Peruvian University Consortium in the QB50 Project

Peruvian University Consortium[1]

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With the development of nano-engineering and its usage for space applications universities and educational institutions worldwide have started exploring new frontiers in the field of space operations with projects called technology demonstration missions. Peruvian engineers have realized that nowadays they have the managerial and technical capabilities to demonstrate that Peruvian institutions are able to cooperate internationally working in this field. Therefore a consortium of universities from Peru envisages participating in the European project "QB50, an international network of 50 CubeSats for multi-point, in-situ measurements in the lower thermosphere and re-entry research". The first step has been successfully achieved when the organizational committee accepted the letters of interest of these universities. The task of the Peruvian team would be the provision of a satellite, based on the CubeSat standards, for launch into space and its operation while in orbit. The CubeSat will have a size of 10x10x30 cm with one functional unit providing the usual satellite functions and science units accommodating the selected payloads or sensors for upper atmosphere and re-entry research. However the Peruvian consortium would not only participate providing a 3U CubeSat but also would contribute to the program with a valuable infrastructure like a network of radio amateur and university ground stations located in the Peruvian territory. This paper will briefly describe how Peru becomes the only country in South America with 7 interested universities in joining the European project. It will also provide insight into the educational benefits while participating in such international project. The proposed satellite mission design and planning, available infrastructure and how the consortium prepares to succeed in the realization of this challenging endeavour will be discussed.

I. Introduction

THE rapid development of nanotechnology in the last decade has impacted on every major sector of engineering enabling to design and utilize new devices in innovative applications that have not been possible before. It is the case of space technology where the use of nano-engineering makes possible the development of new electronic components that are reduced in size but they still support the efficient execution of integrated satellite systems. It was difficult to believe that a satellite could be of low weight and of small dimensions. Nowadays satellites with those characteristics exist and they are capable of carrying out complex tasks. The so-called nano-satellites are spacecrafts based in the CubeSat technology [1] developed mostly by universities.

Certainly, small satellites offer valuable support in performing space missions with emerging technologies. Almost all fields of science and applications can be sustained moreover technology demonstrations and space education and training are the objectives of such satellite missions. It is important for developing countries emerging in the space technology, to invest time and effort to access to space, its applications and spin-off technologies. Together with the decrease of development times, the inherent low investment of launch costs offered by the reduced size and mass of the spacecraft and their more manageable proportions, small satellites become attractive ways to develop and establish a national expertise in space technology.

The aim of this paper is to inform the space community on the steps and achievements carried out by some Peruvian universities to start playing a role in the national aerospace program. The following sections provide a

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short description of how the so called Peruvian University Consortium has been established in Peru with the objective not only to actively participate and contribute to the European project QB50 but moreover being a partner of the project organization and making the first CubeSat network a reality.

II. The European Project QB50

The project QB50 [2] is a European initiative, organized and coordinated by the Von Karman Institute of Brussels, Belgium. It is promoted and partly financed through the Seventh Framework Program (FP7) [3] of the European Community (EU) and the European Space Agency (ESA). The purpose of this project is to launch into space a constellation of 50 nano-satellites (designed and based in the CubeSat standards) to carry out investigations and scientific measurements of the low atmosphere or Thermosphere. The nano-satellites will be launching together within a Russian rocket (Shtil-2.1) in the first half of 2015. Deployed into a 320 km orbit, the mission lifetime of individual CubeSats is estimated to be not less then three months. Due to its size we are speaking of satellites with a weight between 2 and 3 Kg.

A. Mission Objectives

QB50 has the scientific objective to perform atmospheric research especially to study in situ the temporal and spatial variations of a number of key parameters in the lower thermosphere, between 90 and 320 km, with the network of 50 CubeSats, carrying a set of sensors selected by the Sensor Selection Working Group (SSWG). QB50 will also study the re-entry process by measuring a number of key parameters during this last satellite's orbital phase and by comparing predicted and actual CubeSat trajectories and orbital lifetimes.

Because the cost of a network of 50 satellites built following industrial standards would be extremely high and not justifiable in view of the limited orbital lifetime space agencies are not pursuing a multi-spacecraft network for in-situ measurements in the lower thermosphere. Furthermore no atmospheric network mission for in-situ measurements has been carried out in the past or is being planned for the future. Taking that into account a network of satellites for in-situ measurements in the lower thermosphere can only be performed using very low-cost satellites, and CubeSats are the only realistic option.

