PROMOTION OF AEROSPACE TECHNOLOGY IN BOLIVIA

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IAC-14, B4, 1.9x21366

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The development of the aerospace industry brings a lot of technology for people to use in everyday life. In issues of satellite technology, Bolivia is developing its expertise in the area, with the creation of the Bolivian Space Agency (ABE), with the launch of its first telecommunications satellite Túpac Katari (TKSat), with the training of Bolivian professionals and the creation of two ground stations. Also, the Bolivian Space Agency announced the country's willingness to purchase a remote sensing satellite in the near future. But Bolivia must move from being a country dependent on others, to being a country applying the learned theory, a country with capacity to do research activities and to be able to develop its own technology, because it has the human resource to meet this challenge. It has been observed in recent years that the nano-satellite technology in South America has been having a remarkable growth, beginning in 2007 when Colombia launched the first nano-satellite called Libertad I; continuing with this technological raid, Brazil, Argentina, Ecuador, Uruguay, and Peru also launched their nano-satellites. Taking this into account, it is necessary to promote and develop aerospace technology in students, professionals and the general public of Bolivia. The military School of Engineering with help of the students has organized the First Bolivian Congress in Aerospace Technology – ABC (Aerospace Bolivian Conference). Also the development of a nano-satellite is proposed to acquire knowledge on this issue and especially so that Bolivia can acquire its own access to space.

I. INTRODUCTION

Aerospace development in a country represents its technological level, its development capacity and somehow its power, as is shown in [1]. The development of the aerospace industry brings a lot technology for people to use in everyday life. Technologies that were developed to explore the universe are now used in everyday life.

Aerospace technology emerged from a geopolitical reality during the Cold War and the Space Race. Anyway, aerospace development is associated with the economy and began as a direct government spending (USA and USSR); yet, it always has several effects that allow the creation of new technologies to increase productivity, strength training work in new capacity and technical skills, and the emergence of new side technologies.

Satellite systems have multiple applications for the benefit of humanity, not only to explore the universe, but also to better understand the world in which we live and monitor their characteristics, carry out communication, remote sensing, and so on. as shown in [1] and [2].

The satellite is the main component of a space system. It consists of a platform with generic functions which are necessary for correct operation of an object in the space environment, and the payload that has a specific mission.

The classification of the satellites according to the mass is as follows:

Group	Mass
Medium and large satellites	over 500 Kg
Mini-satellites	from 100Kg to 500Kg
Micro- satellites	from 10 Kg to 100 Kg
Nano-satellites	from 1 Kg to 10 Kg
Pico-satellites	to 1 Kg

Table 1: Satellite clasification

The constant development of nano-technology has allowed reducing the size of the different systems in different engineering fields. Nanotechnology enables the development of innovative solutions for humanity’s problems.

The aerospace field could not be separated from this increasingly accelerated development. Nanotechnology has enabled size reduction in satellite systems and this reduction is also reflected in a decreasing cost, making space more accessible to developing countries as well as for educational institutions that have access to space through the development of nano-satellites.

The continuation of this article is organized as follows: Section II shows the general concepts of nano-satellites. In Section III the main application of nano-satellites are mentioned. Section IV shows the different

South America nano-satellite projects. In Section V the situation of Bolivia in relation with aerospace technology will be discussed. Finally in Section VI we will present our conclusions and recommendations

II. NANO-SATELLITES

Nano-satellites, as we saw in the introductory part of this article, are in this classification because they have a mass between 1 and 10 kilograms. Although there are many models - such as TubeSat or custom models - several developments of nano-satellites are based on the standard known as CubeSat [3] [4] which was proposed by Stanford University and Polytechnic State University California (Cal Poly) in 1999.

The CubeSat standard describes nano-satellite dimensions for a volume of 1 liter (10 cm of cube edge) and an approximate mass of 1 kilogram.

Fig. 1: CubeSat of the Universidad Alas Peruanas [UAPSAT].

The lifetime for nano-satellites is between 3-6 months (the lifetime may be extended depending on the orbit, radiation factors and propulsion). The main objectives for developing the nano-satellite are education, preparing students and professionals within the aerospace branch, and in-situ testing of new components for space applications, testing, as discussed in greater detail (see Section III) nano-satellites are also used to support the solutions to humanity's problems.

The nano-satellite will consist primarily of the following required modules: [5]

- On-board computer
- Power module
- Thermal Control Module
- Communication system
- Attitude control system
- Structure
- Payload

On-Board Computer

The on-board computer is the centerpiece of the nano-satellite and is responsible for the largest number of tasks running on board as well as the interconnection of the other modules. This module is responsible for the different calculations of the system and generates the necessary information about the state of the system, which will be sent to Earth to be analyzed. It is also responsible for the interpretation of the different commands from Earth to perform experiments according to an established schedule.

