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## NANOSATELLITES: ACTUAL MISSION THAT CAN PERFORM

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Today, thanks to the miniaturization of various electronic systems, one was developing small crafts called nano-satellite, which can be launched into space and complete the basic functions of a standard size satellite. During some years, it has been observed that the popularity of nano-satellites has grown considerably. Already several countries and institutions have developed and currently are developing nano-satellites with different primary objectives, but with one purpose: access to space.

Given this emerging technology, there are some questions that still open: Does serve a nano-satellite?, Is it functional?, What is its primary contribution? Most of the nano-satellites have a purely educational purpose since its development is looking to venture into the research and application of aerospace technologies, establishing the basis for implementing major projects in the future.

On the other hand, the nano-satellite development serves as an introduction and training of new professionals in the aerospace field. A nano-satellite is a tool for demonstrating scale development of a spatial element that can be placed into an orbit and can communicate with the Earth, at least with a simple "beep" transmitted on its waves. But, on the other hand, there are much more complex nanosatellite missions oriented to different complex tasks. These tasks could be remote sensing missions, communication, physical characteristics monitoring, magnetic field, radiation monitoring, climate change, meteorology, agriculture, deforestation, communication, astronomy, planetary sciences, etc.

Due to this wide range of possibilities at the engineering level, this paper aims to analyze the actual capabilities of a nano-satellite to perform the different missions giving today. One analyze different nanosatellite missions, their goals, and successes. Based on this information, the idea is to present a series of conclusions about what we can realistically expect of a nanosatellite mission today.

### I. INTRODUCTION

The development of nano-technology, after the cold war, has allowed reducing the size of the different systems in different engineering fields.

The aerospace field could not be separated from this development. Nanotechnology has enabled create systems with a new principle: "Faster, Better, Cheaper", [18] with size reduction, time reduction, we can achieve a decreasing cost, thus ensuring that space is accessible not only to developed countries.

In this context we see a huge reduction of the costs/time of manufacturing and launching a satellite, which is by far the most expensive part of the space research endeavor, making space more accessible to developing countries, like several South American countries who are investing in space systems.

This can prove the interest of these countries in South America in promoting the development of the space technology industry, with the use of nano-satellites as scientific research and technology validation platforms is now increasingly recognized, first by the needs of different applications that can be given to this type of technology, also we have to take in to account that the new capabilities offered by the nano-

satellites promises to increase research in this type of nano-systems [19].

The nano-satellites development serves as an introduction and training of new professionals in the aerospace field. to develop a nano-satellite would venture into aerospace research and application of technologies providing the possibility to establish the basis to implement large projects using local knowledge and technology.

The experimental science of designing, implementing, and putting a nano-satellite into orbit involves the use of engineering and technology in such knowledge areas as: communication, telematics, telemetry and remote sensing, also others inherent subjects as automation, control, and remote control [14].

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meteorology, agriculture, deforestation, communication, astronomy, planetary sciences, etc.

## II. NANO-SATELLITES MISSIONS

This section describes the background of this study, are presented, the current situation of nano-satellites, as emerging technology worldwide, first we present a South American approach and finally we provide a global approach.

Thanks to the miniaturization of various electronic systems, one was developing small crafts called nano-satellite, which can be launched into space and complete the basic functions of a standard size satellite.

### Nano-Satellites Missions in South America

#### A. Argentina

CubeBug-1 is the technical name of "Capitan Beto" the first Argentine nano-satellite, weighing 2 kg and dimensions of 10 cm square. This CubeSat was launched from the space center in Jiuquan-China by the rocket Long March 2 on April 26, 2013. This nanosatellite had the scientific mission of this nano-satellite was to explore the universe and its conditions. The CubeBug-1 was conceived, designed and manufactured by the Satellogic Company in collaboration with the Applied Research Company (INVAP) in the province of Rio Negro and funded by the Ministry of Science, Technology and Innovation. "Capitan Beto" meant the first step to democratize access to space. On the other hand the project has educational and scientific purposes not only for Argentina but throughout South America since both hardware and software of CubeBug-1 are open platform and available to any university or research institute. [14]

#### B. Brazil

The South Regional Center for Space Research at the University of Santa Maria of Brazil developed the first nano-satellite called NanoSatC-Br1; this CubeSat mission was primarily to provide monitoring of the Earth's magnetosphere, making measurements of the magnetic field on Brazilian, Ecuadorian, and South Atlantic territory. [9] The NanoSatC-Br1 is  $10 \times 10 \times 11.3$  cm and weighs 1.33 kg and was launched as a secondary payload on a Chinese vehicle in 2014 with the Satellite China-Brazil Earth Resources Satellite (CBERS-4) [15].

In August 29, 2015 Brazil launched the SERPENS mission a nano-satellite of 3U, developed by a University Consortium.