Figure 1: Project QB50 of the von Karman Institute

B. Participants

The project organizers consider that the entire program has to be carried out mainly by academic institutions i.e. with the participation of "Universities" worldwide. The project organization does not only invite universities from Europe but from the rest of the world and moreover encourages them to get involved in this unique endeavour. For the universities the main objective of developing, launching and operating a CubeSat is educational. The educational value of participating to QB50 is valid not only for universities, but for all institutions that are involved in hands-on and multi-disciplinary CubeSat building activities. National teams launching their country's first satellite as part of QB50 have the opportunity to introduce space awareness and satellite know-how to their country.

This project is unique in its class, because of the novelty of mission purposes and proposed scenario. In addition it will be the first time a space mission is going to be organized in such a manner where especially the joint participation of educational institutions around the world is promoted, contributing each of them with an own space system conceived, designed and built by each house of studies. Therefore for the universities a short mission lifetime is not a showstopper since the primary purpose of a CubeSat project is educational and this objective can be fully met even if the orbital lifetime is short.

Since the beginning of this program in 2009, the Peruvian engineers Alberto Gutiérrez and Juan Martín Canales Romero have been in touch with the organizers of the project at the Von Karman Institute. They started the initiative of involving and inviting Peruvian universities to take part of and become members of this project. As an outcome of this initiative Peru was the first South American country in presenting his interest of participation and so far it is known the first country represented by a consortium of academic institutions.

III. Peruvian Universities and the Project QB50

Peruvian Universities will join the QB50 project having the opportunity to contribute to this exciting scientific endeavor and being part of the first CubeSat network in orbit. Nowadays Peruvian academic institutions have the

technical capabilities to achieve the mission goals and are able to cooperate internationally working in the emerging field of small satellites. The Peruvian team plans its participation and contribution in the project with an integrated team of universities. As a first step the "Letters of Intent or LoIs" signed by the interested Peruvian universities were gathered between 2010 and 2011 and these were sent to the VKI. On February 24, 2012 the "First Workshop on the Project QB50 in Peru" was held in the city of Puno (South of Peru) with the aim to provide essential background information regarding the QB50 Project to the interested universities. At the end of this event the participating universities decided to officially establish the non-profit consortium called "Peruvian University Consortium" and to kick-off a national project with the goal of developing the required CubeSat for the project QB50.

The WARA[3] CubeSat is the result of the project started by a partnership between the National University of Highland Puno (UNAP), the National University of San Antonio Abad of Cusco (UNSAAC), and the National University San Agustin of Arequipa (UNSA). These three universities came to the mutual agreement to design, build and deliver for launch a flight model CubeSat to VKI, in time as requested by the QB50 organization. In parallel, coordination has been performed with other universities of the Northwest and Central regions of the South American country. Even these last could not joint the workshop but decided to support and follow this initiative. The State University San Martín of Tarapoto (UNSM), the Central University of Huancayo (UNCP), the University Juan Luis Gonzaga of Ica (UNICA), and the State University San Marcos (UNMSM) of Lima will be mainly supporting the project WARA with the implementation of a national ground segment.

Figure 2: Peruvian Project WARA

The project QB50 is multidisciplinary where different areas of engineering, like mechanical, electrical, electronics, and even Informatics complement each other. Therefore it is very important to have the involvement of students and engineers of different engineering branches who can work and collaborate together. The project coordination with the above mentioned entities has began and each university will focus in the development of dedicated tasks. Additionaly this project offers the opportunity to Peruvian universities, not only to cooperate with other academic institutions on a national level but also internationally, establishing a basis for future projects.

The objective of our participation in this promising project apart from the delivery of a CubeSat while introducing technical expertise and satellite technology to the country is also to demonstrate that we are capable of complying with the requirements the mission QB50 demands from us. It is a challenge that can be achieved taking into account the technical and intellectual ability of Peruvian students, engineers and scientists.

Due to our active initiative since the beginning of the QB50 project a Peruvian delegation represented by Mr. Alberto Gutierrez participated in the first QB50 Workshop held at the Von Karman Institute in Brussels, Belgium, in November 2009. Last but not least Mr. Avid Román Gonzalez attended the third Workshop last February.

The following sections provide a short overview of the core team and universities partners of the consortium.

A. University of the Highland Puno

The National University of the Highland Puno (UNAP, for its initials in Spanish – Universidad Nacional del Altiplano Puno [4]) was created in 1856. This university is one of the most important universities in the Andean region. The university offers bachelor and master degrees in 35 professional specialties. Involved in the QB50 project are the faculty of Electronics, Mechanical-Electrical and Systems engineering. The UNAP is in the process of creating a new faculty of Aeronautics and Space engineering and for this reason they are very interested in participating in international projects like the QB50. The university will be contributing to the consortium with the ground infrastructure and with the implementation of a ground station (UHF band), which will be located in the campus of the university. Already three years ago students of the mechanical faculty have started designing and developing small sounding rockets.

