altitude, the CubeSat is launched to the target orbit.
3. When the system stabilizes it deploys the Seismic Sensing System.
4. The CubeSat fulfils its life cycle and reaches its end of operation.
5. The CubeSat re-enters the Earth

Modes of operation

- **OFF:** All subsystems off
- **Stand by:** If the CubeSat doesn't receive commands to activate the Seismic Sensing System
- **Observation:** When the CubeSat receive the commands the Seismic Sensing System receives
- **Data transmission**
- **Safe:** If an error occurs during the operation of CubeSat

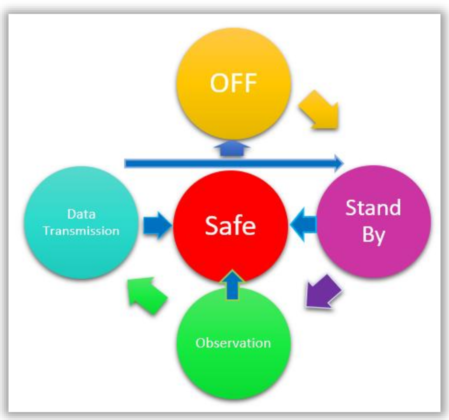

Illustration 1. - Mode Operation Diagram

Orbit Operation:

1. Immediately after leaving the space vehicle the CubeSat stabilizes passively.
2. The CubeSat initiates its active stabilizing system so that it is oriented towards the desired direction during operation mode.
3. When the CubeSat is not in the operation mode it collects energy and stores it in the batteries to be operated when the sun is not charging the solar panels.
4. During the standby mode the CubeSat will be oriented so that the aerodynamic drag is minimum.

Key performance parameters

- Microwave radiometers of high precision.
- Spectral emissivity, which strongly influences TIR signal, takes values within 0.9 and 0.98 over land, mainly depending on soil cover and humidity.
- Spectral transmittance depends mainly on atmospheric temperature and humidity.
- Temporal variations of surface temperature are related to regular daily and sun cycles.
- Variation in observational conditions related mainly to differences in satellite zenithal angles.
- A perfect image-to-image co-location is impossible (due to change in the size of each ground resolution consequent to the change of the satellite angle view).

Space segment description

The constellation is formed by 10 satellite systems that consist on a 2U CubeSat. These CubeSats have multiple subsystems: power, communication, payload, structure and stabilizing systems.

The components are listed in the next table: Table 1. - Mass budget, volume and cost

Component	Volume (cm3)	Mass (kg)	Cost ($)
Communication			
On Board Computer	107.1	0.094	8,525
Antenna	67.2	0.085	5,834
Transmitter	129.6	0.085	7,778
Power			Bundle: 9,764
Battery	181.6	0.27	-
Solar cells (12 units)	106.85	0.324	-
Power card	126.9	0.1	-
Stabilizing			Bundle: 9,577
Magnetorquer	146.89003	0.196	-
Gyroscope	31.02	0.025	-
Structures	2270	0.206	3,481
Payload (Argus 1000)	180	0.23	47,115
Total	-	1.615 kg	92,074

Power Budget: Table 2. – Power budget during different operation modes

Component	Stand By (W)	Transmission (W)	Observation (W)
AOCS	1.2	1.2	1.2
OBC	0.2	0.2	0.5
Antenna	0.05	0.05	0.05
Transmitter	0.2	1.7	0.2
Payload	1.3	1.3	1.3
Power Card	0.15	0.15	0.15
Total	3.1	4.6	3.4

The solar panels can provide a total of 4.6 watts for a 2u configuration.