The main objective of SERPENS was have a transponder to test VHF and S-band communications for store and forward messaging, a UHF transponder fully compatible with the HUMSAT store and forward

messaging system and pulsed plasma thruster (PPT) built by Mars Space Ltd. and Clyde Space. [14]

#### C. Colombia

April 27, 2007 the first South American nano-satellite was launched from the Baikonur Cosmodrome in Kazakhstan. Less than a kilogram of mass and a volume of 10 cm<sup>3</sup>, this project was called Libertad I, which was the first foray into nano-satellite technology by Colombia and was developed by three teachers and three students from the Universidad Sergio Arboleda. This CubeSat orbited the Earth about 30 days and sent temperature data every 45 minutes. This project was a first step for Colombian in space development and meant an appropriation of technology and knowledge.

The University Sergio Arboleda is currently leading its second nanosatellite design and development, which will be called "Libertad II" [16].

#### D. Chile

SUCHAI is a 1U Cubesat, developed at the Space and Planetary Exploration Laboratory (SPEL), this nano-satellite carries a Langmuir probe, a small camera, and his main mission is operate in coordination with ground-based instruments such as magnetometer networks and Incoherent Scatter Radars (ISRs) for measure the plasma density at low orbit at all latitudes this measurements will help to study the magnetospheric/ionospheric plasma parameters.

The Cubesat SUCHAI is expected to be in orbit in 2016, it will be launched in a Space-X Falcon-9 rocket [17].

#### E. Ecuador

The NEE-01Pegaso was developed in 2011 entirely by Ecuadorian professionals belonging to the Ecuadorian Civilian Space Agency (EXA), the objective of the nano-satellite was to transmit video in real time since it was equipped with a camera. The launch of the first Ecuadorian nano-satellite was from Jiuquan spaceport in China by the Long March 2 rocket in April 2013. On 16 May of the same year, Pegaso was broadcasting its first images in real time while orbiting Ecuadorian territory. On May 23, 2013 the NEE-01 stopped broadcasting since it collided with space debris. [14]

#### F. Peru

Peru, with the support of its national space agency CONIDA (Comision Nacional de Investigacion y Desarrollo Aeroespacial) is trying to make inroads in the development of space technology. The Pontificia Universidad Catolica del Peru (PUCP) launched the first peruvian nano-satellite PUCP-SAT in November 2013 The University Alas Peruanas (UAP) launched his nano-satellite UAPSAT in January 2014. This CubeSat a cubic shape and measures  $10 \times 10 \times 10$  cm with a

mass of 1 kg, the same will be dedicated to meet technology demonstration objectives for scientific and educational purposes. On the other hand, the National Engineering University (UNI) developed a CubeSat called Chaski-I will have a weight of 1 kilogram and dimensions of  $10 \times 10 \times 10$  cm and its main objective is to transmit images of Earth in color and infrared range, its launch was in February 2014. [14]

#### G. Uruguay

The first experience in development of space systems in Uruguay has been carried out by the Institute of Electrical Engineering (IIE) and the entity ANTEL (Administración Nacional de Telecomunicaciones), the two entities supported by the Uruguayan government have achieved development a nano-satellite called ANTELSAT whose mission is to transmit in color and infrared images of Earth's surface. ANTELSAT also seeks to promote education and research in the field of aerospace technologies for undergraduate students and develop in them skills in radio communication and handling of nano-satellites, ANTELSAT was launched on June 19, 2014. [14]

### Nano-Satellite Missions in the World

#### A. China

3CAT2 is a 6U CubeSat mission designed to perform ocean altimetry by means of Global Navigation Satellite Systems Reflectometry (GNSS-R). The main payload is the novel dual-band altimeter P(Y) & C/A Reflectometer (PYCARO). Was developed by the Universitat Politècnica de Catalunya – Barcelona TECH. This Cubesat was launched by the rocket Long March 2D on August 15, 2016. [22]

GAMALINK, which is an S-band inter-satellite communication module, a novel dual band GPS/BD receiver, an AIS receiver, and an ADS-B receiver, all being designed based on SDR technologies. Also a novel cold-gas micro propulsion module based on MEMS technology will be used for orbit and constellation control. TW-1 project consists of three nano-satellites carrying different payloads and instruments with one 3U CubeSat and two 2U CubeSats, forming an along-trace satellite network. [22]

Tianwang-1C was developed by the Shanghai Engineering Centre for Microsatellites and was launched by the rocket Chang Zheng-11, on September 25, 2015. Tianwang-1C was developed by the Shanghai Engineering Centre for Microsatellites and was launched by the rocket Chang Zheng-11, on September 25, 2015. [22]

CAMSAT (AMSAT China) developed a constellations of nano-satellite for amateur radio missions. They was launched by the rocket Long March 6, on September 19, 2015.

CAS, Chinese Amateur Radio Satellite, have the amateur communications payload and it consists of U/V 20 kHz wide transponders with 145 MHz CW beacon and 19k2 GMSK AX25 telemetry downlinks. Also have atmospheric physics experiments. [22]

#### B. United States of America

Flock-2p, it is a constellation of 12 nano-satellites of 3U for optical earth observation with 3-5m resolution. Was developed by the private Company Planet Labs. This constellation was launched by the rocket PSLV-XL on June 22, 2016. [22]

Lemur-2, it is a constellation of 12 nano-satellites, 3U with the main mission to provide weather data for government and commercial customers. Spire plans to provide this data by measuring signals from GPS satellites as those signals pass through the atmosphere. This technique, known as GPS radio occultation, provides profiles of temperature, pressure, and humidity in the atmosphere that can be incorporated into weather forecasting models.

