

Sounding Rocket Program in Peru

J. Martin Canales Romero¹

Consulting Engineer, Space Agency of Peru, CONIDA, Lima, Perú

The National Commission for Aerospace Research and Development (CONIDA) is the space agency of Peru. Its mission is to promote scientific research, to develop space technology for national interests, and to create services for driving the national aerospace program. Moreover CONIDA has its own sounding rocket program. The development of such activities is for seeking ways to access space with an own national technological solution. CONIDA carries out this program in close collaboration with the local industry. The first “made in Peru” sounding rocket, named “Paulet I”, was a joint venture between CONIDA and the Peruvian Air Force. It was launched from Punta Lobos on December 27, 2006. A second version of this rocket lifted off September 2, 2009 carrying into space a payload of 5 kilo. The last 30th of September 2011 CONIDA launched the rocket X-PAX-II, designed and manufactured integrally in the South American country. It contained a payload weighing 6.5 kilo. Punta Lobos is the Peruvian launch site for sounding rockets and research balloons located at the central part of the western pacific coast at 12°30’S and 76°48’W. Because of its location close to the magnetic Equator from there significant experiments in cooperation with international institutions, like NASA and the Max-Planck Institute of Germany, have been carried out especially for investigations of the Ionosphere. Early missions with sounding rockets began in the 70s and ended in the 90s. Over 50 sounding rockets of the type Loki, Nike Orion, Taurus Orion and Taurus Tomahawk were launched there. Currently CONIDA and its engineers work on the development of solid propellant and perform static tests on small rockets in the installations of the above mentioned launch site. This paper has the goal to inform the space community about CONIDA’s past and present activities in this field.

I. Introduction

PERUVIAN space technology is still in its infancy. It will continue, for the moment, to rely on major foreign supporters for launch vehicle technology, expertise and launch capabilities however the development of home-grown space technology especially in rocketry has been defined as both a short-term and long-term projects.

As it is known, sounding rockets contribute to atmospheric investigations due to their low cost and their ability to conduct research in areas inaccessible to either balloons or satellites. Furthermore, the lead time for experiments is very short and payloads can be developed in only few months. Sounding rockets are also used as test beds for equipments and payloads that will be used later in more expensive satellite missions. The smaller size of a sounding rocket also makes launching from temporary sites possible allowing for field studies at remote locations, even in the middle of an ocean or at high latitude Antarctic sites.

Certainly, rocket technology offers 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 space programs. It is important for developing countries emerging in launch vehicle technology, to invest time and effort to access to space, its applications and spin-off technologies. The first steps and guidelines for the development, design and construction of launch vehicles have been performed by Peruvian government and research entities. In the last years sounding rocket projects have been initiated by some universities.

The aim of this paper is to present to the space community on the past and present activities in rocketry of the Peruvian space agency, National Commission for Aerospace Research and Development (CONIDA). The following sections provide a short description of what has been done in Peru. An overview of past and current activities related to sounding rockets performed by scientific and research institutions as well as by academia is also treated. What is

¹ Columbus Operations Coordinator, ESA Flight Control Team, GSOC - DLR, Martin.Canales@reip.org.pe

being done in this direction with contributions of Peruvian engineers who would like to guide Peruvian decision makers in order to strengthen the development of rocket technology for the industrialization of our country is as well presented.

II. Historical Path – From the Theory through Paulet I

Even if it is not known, research and activities related to aerospace topics have a very long tradition in Peru. The science of rocket design, development and flight was supported worldwide by the Peruvian engineer and scientist Pedro Paulet (July 2, 1874 in Arequipa, Peru – 1945 in Buenos Aires, Argentina) who in 1895 conducted experiments on a rocket motor made of vanadium steel that burned a combination of nitrogen peroxide and gasoline. The impulse of this engine reached some tens of kilograms and worked without deformations for about one hour. There are indications that actually Paulet had invented this first liquid fuel rocket engine at the Applied Chemistry Institute of the Sorbonne University, in France, where he graduated by the end of the 19th century. Analyzing the direct sources from the late 1920's among others, books and magazines from members of German Society for Space Flights (VfR, German abbreviations of Verein für Raumschiffahrt), it have been found that, at that decisive time in the history of space rocketry, Paulet's studies were an important reference for those German pioneers, specially for scientists and engineers who would construct the V2 missiles and later contribute to put the first men on the Moon. Paulet also worked on the design of propulsion systems and beginning of the last century he proposed a futuristic, for that time, spacecraft using thermoelectric batteries and propelled by rockets engines, called the Torpedo Plane. It was during the first decade of last century.