CAD

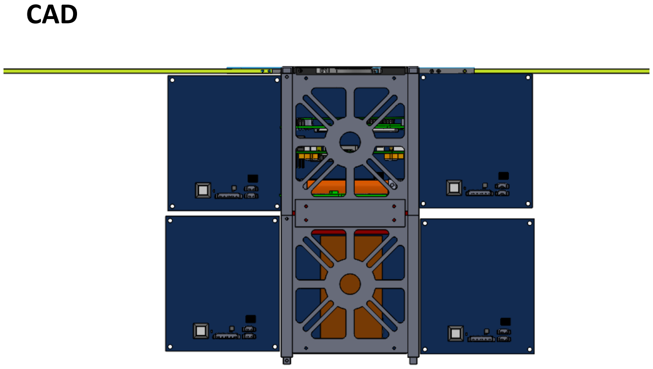

Illustration 2. - Front View of the CubeSat

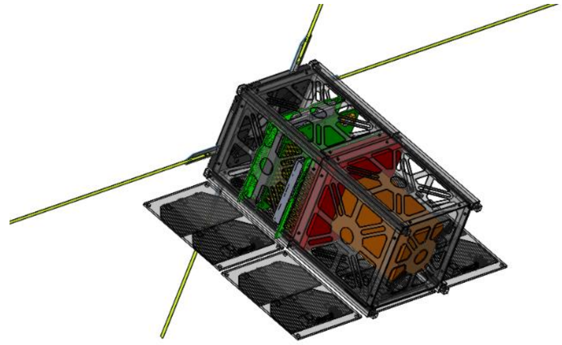

Illustration 3. - Isometric View of the CubeSat

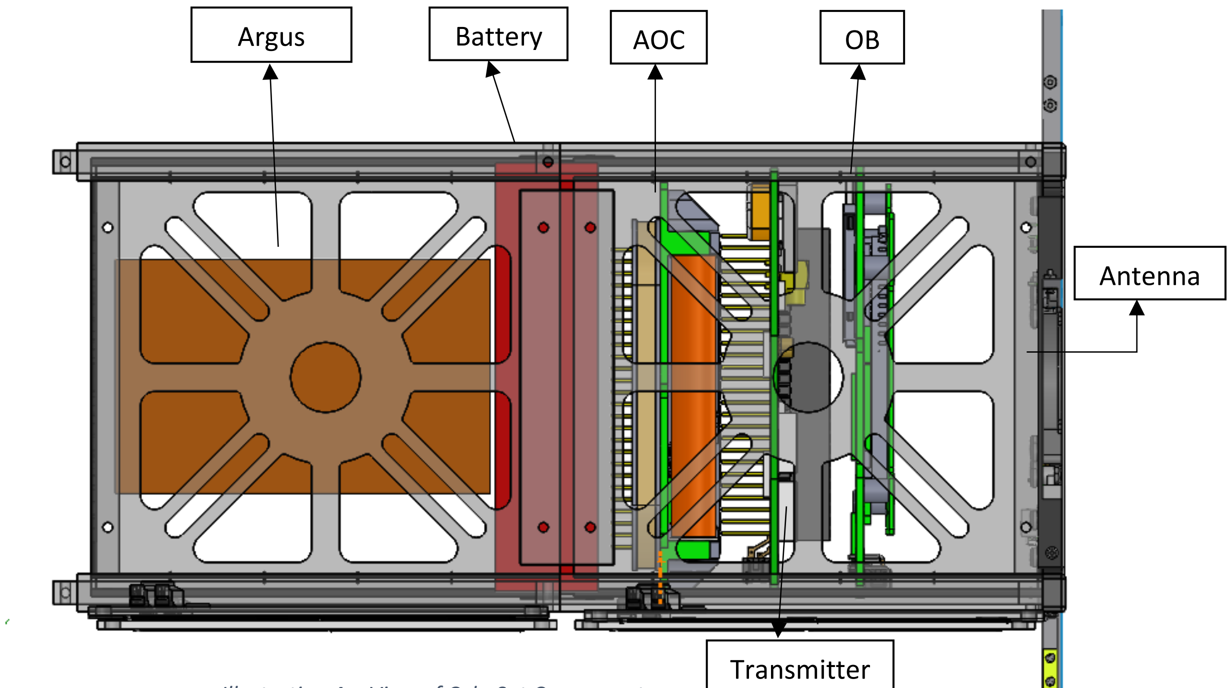

Illustration 4. - View of CubeSat Components

Orbit/Constellation description

- For the constellation design we chose a LEO orbit, to have a precise lecture of the radiation.
- Inclination 70.04
- RAAN: 119.75
- Altitude: 900 km