Power Module

The power module is responsible for providing the necessary energy to the satellite platform. This module is composed of solar cells and batteries. The energy generated by the solar cells can feed directly to the nano-satellite or can be used to charge the batteries. The batteries are used when the solar panels do not produce enough power for the platform.

Thermal Control Module

The thermal module is responsible for maintaining the most critical components of the system in a suitable temperature range for proper operation. This module can consist of thermistors, which will be responsible for sensing temperature and then transmitting the information to the on-board computer. At low temperatures, it has heaters; in the case of high temperatures, it has heat sinks.

Communications Module

The communication module is responsible for connecting the nano-satellite (space segment) with Earth stations (ground segment). This module first transmits information from the on-board computer to the ground segment and then transmits information obtained on Earth back up to the on-board computer. Communication between the space segment and ground segment is performed using RF waves (radio frequency).

Attitude Control Module

The attitude control module is responsible for determining the position and orientation of the nano-satellite, as well as changing its orientation according to the system requirements and the requirements for the operation of the experiment. This module could consist in orientation sensors: accelerometers, gyroscopes, GPS, and the orientation can be changed as needed with reaction wheels or propulsion systems.

Mechanical Structure

The mechanical structure becomes the chassis of the nano-satellite. This module can be made based on aluminum, duralumin, or titanium as in the case of the Ecuadorian nano-satellite Pegaso. This module is responsible for holding the solar panels and the various modules that make up the nano-satellite.

the nano-satellite will also need a deployment system in which the nano-satellite is introduced for better fixation in the launcher, and allows it go out of the launcher when it reach the desired orbit. Once in the desired orbit, the nano-satellite goes out of the deployment system. In [6], the authors show an example of a deployment system for nano-satellites.

Payload

The payload module refers to the experiment itself. It is the mission for which the nano-satellite was designed and implemented (nano-satellite mission). The mission can be a timely application, an engineering application or an application for in-situ demonstration. Most nano-satellite missions carried a camera as payload (as seen in [7]) to take pictures of the Earth and analyze these images for different applications such as agriculture and deforestation.

III. APPLICATIONS

Nano-satellites have mainly academic goals, but also may have specific missions for some applications that include:

Communications

A nano-satellite as an isolated element can perform delayed communication with low rates of information. As part of a constellation it may be a discrete antenna element that can have a large scale resolution.

Observation and Monitoring

Earth and space observation in medium and large scale can be performed with a nano-satellite, for example in applications for weather monitoring or climate changes, astronomy, planetary science, agriculture, deforestation and pollution purposes. Nano-satellites can also perform scientific missions for radiation or magnetic field reconnaissance. On the other hand, a nano-satellite can perform the function of monitoring and surveillance the orbiting platforms, as happened in the Remora project, where the main objective of that project was surveillance the International Space Station (ISS) [8].

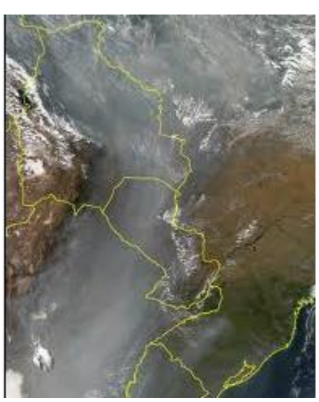

Fig. 2: Satellite image, forest fires in South America [NASA].

Scientific Experimentation

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.

On the other hand, 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.

IV. SOUTHAMERICAN NANO-SATELLITES

In the South American region, different countries have entered in the development and implementation of nano-satellites projects, as summarized here:

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^3, this project was called Freedom 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.

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 × 10 × 11.3 cm and weighs 1.33 kg and was launched as a secondary payload on a Chinese vehicle in 2012.

Argentina

CubeBug-1 is the technical name of "Capitan Beto" the first Argentine nano-satellite, weighing 2 kgr 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 nano-satellite 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.

Ecuador

The NEE-01Pegaso was developed in 2011entirely 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

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.

Peru

Peru, with the support of its national space agency CONIDA (Comision Nacional de Investigacion y Desarrolo Aeroespacial) is trying to make inroads in the development of spce 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 × 10 × 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 1kilogramo and dimensions of 10 × 10 × 10 cm and its main objective is to transmit images of Earth in color and infrared range, its launch was in February 2014.

Likewise, there are other Peruvian universities are participating in a project that plans to launch a constellation of 50 nano-satellites to study the thermosphere (QB50 Project) [10].

V. SITUATION IN BOLIVIA

In issues of satellite technology, Bolivia is developing its expertise in the area, with the creation of the Bolivian Space Agency (ABE), with the launch of its first telecommunications satellite Túpac Katari (TKSat), which was released on December 20 of 2013, with the training of Bolivian professionals on the Great Wall Industrial Corporation (CIGM) and the creation of ground stations in the cities of La Paz and Santa Cruz for management and monitoring of TKSat, and also, the Bolivian Space Agency announced the country's willingness to purchase a remote sensing satellite in the near future.

