THE SUCHAI EXPERIENCE IN CHILE: TRANSITING FROM UNIVERSITY PROJECTS TO A CIVIL SPACE PROGRAM

SPEL Space and Planetary Exploration Laboratory

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INTRODUCTION

The Satellite of the University of Chile for Aerospace Investigation (SUCHAI) was a seed project developed and funded by the Faculty of Physical and Mathematical Sciences at Universidad de Chile. It was part of a strategy to evaluate the possibility of developing a university space program by transferring the engineering capabilities developed for the astronomy subject in Chile and the new trend of standardized nano-satellites or Cubesats.

SUCHAI-1, a 1U Cubesat, was launched in June 2017 from India in a PSLV rocket. It was operated until early 2019. The main goal of this project was to probe the ionosphere specially the South Atlantic Magnetic Anomaly (SAMA), and evaluate the impact that ionospheric activity there has in components and subsystems. Cubesats usually uses modern electronic with limited flight heritage. To know how systems reacts to the space environment is key not only to have more robust nanosatellites, but also to estimate with precision the state of health and coordinate a proper satellite decommission.

SUCHAI-1 motivated the creation of the Space and Planetary Exploration Laboratory (SPEL) at University of Chile. The strategic vision of the laboratory is to become a world player in space research taking advantage of the country location and the priorities research areas in the country, such as: astronomy, geophysics, computer sciences, transportation, math, computer sciences, agronomy, neurosciences, renewable energies, and mining robotics. For instance, space situational awareness (SSA), requires information of in-situ points in space but also from ground. Knowledge and technology related to astronomy, computer science, transportation and space physics present in the country can be coordinated to study and support SSA. In addition, the space exploration might require the creation of sustainable ecosystems, where agronomy, mining robotics, renewable energies and even neurosciences could support this by taking advantages also of hard environments in Chile such as the Atacama Desert and the Peru-Chile trench. Another case is communications. Chile not only has austral areas that facilitate RF and microwave communications, but also the clearest skies for optical communications. However, multiple objects, optical communication might affect the astronomy activity in the country. We need to study the impact and propose possible solutions or coordination. With this strategic view for the laboratory the new projects were proposed.

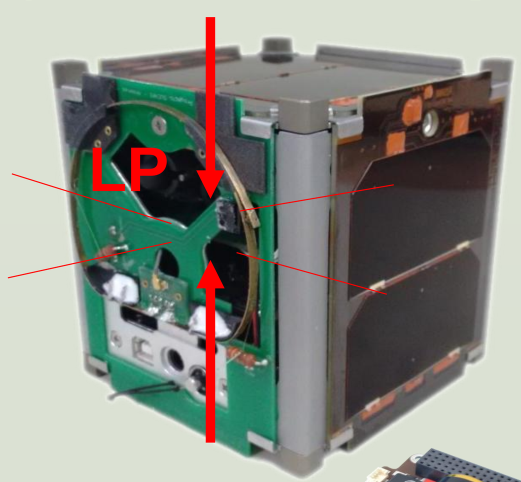
The SUCHAI-2 and SUCHAI-3 projects, two 3U Cubestas, funded by the scientific research agency of Chile, Conicyt, continues the research started by SUCHI-1. SAMA is the region of the planet where most of the low earth orbit satellites suffers of some type of malfunction. This magnetic anomaly is located in great part over south America including Chile. Combining space and ground measurements of these region can be done from south America and in particular from Chile. However, to study the dynamics of SAMA, simultaneous multiple points measurements, including different altitudes, have to be performed. Thanks to Cubesats technology it can be done by constellations of them or smaller sensor crafts carried to space and deployed by these Cubesats.

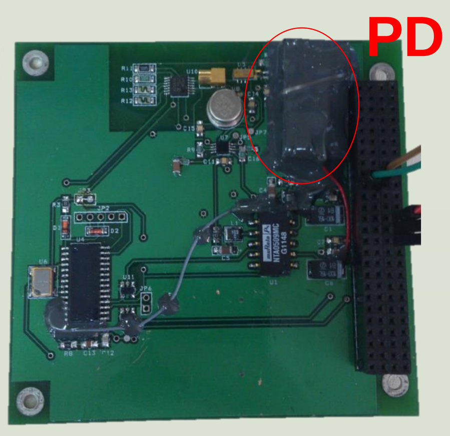
In collaboration with international partners we have embarked in a fourth mission to study the possibility of maintaining autonomously a tillandsia plant in a 3U Cubesat. Tillandsia as aerophytes does not need soil to grow, which makes it a great candidate to generate ecosystems in space and in this manner create oxygen through a natural process. Tillandsia landbeckii, endemic from Atacama Desert, and Tillandsia ionantha, from North America, are the candidates to be in the PlantSat.