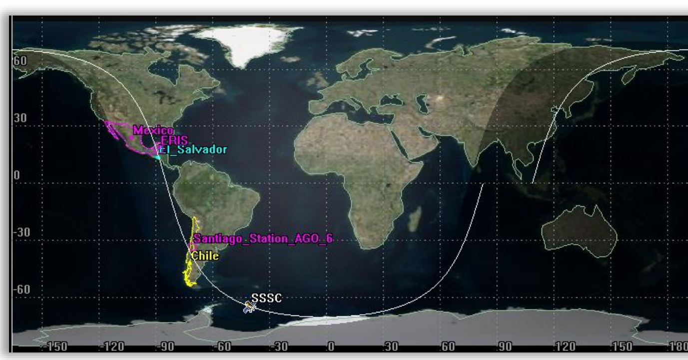

Illustration 5. - 2D CubeSat Orbit

Access time*:*

To ERIS: Total duration 4535 sec = 1.26 hours

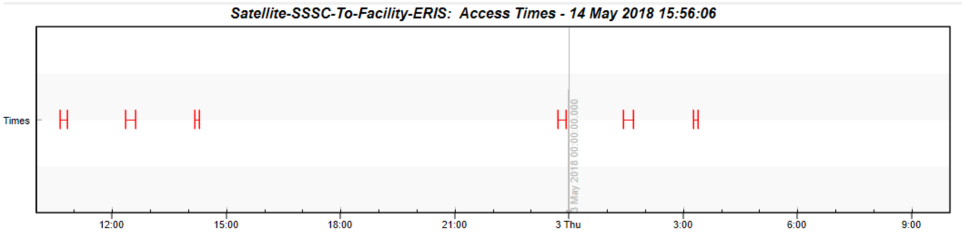

Illustration 6. - One Day Access Time between CubeSat and ERIS Ground Station

To Santiago Station: Total duration 4919 sec = 1.36 hours

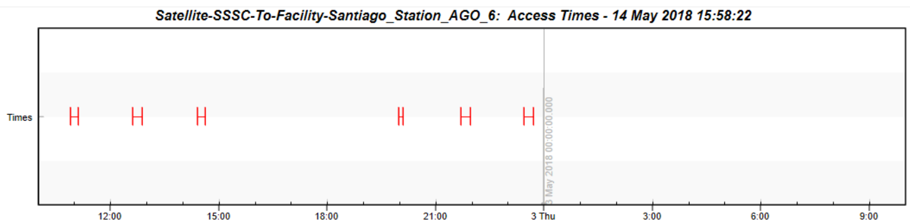

Illustration 7. - One Day Access Time between CubeSat and Santiago_AGO_6 Ground Station

If we want to have connection all the time to at least one ground station, the CubeSat constellation must consist on 10 CubeSat units.

- Period 6133 sec
- Orbital speed 7.23 km/s

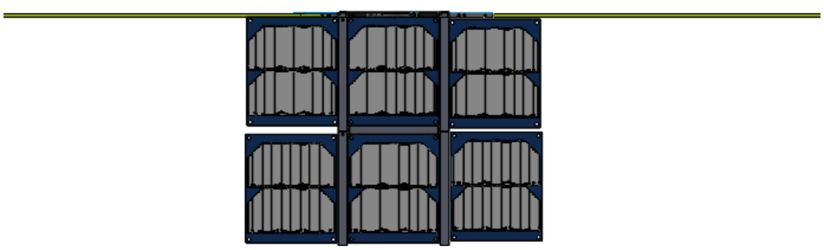

Illustration 8. - Back View of the CubeSat

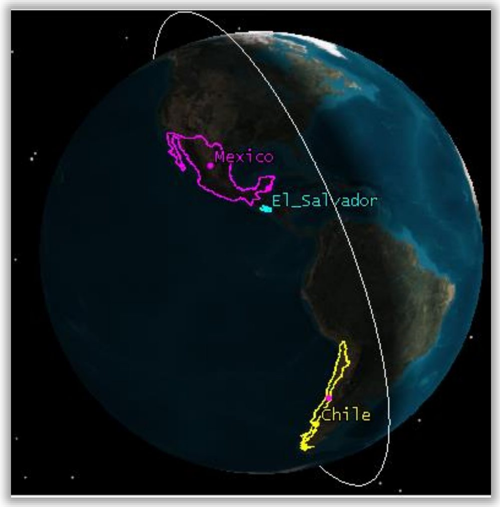

Illustration 9. – 3D CubeSat Orbit

Implementation plan

The implementation of this project consists on several future steps including a deeper development of the design of the CubeSat, funding of the project, testing the final product and launching the CubeSat to the operation orbit.