Decades later and to be precise almost one century after Paulet's achievements Peruvian engineers working for the National Commission of Investigation and Aerospace Development of Peru (CONIDA) followed the path of the Peruvian engineer developing and launching the sounding rocket Paulet I, which was named after the scientist.

During the second half of last century starting from 1960 there were projects conceived by Peruvian universities and scientific institutions in the field of rocketry. During the 70's the Geophysical Institute of Peru (IGP, for its initial in Spanish) has been extendedly working in the area of atmospheric research. A decade later national and international research institutes initiated projects related to the aerospace field. American research centers and also the National Aeronautics and Space Administration (NASA) started cooperating and working together with Peru in the area of sounding rockets.

III. National Commission for Aerospace Research and Development (CONIDA)

The National Commission for Aerospace Research and Development (CONIDA) plays the role of the aerospace agency in Peru and was established on June 11, 1974. Its mission is to promote scientific research, to develop space technology for national interests, and to create services for driving the national aerospace program.

The major tasks of CONIDA are:

- a) Promote in Peru the development and peaceful research in the space field.
- b) Organize studies, theoretical and practical research about space topics with national and foreign entities
- c) Conclude cooperation agreements with similar national and international institutions.
- d) Encourage the exchange of technology and support and execute the training of national specialists. Administrate the national law and legislation applicable to space.
- e) Support national and educational space projects.



A. CONIDA Fields of Research

The most important activities performed by CONIDA are:

1. Geomatics

The main objective of this research section is to promote the use of satellite data through development, transfer, and application of this technology to all sectors in the country in order to use natural resources efficiently and for improving the socio-economic activities in the country.

2. Sounding Rocket Program

The development of such activities is seeking ways to access space with an own technology. CONIDA carries out such activities since the 80's. Like it has been done in the past currently CONIDA does this in close collaboration with local industry and universities. Advance and improvement in the area of chemical propellants is undergoing.

3. Scientific Instrumentation

This is the unit in charge to develop a functional system and create a database for acquisition and storage of scientific and technical parameters taken during sounding rocket flights.

4. Astrophysics

The astrophysics section is devoted to the research and development of scientific projects and educational programs (basic and advanced levels) in the areas of solar physics, planetary systems and minor bodies, Sun-Earth connection (forecasts of climate and space environment, solar activity among others), stellar and galactic astrophysics, cosmic rays, space radio-astronomy and geophysics. CONIDA operates the Radio Solar Observatory at the base Punta Lobos (south of Lima) and is working on the implementation of an astronomical observatory in the city of Moquegua, south part of Peru, at an altitude of 4600 meters above sea level. Since 2007 CONIDA participates in the Latin American project for observation of high energy solar flares through a network of antennas in the VLF band. This project is known as the South America VLF Network (SAVNET).

5. Educational activities

The space agency coordinates programs in science education and pre-professional training for university students interested in astronomy and astrophysics. Other educational programs support the definition of research theses for undergraduate and graduate students to obtain master and doctoral degrees. CONIDA offers courses and workshops on astronomy and astrophysics for primary and secondary schools and university students. These are given by Peruvian astronomers as well as by invited scientists.

B. CONIDA Infrastructure - Launch Base Punta Lobos

After the foundation of the National Commission for Aerospace Research and Development (CONIDA) in 1974 the launch site Punta Lobos was established. Because of its location along the Pacific coast from 1970 through 1990 some international sounding rockets missions were started from this sea-side base. Currently this place is mainly used as a launch facility both for sounding rockets and stratospheric balloons. The launch site is part the national infrastructure of the Peruvian space agency.