But Bolivia must to move from being a country dependent on other, to be a country applying the learned theory, a country with capacity to do research activities, to be able to develop its own technology, since it has the human resource to take this challenge.

Fig. 3: Ground Station of Amachuma-La Paz [ABE].

Taking this into account, it is necessary the promotion and development of aerospace technology in students, professionals and the general public of Bolivia, in this sense; it has organized the First Bolivian Congress in Aerospace Technology – ABC (Aerospace Bolivian Conference). Also the development of a nano-satellite is proposed to acquire knowledge on this issue and specially to acquire own access to space.

The conference ABC 2014 was held from Wednesday July 23th through Friday July 25th 2014 at the Military School of Engineering – EMI – Campus Irpavi in the beautiful city of La Paz - Bolivia, the congress had the support of various public institutions, private companies and various Bolivian and foreign universities.

The conference had the support of the Military School of Engineering (Escuela Militar de Ingeniería – EMI) and of the Cultural Cooperation Section of the Embassy of France in Bolivia, who were co-organizers of the conference.

This event was organized to promote interdisciplinary understanding of aerospace systems, their underlying science and technology, and their applications to government and commercial endeavors.

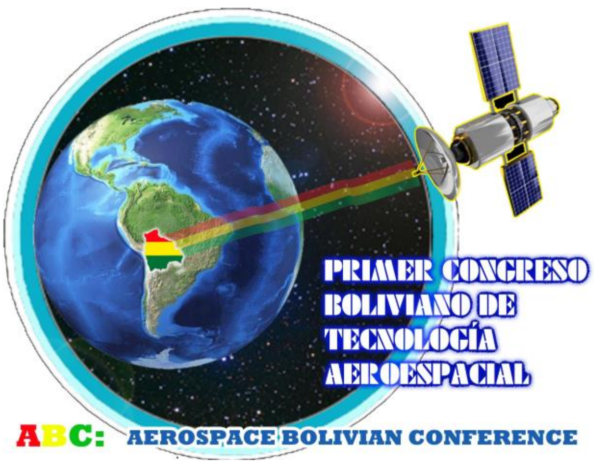

Fig. 4: Logo of the ABC 2014.

The congress had 3 days of conferences with keynote-speakers with great national and international reputation, plus one day of recreation. Likewise, the event had the following additional activities:

- Call for Papers: Call for articles where students from different national or international universities had the opportunity to present their papers related to aerospace technology.
- Technology Fair: Where the event sponsoring companies shown their work, services and/or products offered to the general public.
- Panel of experts: Where was attended by representatives of the Andean region of Latin America and two specific topics were discussed: The aerospace development in Latin America and the possibility of creating a Latin American space agency.

The conference had the participation of national and international keynote-speakers from countries like France, Germany, Brazil, Uruguay, Ecuador, Paraguay, Peru and Bolivia.

By France the conference had the presence of representatives of major companies specializing in aerospace technology as TIMA Laboratory, The National Center for Scientific Research of France (CNRS), THALES Alenia Space, Airbus Space and Defense (ASTRIUM) and Arianespace.

The topics of the conference were: Ground station design, test radiation on EEE components, space monitoring applications, propulsion systems for satellites, nano-satellites, analog astronaut missions and the use of remote sensing for the study of water resources.

Fig. 5: ABC 2014.

The main objectives of the event were:

- Promote and encourage students and Bolivian professionals to acquire new knowledge in the area of aerospace technology that has been having so much growth in our country.
- Encourage students of different Bolivian universities to have interest to attend this type of academic events with national and international keynote-speakers.
- Build a framework in the different Bolivian universities to support and organize academic events in Bolivia.

The ABC 2014 had the presence of 17 national and international keynote-speakers, over than 150 attendees, and 50 invited professionals of different Bolivian companies.

VI. CONCLUSIONS AND RECOMMENDATIONS

- Generally speaking, the aerospace technology brings development to the country that invests in this field; you can meet social inclusion objectives, military control, management of mining areas, pollution monitoring, deforestation monitoring, etc.
- The implementation of nano-satellite systems for a country and/or for a institution, is a starting point to development of aerospace technology

and further develop of larger projects in aerospace technology.

- The participation of professionals and students in this kind of projects, allows the training and development of skills that will continue to advance the development of new projects with increasingly greater scope and more complex space missions.
- It is recommended that countries that have not yet joined the space age, do so first through nano-satellite development and can do so as soon as possible to acquire knowledge and technology that allows them access to space.
- Likewise, the creation of training modules at both undergraduate and graduate aerospace engineering topics is recommended.

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