- The Future development of the design consists in a more profound study of the production of each subsystem, it would include the study of manufacturing and refining processes of the structures, stablishing the interfaces for each subsystem, thermal studies of operational system and software development.
- The funding of the project could be realized as an international effort with the cooperation of several South American and Central American countries, such as Mexico, Chile, El Salvador, interested in the services provided by the constellation of CubeSats.
- The testing of the CubeSat would consist on several tests on separate components to guarantee technical data obtained up to this moments form datasheets. Other than these basic tests overrun in an equipped lab there are three tests requested by every launching agency. These three tests are:

- **Day in The Life (DITL) Testing,** an overall system test which goal is to see if the electronics and fly software are working properly.
- **Dynamic Environment Testing (Vibration/Shock),** this test seeks to put the CubeSat in dynamic environment, similar to the one in the rocket. If the CubeSat can endure the strength of the vibration and shock experienced during the tests it can easily endure the launch.
- **Thermal Vacuum Bakeout Testing**, in this test the CubeSat is heated to prescribed temperatures while in a high-vacuum environment. This bakeout is required on almost all missions, primarily to allow the CubeSat's materials to outgas any possible contaminants before the actual launch.

- For the launch there are two options, the first one is to pay a third party launching company like Space X or Rocket Lab to put the system in orbit. The disadvantage with this option is that it is very expensive, and the first sponsors would have to pay for these expenses two.

  The second option is to apply for NASA's CSLI (CubeSat Launch Initiative) which covers for the costs of launch (up to $300,000), which makes the launch of the project more affordable.

Implementation plan	Start Date	End Date	Duration
Design Phase	**02/18/18**	**09/28/18**	**161d**
Preliminary satellite mission design (PDR)	02/18/18	05/17/18	65d
Detailed satellite mission design (CDR)	05/18/18	09/28/18	96d
Development Phase	**10/01/18**	**03/29/19**	**130d**
Systems sizing and design	10/01/18	11/01/18	24d
Manufacture custom components	11/05/18	03/29/19	105d
Procure COTS components	11/01/18	12/03/18	23d
Ground segment subsystems	11/01/18	01/31/19	66d
Integration ans Assembly	**04/01/19**	**05/31/19**	**45d**
Satellite systems integration	04/01/19	04/30/19	22d
Ground systems integration	04/01/19	05/31/19	45d
Testing	06/03/19	11/29/19	130d
Satellite validation	06/03/19	07/01/19	21d
Satellite verification	07/01/19	08/01/19	24d
Complete systems testing	08/05/19	11/29/19	85d
Launch	12/23/19	12/23/19	1d

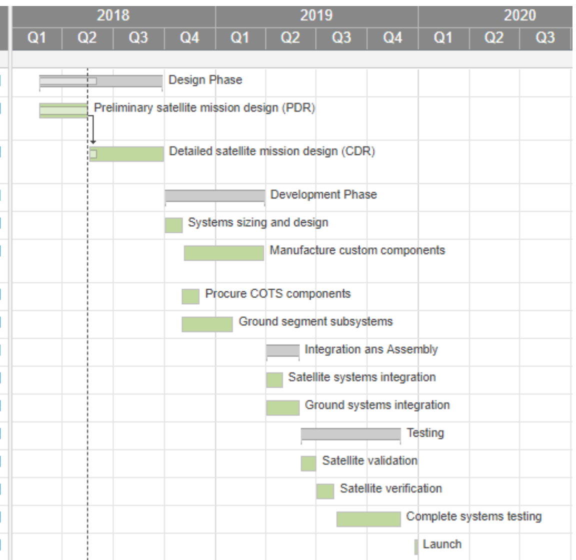

Illustration 10. - Gantt Chart

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