The SUCHAI missions: scientific and technology motivations

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Chilean Space Timeline

1959: NASA CEE
1995: FASAT-Alfa
1998: FASAT-Bravo
2008: FASAT-Charlie (SSOT)
2017: SUCHAI I
SPEL
Space and Planetary Exploration Laboratory

- PI: Prof. Marcos Díaz
- Undergrads: 6
- Grads: 10
- Engineers: 5
SUCHAI Nanosatellite
SUCHAI CubeSat
First chilean made nano satellite. It is a 1U CubeSat for education and space physics research.
Objectives
Create novel knowledge and technology for the country and humanity

Education
Development of human capital

Science
Scientific experiments in space environment

Technology
Integration and development of space technology in Chile
SUCHAI CubeSat
First chilean made nano satellite. It is a 1U CubeSat for education and space physics research.
Timeline

2009
Conception

2011
Development starts
Team is found

2013
Tests in INPE, April 2014
Construction finishes

2015
Integration in Delft
Leaving Chile

2017
Launch
SUCHAI components
SUCHAI Preliminary Results
SUCHAI-1: In operation until now

Monitoring the South Atlantic Anomaly.- Semiconductor based particle counter. More than a year of monitoring.

Monitoring state of health of components, in particular the battery.

Studying that using simple attitude estimation, Langmuir probe measurement can be improved.
Flight Software

Flight software validation helps to reduce mission risks. Key component for mission functionalities, fault tolerance and payloads integration.

Open Source project
www.github.com/spel-uchile/SUCHAI-Flight-Software
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Space program
**SUCHAI 2 & 3**

New generation of satellites for scientific purposes. They are two 3U CubeSats. Expected to be ready for mid 2019.

**Ideal Orbit:** SSO (Polar Orbit close to 500Km). Ideally they will be launched together.

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2 CubeSats: One will travel with comm. leaves pointing Earth and the other one with leaves pointing backward. Thus, separation is accelerated.
**SUCHAI 2 & 3**

**Phased Array**

Phased patch antenna arrays at 2.4 GHz (with deployed leaves), at 4 GHz and 18 GHz (in CubeSat faces) allow fast electronic steerable beams. It simplifies the pointing of the satellite for communication (inter-satellite or with ground), but also allows location and orientation in swarm formation and for estimation of the environment with changes in the link.

Deployment system of the 2.4 GHz phased array (long leaves). They are being constructed with 3D tools in Windform.

Phased patch antennas array at 1.9 GHz prototype for radio-vision ([http://repositorio.uchile.cl/handle/2250/145837](http://repositorio.uchile.cl/handle/2250/145837)) We are adapting this solution to fit CubeSats (increasing frequency, using digital phase shifters and optimizing the number of phase shifters). Software Define Radios are used to add flexibility to the system ([http://repositorio.uchile.cl/handle/2250/141321](http://repositorio.uchile.cl/handle/2250/141321)).
SUCHAI 2 & 3

Close to the equator with 3 microwave links between satellites, we can make estimations of electron density and magnetic field:

Microwave links are composed by phased array to facilitate pointing.

Phase difference between 4 GHz and 18 GHz - electron density can be estimated.

Polarization change (Faraday’s rotation) at 4 GHz – magnetic field estimation.
**SUCHAI 2 & 3**

Close to the south pole with 3 microwave links between a satellite and a balloon platform, we can make estimations of electron density and magnetic field:

Same frequencies than that used between satellites (2.4 GHz, 4 GHz and 18 GHz) This can also demonstrate a communication system over Antarctica.

In the South Pole there are ring winds that might allow rotation over Antarctica.
SUCHAI 2 & 3 and SAMBA

The Ionospheric and Magnetospheric measurements of SUCHAI-2 and SUCHAI-3 will be combined with ground data, in particular with magnetic measurement of SAMBA magnetometer network deployed along Chile (Blue dots are the location of the magnetometers).

For instance, the measurement at different altitudes can be used to study field line resonance.
Some lessons

- A versioned agile approach, going from simple to more complex versions, was useful to deal with uncertainty both in deadlines and budget.
- Flight software is a key component:
  - Adds flexibility
  - Enables team collaboration
  - Key for fault tolerance
- Use the restrictions and limitations as research drivers.
- Communications systems are key to enhance CubeSat missions. Geography of Chile is useful in the ground segment.
  - More data downloaded, better science
  - Constellation
  - Deep space missions
Some lessons
(not so technical)

- Cubesat democratized the access to space (we started from scratch - cost of USD 300k including Labs)
- Cooperation is key to success
  - Specially HAM radio community.
- Failures are difficult to avoid, use them as a learning process (attention to them avoid mistakes repetition).
- There’s no better way to train engineers than a hands on project
- Always think your project as a program.
- We are conscious that space is a global resource therefore we have to be careful about using it.
Final Idea:
Collaboration among the existing Latin-American projects to have a constellation?

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