Lemur mission has two payloads: STRATOS imaging payload and the SENSE AIS payload. The SENSE payload enables tracking ships worldwide by receiving their AIS signals. Spire satellites listen for GPS satellite signals - which are impacted as they pass through Earth's atmosphere. Using a process called GPS radio occultation, Spire measures the change in GPS signal readings to calculate very precise profiles for temperature, pressure, and humidity here on Earth. Was developed by the private company Spire. This constellation of cubesats was launched by the rocket Atlas V on March 23, 2016. [22]

NODES is a technology demonstration of a pair of lowcost 1.5U nano-satellites, each weighing approximately 2 kilograms and measuring 10 centimeters by 10 centimeters by 17 centimeters, in Low Earth Orbit (LEO) with advanced cross-link and downlink communications capability, suitable as a platform for Space Weather or other science applications requiring geographically distributed, synchronized data acquisition.

Was developed by the NASA Ames Research Center and the Montana State University, Santa Clara University. This two cubesats was launched by the rocket Atlas V on December 6, 2015. [21]

### C. United Kingdom

UKube-1 (United Kingdom Universal Bus Experiment 1), it is a cubesat of 3U, developed for the United Kingdom Space Agency and the Clyde Space, University of Strathclyde, launched by the rocket Soyuz-2 1b on July 08, 2014.

This nano-satellite aimed measure the plasmaspheric space weather. The CMOS Image Demonstrator by the Open University is a camera that will take images of the earth and test the effect of radiation on space hardware using a new generation of image sensor. Astrium's "Janus" Experiment to demonstrate the feasibility of using cosmic radiation to improve the security of communications satellites and to flight test lower cost electronic systems. AMSAT's FUNcube-2, an outreach payload allowing school children of primary and secondary age to interact with the spacecraft. [22]

## III. NANO-SATELLITES IN THE NEAR FUTURE

### GNSS (Global Navigation Satellite Systems)

The GOSTE-1 Mission will develop and deploy a Global Navigation Satellite Systems (GNSS) radio occultation (RO) system that will contribute to our understanding of tropical cyclogenesis. GPS Radio Occultation Experiment and Comprehensive Open Source Mission Operations Software (COSMOS) Technology Demonstration. Observations from the tropics will be combined with observational data from other sources to provide improved maps of mid-level moisture, vorticity, and temperature in the upper troposphere and lower stratosphere. These products will improve estimates of the potential intensity of developing tropical cyclones and their intensity predictions, while the temperature profiles through the stratosphere will provide observations for testing general circulation model predictions.

GOSTE-1 is a nano-satellite of 3U and is been developed by the University of Hawaii at Manoa, the launch year have to be determine. [21]

### Remote Sensing Missions

CaNOP (Canopy Near-IR Observing Project), this 3U nano-satellite is being developed by Carthage College in United States of America.

This cubesat will have a remote sensing platform for performing multispectral imaging of global forests to help understand large-scale biomass production and carbon uptake in both mature and harvested forests. The launch year of this nano-satellite have to be determine. [21]

### Meteorology

CONASAT mission is developed by the National Institute for Space Research in Brazil, this nano-satellite mission will have at least two identical satellites of 8U, CONASAT A Y B. The main objective is gather environmental data like rain volume, temperature, humidity, air pollution, ocean streams, environmental hazards, etc. collected and transmitted to satellite by remote platforms on ground, and to retransmit them to the mission center. The launch year have to be determine. [20]

### Planetary Sciences

CHIRP is a 6U nano-satellite developed by NASA Jet Propulsion Laboratory (JPL) this CubeSat will have a VHF transmitter to study Ionospheric dispersion of Radio Pulses. Science mission concept in which a CubeSat mounted antenna would transmit wideband Very High Frequency (VHF) 30-300 MHz pulses through the ionosphere to a ground receiver. The objective of the mission would be to verify dedispersion algorithms and to quantify the day-to-day variability of the ionosphere as a function of geophysical inputs required for the advancement of charged particle astronomy. The launch year have to be determine. [21]

## VI. CONCLUSIONS AND RECOMMENDATIONS

- In recent years it has presented a significant increase in interest from South American countries to invest in aerospace technology.
- The investment made by countries in South America, mainly consist in acquire the aerospace technology to other countries outside Latin America.
- In South America's market do not exist a company that could offer satellite technology.
- The foray into the aerospace market can be initiated through nanosatellite missions, who is showing a significant increase in recent years.
- The nanosatellite market should only be the first step to venture into the development of the industry of satellite technology in South America.
- Another potential market is for space launches, because South America is in a favorable geographical position for that purpose.

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