The UNAP is also in the process of establishing a Science and research Center with a first project being the design, development and construction of the nano-satellite for the QB50 project.

Figure 3: UNAP

[3] WARA is the name of the CubeSat to be developed by the Peruvian University Consortium and it is an Aymaran word used for "Star". Aymara is a native language spoken in Peru and Bolivia.

B. University San Antonio Abad of Cusco

The National University San Antonio Abad of Cusco (UNSAAC, for its initials in Spanish – Universidad Nacional de San Antonio Abad del Cusco [5]) was created in 1692. Currently the university counts with 21 faculties, 37 professional careers and 29 academic departments. Involved in the QB50 Project are the faculties of Electronic engineering, Electrical engineering, Mechanical engineering and Systems engineering. Innovative research projects are being intensively supported by the Vice-Rectorate for Research and Development, one of these are investigations on renewable energy. The university finances all these projects with financial support from the mining industry. The Faculty of Electronics and Electrical engineering is very active in the telecommunication area.

The university is supporting the Consortium principally with the implementation of a main ground segment. A Mission Control Centre, two UHF ground stations and also related infrastructure will be built supported by the Center for Research in Rural Telecommunications (CEDITER for its initial in Spanish).

Figure 4: UNSAAC

C. University San Agustin of Arequipa

The National University San Agustin of Arequipa (UNSA, for its initials in Spanish – Universidad Nacional San Agustin de Arequipa [6]) was created in 1828. The UNSA is the most important university in the city Arequipa. The UNSA cooperates and collaborate with the National Aeronautics and Space Administration (NASA) providing a Laser Tracking Satellite Station [7] which belongs to the International Laser Ranging Service [8] and is located at the premises of the university. Arequipa was the first city in Latin America where NASA installed such a station. Since two decades this tracking station is supporting several satellite missions and will be able to support another international program like the QB50.

The university also counts with telescopes that are used for performing investigations in astronomy. One year ago the UNSA created the Institute for Astronomy, Astronautics and Aeronautics in honor of the Peruvian engineer Pedro Paulet. This institute has the goal to support research in aerospace engineering and promote the development of the industry in South of Peru. The UNSA will also participate in the implementation of the ground segment.

Figure 5: UNSA

D. UNIVERSITY PARTNERS

Other participating universities are supporting the Peruvian Consortium mainly with the implementation of the ground segment. The state universities Juan Luis Gonzaga from Ica (UNICA), Central Peru from Huancayo (UNCP) and San Martín from Tarapoto (UNSM) will contribute with the installation UHF antennas which will constitute the first configuration of ground stations network. Also the University San Marcos of Lima (UNMSM) will support with the design of some electronic circuits for the satellite bus.

UNSM

UNICA

UNMSM

UNCP

Figure 6: University Partners

E. CONSORTIUM STAFF

The staff of the Peruvian University Consortium is divided in three groups presented bellow:

- Principle Investigators are representatives of the three univeristies described above and represent the core team in the consortium:
  - Prof. Teobaldo Basurco (UNAP)
  - Prof. John Quispe (UNAP)
  - Prof. Artemio Janqui (UNSAAC)
  - Prof. Dr. Raul Yanyachi (UNSA)

- Project Coordination and Consulting Team is a group of experienced Peruvian engineers who have been working in the aerospace field for many years and are involved in international aerospace projects at reputable Institutions and companies like the German aerospace agency (DLR), Max-Planck-Institute, Astrium GmbH, and MTU Aero Engines in Germany and CNES in France, They

have extensive background in satellite design and development as well as in mission operations and ground segment.
  - Dipl.-Ing. Juan Martín Canales Romero
  - Dipl.-Ing. Jaime Alberto Estela Gutierrez
  - Dr.- Phys. Michael Schlüter
  - M.Sc. Eng. Avid Roman Gonzalez (UNSAAC)

- Collaborators is a team of engineers and academic researchers coming from the universities partners:
  - Prof. Carlos Álvarez (UNMSM)
  - Prof. Victor Cruz Ornetta (UNMSM)
  - Prof. Armando Cruz (UNAP)
  - Prof. Carlos Rios López (UNSM)
  - Prof. Carlos Rodríguez Grandez (UNSM)
  - Prof. Carlos López Rodríguez (UNSM)
  - Prof. Bartolome Saenz Loayza (UNCP)

IV. Contribution to the Project QB50

The Peruvian consortium will contribute to the QB50 program in following areas:

A. Space Segment

As main contribution to the project QB50 the consortium will deliver for launch a flight model CubeSat to VKI. It will be a triple CubeSat, with one unit providing the usual satellite functions (attitude determination and control, uplink and downlink telecommunications, power subsystem including a battery and body-mounted solar cells, on-board data handling and storage by a CPU); the second unit accommodating a set of experiments, as selected by the Sensor Selection Working Group (SSWG), which consists of standard sensors for investigations of the lower thermosphere and ionosphere and for re-entry research; and the third unit serving as platform for the accommodation of Peruvian national experiments.