The launch base Punta Lobos belongs to the Peruvian Air Force (FAP, for its initials in Spanish) and is located at the central part of the western pacific coast 70 km south of the Peruvian capitol Lima. The exact location of the launch base is latitude 12.50 deg and longitude 76.80 deg.

Punta Lobos is situated near the town Pucusana and Chilca and is very close to the magnetic equator of the Earth (Figure 2), making it an ideal location for scientists to conduct low altitude, upper atmosphere and ionosphere studies.

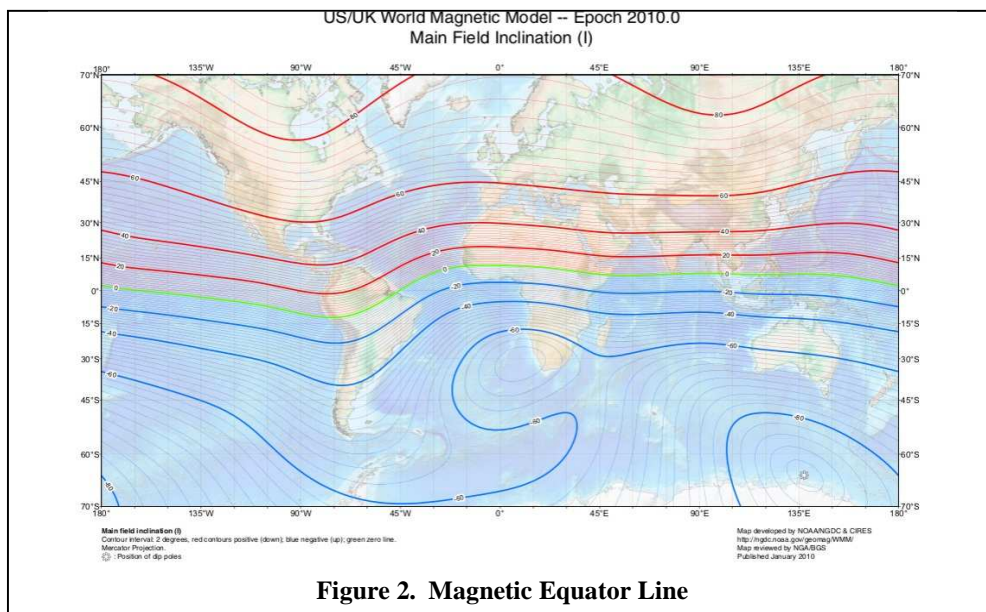


Figure 2. Magnetic Equator Line

This location was chosen as a launch station because of the term referred to as ‘geomagnetism’. It refers to the fact that Earth behaves like a magnet. That is why a compass needle always points towards “North”. In the northern hemisphere, the north-seeking end of a compass needle when freely suspended in the middle, would, in general, dip down. The angle by which the needle dips depends upon the latitude of the place. Similarly, in the southern hemisphere, the south-seeking end dips down. In between is a region where the needle does not dip at all. It remains strictly horizontal signifying that the dip is zero. The line joining all such points on earth where the dip is zero is called the magnetic equator.

Directly above the magnetic equator, at altitudes of around 110 km in the atmosphere, a system of electric currents exists. Known as the equatorial electrojet, this has always fascinated scientists. The closer you are to the magnetic equator, the better placed you are to study the electrojet. In the early 1960s, there were very few places in the world close to the magnetic equator with adequate infrastructure to support research in this field.

Punta Lobos infrastructure consists of a launching area which is located in an area about 1.5 km south west of the main building. All operations that are required from storage to preparation, assembly, integration, testing and launch of sounding rockets are performed in this area. The main building has offices for operational staff, the operations centre for sounding rockets and rooms for timing, telemetry and scientific instruments. Apart from standard tools and instruments, a variety of equipment for laboratory work is available for use.

IV. Beginning of a National Sounding Rocket Program

Peru possesses an even small space program than other neighbour countries, like Argentine and Brazil, though it has achieved some success in the development of sounding rockets. The sounding rocket program in Peru has also a well based background.