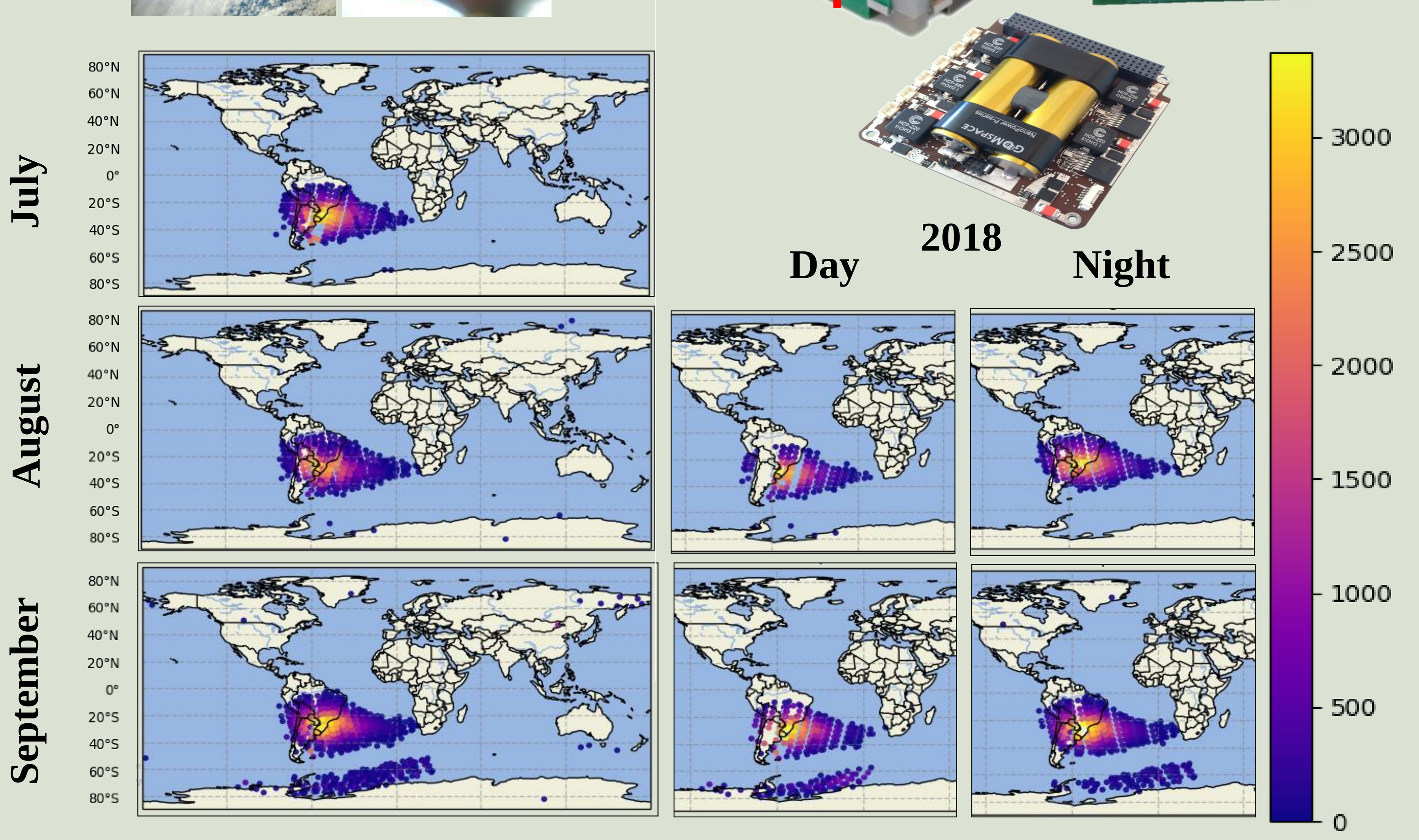
We also present our efforts to engage the national and international community to support a long term civil research oriented program in Chile that collaborate actively in the endeavor of a sustainable space for all.

MOTIVATION

The nano-satellite are democratizing space but we need to responsible to have a sustainable development of space. Our goal is to study the South Atlantic Anomaly [1] and the south pole activity, where LEO satellites are more likely to fail due to high particle radiation. Latin-America is under these regions. Thus, we are developing infrastructure (space- and ground-based) to provide information about these regions and the impact in the state of health of components and systems. This might support when deorbiting the satellites. The seed project was the SUCHAI-1 [2].