The nano-satellite system will be a triple CubeSat with enhanced payload capacity. Together with the VKI experiments, which correspond to the experiment Set 1 of the SSWG group, a number of national experiments are going to be placed aboard the space probe. All of them will be interconnected efficiently in order to support each other and the overall system. The following subsections give a short overview of the payloads and experiments:

a) VKI Atmospheric Experiments

The sensors selected by the SSWG group and defined as Set 1 will be:

1) Ion/Neutral Mass Spectrometer
2) Corner cube laser retro-reflectors
3) Thermistors and thermocouples

b) National Experiments

The participation in the European project permits the Peruvian consortium to compete internationally and at the same time to promote science and research in the country. The establishment of a national technology for academic purposes is envisaged. This will be an opportunity to educate and train the new generation of Peruvian experts in this field. The following research topics are considered:

1) Alternative power generation system
2) Faster up- and downlink transmission and reliable data transfer
3) Accurate positioning system
4) Remote Sensing for nano-satellites missions

B. Ground Segment

In order to support the QB50 project and the space-to-ground communications during the whole life of the satellites the Peruvian Satellite Network (PSN) program [9], which has been conceived in 2009, is going to cooperate with the participating universities of the Peruvian Consortium and build a Peruvian Mission Control Centre (PMCC) including a wide network of ground stations.

This control centre will become a member of the global QB50 Mission Control Centres, which currently is integrated by three mission control centres located at the VKI in Belgium, Stanford in the USA and NPU in China. Moreover the Peruvian control centre will be supporting the Global Educational Network for Satellite Operations (GENSO). As requested by the QB50 organization the PMCC will be complied with the following real-time functions:

- Monitoring the health and status data of all the 50 CubeSats and the deployment system during the first flight phase,
- Providing information which ground station is in contact with which CubeSat and displaying the link quality,
- Comparing predicted with actual trajectories, using different trajectory simulation software tools, atmospheric models and CubeSat drag coefficients,
- Predicting and continuously updating the approximate time and latitude / longitude of atmospheric re-entry of the 50 CubeSats.

V. Educational Benefits

The main objective of developing the CubeSat WARA is educational. Furthermore the involvement of the Peruvian Consortium in this project is to demonstrate that Peruvian universities are able to cooperate and collaborate in a harmonic and fair mode, sharing duties and benefits along the project.

Designing and building a satellite, even one the size of a Cubesat, is a very complex task, combining multiple engineering disciplines and skills. The QB50 program provides the Peruvian engineering students with a hands-on design, build, test, and operations experience working on a real satellite project. Its interdisciplinary nature exposes the students to the broader issues related to systems engineering, and provides them with invaluable experience. The project will open the doors to Peruvian students for entering the fascinating and immense world of research and investigation with engineering topics for pre-graduate thesis, master thesis and even dissertations. It will also provide enough opportunities for practical training and complementary activities. The students will be involved in multidisciplinary activities during the CubeSat development. This considers not only the satellite design and building itself but also all other related supporting and testing activities. Until now more then 10 research topics related to the design, construction and operations of nano-satellites have been proposed to the students.

The possibility to participate in the QB50 project has generated a positive impact in Peru. The University of Puno (UNAP) has started the process to establish a Research and Investigation Centre for new technologies with emphasis in space engineering and related topics.

VI. Conclusion

The QB50 project will set a milestone in the history of the space age in Peru and Latin-America. For this reason the Peruvian Consortium envisages to be part of the QB50 program to promote this endeavour in the South American region. Getting the opportunity to join such an international project the Peruvian universities can demonstrate their managerial and technical capabilities working in a high professional environment. This will significantly contribute to motivate and impulse the space science and research in Peru where at the present the interest in this field is poor.

The realization and development of a space project in Peru, like as an academic satellite is nowadays possible. For the first time, a spacecraft – primarily designed and built by Peruvian professionals, engineers and students is going to be developed and launched into space. The intention of the work presented in this paper is to promote the use of space science and technology in the country giving the opportunity to several educational and research institutions to play an important role in this field. Raising this kind of technology in our country will contribute for a better future of the Peruvian society and industry.

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