A. Rocketry Activities in the 1960s

At the beginning of the sixties two Peruvian universities, the National University of Engineering and the Catholic University performed static tests with small rockets. In July 1964, in the sands area of the Km 32 of the freeway between Lima and the town of Ancón, students and educators of the National University of Engineering launched five sounding rockets; these five rockets were built and developed in two academic projects: CFYM III and CFYM IV. Solid propellant was used for launching their vehicles.

B. Rocketry Activities - from 1970 until 1990

This section has the goal to shortly describe what has been done in Peru in the rocketry field starting from the seventies and going through the last decade of the 20th century.

During the first decade after its creation CONIDA began to cooperate and work with others space agencies investigating the equatorial ionosphere. The missions with sounding rockets began in the 70s and ended late in the 90s. Two major periods of usage of the Peruvian launch site can be defined. The first one from 1974 and 1983 and was mainly used for launching Arcas and Nike rockets.

As mentioned in the previous section because of its location close to the magnetic Equator from Punta Lobos in cooperation with NASA and foreign research institutions like the Max-Planck Institute of Germany significant experiments could be carried out especially for investigations of the ionosphere. Over 100 sounding rockets were started from Punta Lobos. During the 20 years service of this launch site used by international entities some rockets of the type Arcas (2.3 m long), Black Brandt (7.41 m), Nike-Apache (8.31 m), Nike-Orion (9 m), Nike-Tomahawk (10.8 m), Terrier-Malamute (12.7 m), Super Loki (3.16 m), Taurus Orion (11.4 m), and Taurus Tomahawk (9.38 m) were launched there.

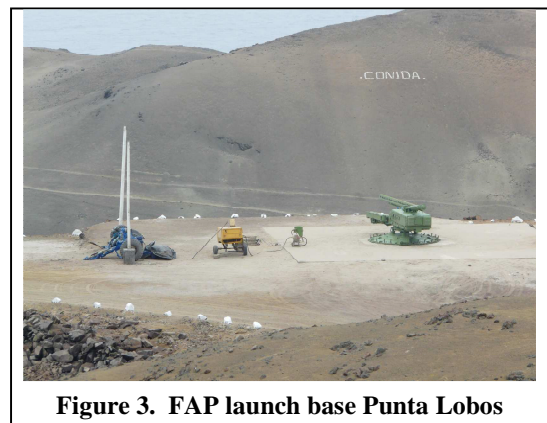


Figure 3. FAP launch base Punta Lobos

Hereafter are listed the sounding rockets missions launched from Peru. Also information about the research field and how many rockets started is given:

- 1) CROATAN: atmospheric research, 94 rockets were launched.

- 2) EQUION: ionosphere research, one rocket Black Brandt IV was launched.
- 3) ANTARQUI: atmospheric research at an altitude between 20 and 160 Km, several rockets and stratospheric balloons were started.
- 4) CASTOR in collaboration with the Max Planck Institute (Germany): atmospheric research at 280 km. Two CR4 rockets were launched (Figure 4).
- 5) 6687-II: atmospheric research of the stratospheric winds, 3 rockets were launched
- 6) CONDOR: ionosphere research, 29 rockets were started.



Figure 4. CASTOR in Punta Lobos

Within the principal objectives of atmospheric research following valuable contributions were achieved:

- In-situ measurements of upper stratosphere, mesosphere and lower thermosphere.
- In-site measurements for specific targets, including noctilucent clouds, thunderstorms, and the equatorial electrojet.
- Flight of scientific instruments with contribution of national research institutions.