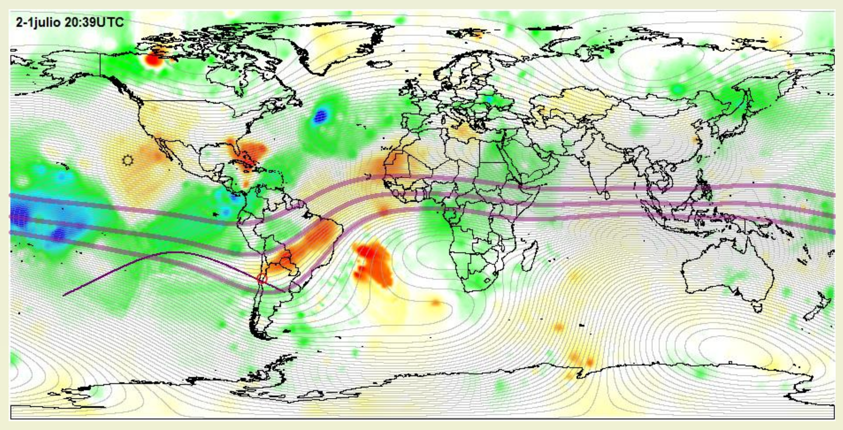


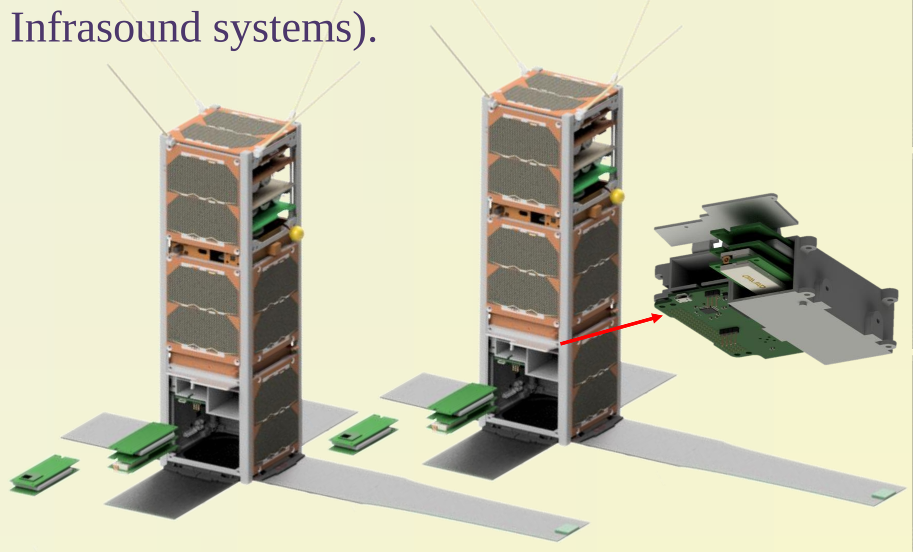


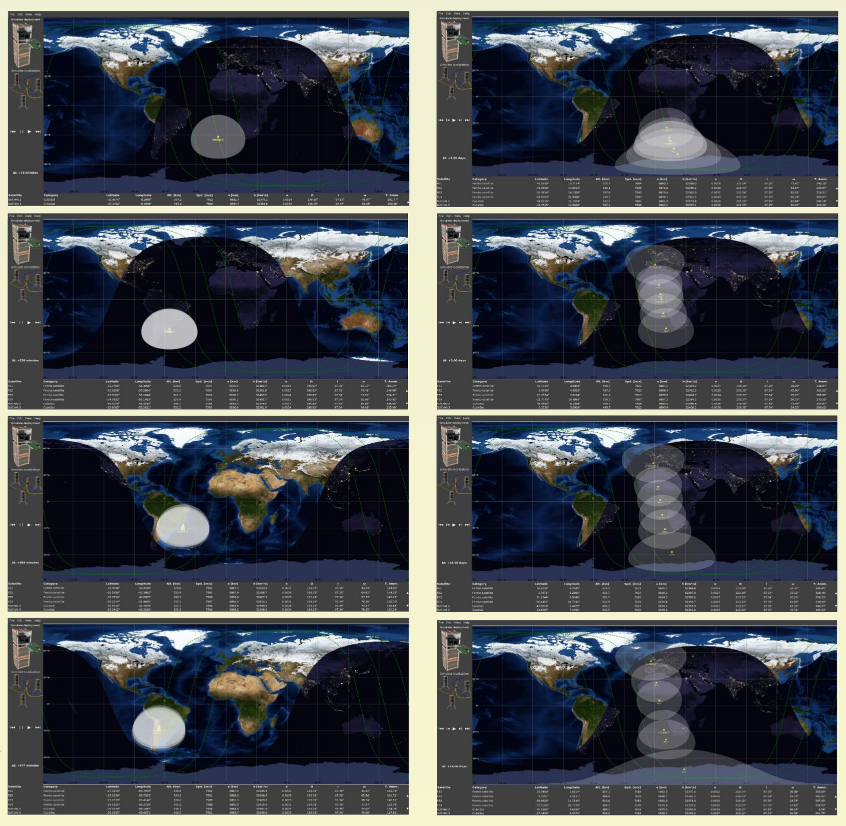


NEW MISSIONS

Currently, we have two missions under development. The SUCHAI-2 and -3 mission [3] and the PlantSat [4]. The next SUCHAI mission will be our first satellite constellation with inter-satellite communication. The main goal is to measure the SAA with multi-sensors and multi-points to study the its dynamics. The 3U Cubesats allow the inclusion of multiple sensors: Langmuir probe, magnetometer, particle detector and double frequency GNSS receivers. In addition, the Cubesats will deploy smaller spacecrafts to increase the number of measurement points. The mission also requires attitude estimation and control for the flight formation and intersatellite communication based on phased arrays [3]. The data obtained in space will be combined with data gathered on ground (GNSS systems, Magnetometers and Infrasound systems).

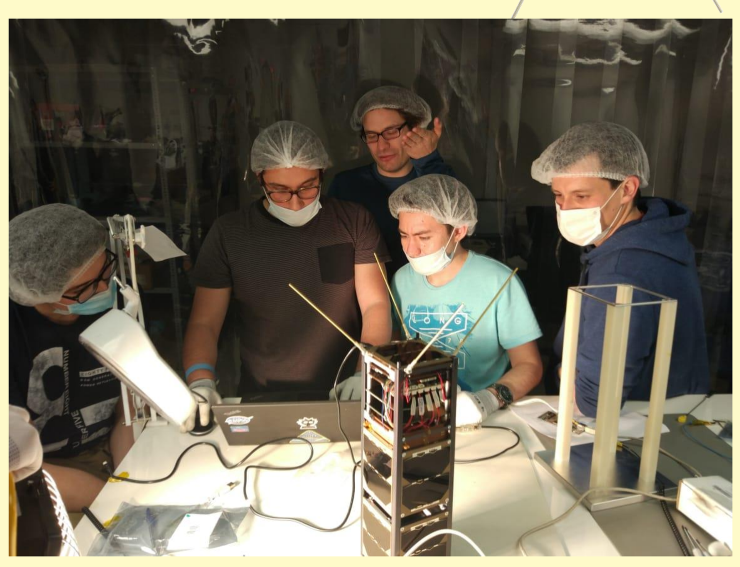






The size of the particle detector (PD) allows to integrate it in a much smaller spacecraft. In addition a 3 axis Honeywell magneto-resistor magnetometer will also be integrated in this miniaturized spacecraft. This data will be transmitted to the Cubesat mother craft by using a UHF link. Precise location of the pico-sat will be obtained by using a miniaturized GNSS receiver and a array of ground station along Chile. A Python-based tool has been developed to study the evolution of the set of satellites after deployment, optimizing the measurement over the SAA. The expected launch of SUCHAI-2 and -3 is late 2021. Together with probing the space environment we are monitoring different sub-systems such as batteries and novel components, such as a CMOS with temperature sensors integrated in each pixel[5], to study their performance under the environmental conditions. This project is also allowing to study the impact of small objects in the space traffic coordination and in astronomy pollution.

In collaboration with Rocket Lab and GOMspace we have started a fourth mission to study the possibility of maintaining autonomously alive a tillandsia plant in a 3U Cubesat. Tillandsia as aerophytes does not need soil to grow, which makes it a candidate to generate ecosystems in space and in this manner create oxygen through a natural process. Tillandsia landbeckii, endemic from Atacama Desert, and Tillandsia ionantha, from North America, are the candidates to be in the PlantSat. The scientific question was proposed by the University of Wyoming MSc student Matthew Lehmitz [4]. We expect this project can open the door to the study of autonomous ecosystem for space in Chile. We also expect to improve the instrumentation studies for proving planetary systems taking advantage of the natural environments in the country.



CONCLUSIONS

Research is key to tackle the coming challenges in the space use and exploration. The missions need to be cheaper and include the contribution of many actors to be cost effective. With a university space program in Chile we envision to channel some of the strengths of the country to contribute in the sustainability of space together with advancing knowledge and skills of the new generation. We also have a collaborative philosophy, which includes open hardware and software development to facilitate the mission success of new actors/missions and in this way avoid excess of debris in space due to the learning process [6].

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