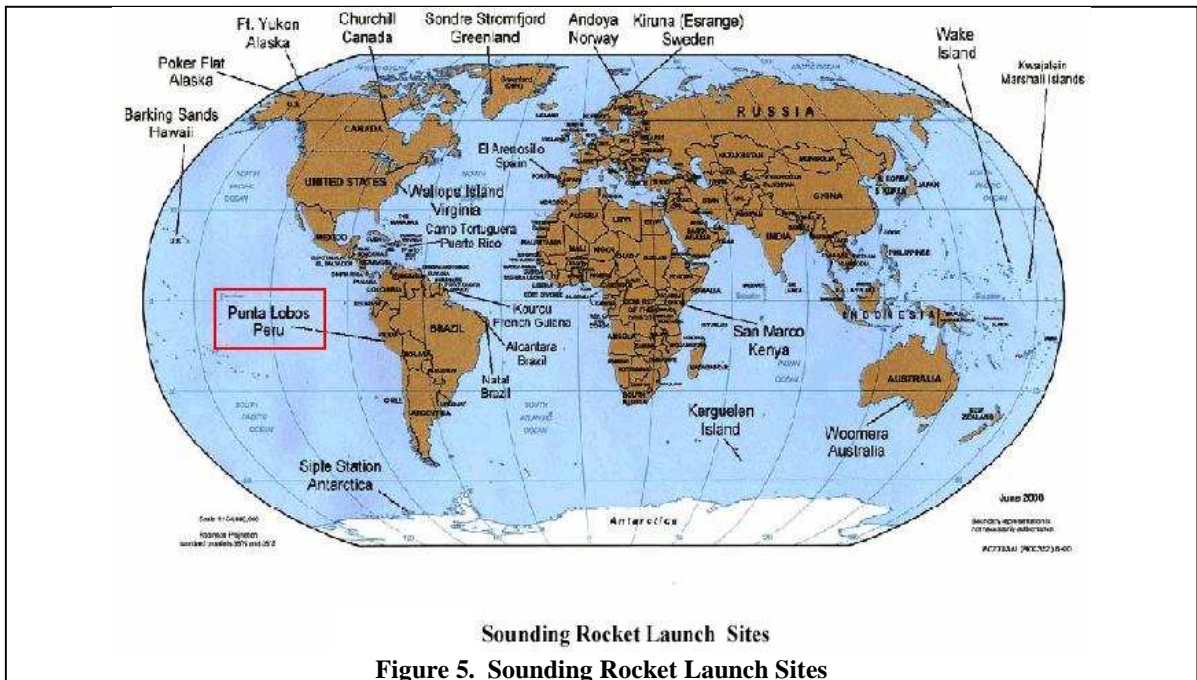


Figure 5. Sounding Rocket Launch Sites

The program purpose of preparing all the national capacities needed for a successful development in national rocketry was fulfilled. Figure 5 illustrates worldwide sounding rocket launch sites where the Peruvian sounding rocket launch base can be found.

C. New Age of Peruvian Sounding Rockets - "Paulet"

During the first decade of the 21st century CONIDA started working with the development of an own sounding rocket program. Research projects were executed together and in cooperation with the Geophysical Institute of Peru, NASA and foreign research institutes in 2004. The first sounding rocket launched in Peru was the "Terra LM". It was a small sounding rocket which reached 20 km altitude. It was a result of international cooperation on space activities between the Commission for Space Activities in Argentina (CONAE) and CONIDA.

In 2006 the first Peruvian space probe was launched from the Punta Lobos Air Force base. The rocket which took two years to be manufactured, carried devices that could measure conditions in the upper atmosphere, including

pressure, temperature and humidity, as well as astrophysics equipment. After the launch, the head of the Peruvian space agency, declared that Peru sought to develop its own space rocket program.

The sounding rocket “Paulet I”, launched on December 27. was the result of a joint venture between the Peruvian Air Force and scientific entities and was named in honour of the Peruvian engineer and scientist Pedro Paulet. It reached an altitude of 45 km carrying to space a payload of 2 kg weight.

Three years later followed the newest version of the last mentioned sounding rocket, the “Paulet IM” (2.8 m long), was launched on September 2, 2009 and reached 90 km altitude carrying 5 kilogram of payload.

The past 30th of September 2011 CONIDA launched the rocket X-PAX-II, designed and manufactured integrally in the South American country. It contained a payload weighing 6.5 kilo.

The space agency does continue working on its sounding rocket program and plans to launch in the following years an updated and enhanced version of the Paulet’s rocket serie. Future plans in this field includes the usage of the rocket Paulet IM for atmospheric research, measurements of air composition, investigations of the ozone layer and ionosphere effects produced under the influence of the sun.

CONIDA’s technicians and engineers do work on the development of solid propellant and perform static tests on small rockets in the installations of the above mentioned launch site.



Figure 6. Static Tests on Small Rocket Engines

V. A New Era for the Peruvian Sounding Rocket Program

In the recent years CONIDA has been signing agreements with others space agencies and research institutions in order to initiate future immediate space activities of mutual interest in a framework of technical cooperation in space science and space technology.

The central idea behind signing agreements and treaties is to start international cooperation for the peaceful use of the outer space. Bilateral cooperation agreements in space research projects have been started with Argentina, Brazil, South Korea, Germany and also Thailandia. After signing a memorandum of understanding with the German Aerospace Centre (DLR) in 2009 there were conversations on a first mission planned with the participation of scientific institutions of both countries. This would be a new sounding rocket mission with aim to launch two sounding rockets at an altitude of 250 km for performing atmospheric measurements and investigations. The participants in this project will be DLR, CONIDA, the Geophysical Institute of Peru (IGP), and the Leibniz Institute of Atmospheric Physic (Kühlungsborn).

Peruvian institutions will continue the development of sounding rockets and payloads. CONIDA and Peruvian academia will joint efforts to achieve this target in a short time. This will be an opportunity to educate and train the new generation of engineers and experts in this field. The development of a satellite launcher is also envisaged and is listed in the plans of the Peruvian space ambitions.



Figure 7. Sounding Rocket: Paulet I

VI. Conclusion

The realization and development of a space project in Peru, like as an enhanced sounding rocket program is nowadays possible. For the first time, space launch vehicles – primarily designed and built by Peruvian professionals and engineers is being developed and it will influence the utilisation of sounding rocket for bringing Peruvian technology into space. The intention of presenting this topic in this paper is to promote the use of space

science and rocket technology in the country giving the opportunity to several research and educational institutions to play an important role in this field. Raising this kind of technology in our country will contribute to strengthen the Peruvian industry. Peru participates in space related activities in the area of remote sensing and communications satellite systems with its neighbours countries of the Andean region however there is now the need to develop an own space technology. Based on the heritage of previous rocket programs we are now able to shape a well based space program. Once a well based space program is established it will bring Peru significant economic benefits and expertise through the exploitation of space applications and spin-off in industry, research and education. This manner Peru will also have the chance to participate directly in the preparation and planning of space activities in the South American region.

CONIDA and governmental institutions have started working on a plan to kick-off Peru's space adventure. If we are successful in our plans, at the end of this decade we could have significant progress in the space area. After that, we will have lifted the lid on limited belief towards what we can achieve in Peru.

Acknowledgments

The author would like to thank all contributors and supporters in Peru and especially those Peruvian engineers supporting as from abroad, involved in this challenging endeavour making reality the dream to establish and strengthen a sounding rocket program and a national aerospace program in Peru.

I would like to express my thanks to Mr. Thomas Kuch, Head of Missions Operations Department at the German Space Operations Centre, and the DLR administration. Without their support it could not be possible for me to attend the 12th International Conference on Space Operations.

References

¹ Mejia A., Canales Romero J. M., Estela J., "Pedro Paulet - Peruvian Pioneer of the Space Age", 43rd History of Astronautics Symposium, International Astronautical Congress, 2009.

² <http://www.astronautix.com/sites/punlobos.htm>

³ "La Agencia Espacial de Tailandia y la Agencia Espacial del Perú Firman Memorando de Entendimiento" [online database], URL: http://www.conida.gob.pe/prensa/PDF/2010/18012010_Tailandia.pdf

⁴ "Representantes de la Agencia Espacial Alemana Visitan CONIDA", [online database], URL: <http://www.conida.gob.pe/prensa/PDF/DLR.pdf>

⁵ "International cooperation in the peaceful uses of outer space: activities of Member States", [online database], URL: <http://www.oosa.unvienna.org/>