History of Rocketry and Astronautics

Proceedings of the Forty-Ninth History Symposium of the International Academy of Astronautics

Jerusalem, Israel, 2015

Tal Inbar, Volume Editor

Rick W. Sturdevant, Series Editor

AAS History Series, Volume 47

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 35

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2017

ISSN 0730-3564

ISBN 978-0-87703-639-5 (Hard Cover)
ISBN 978-0-87703-640-1 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 8

South American Space Era*

Bruno Victorino Sarli,† Marco Antonio Cabero Zabalaga,* Alejandro Lopez Telgie,† Josué Cardoso dos Santos,‡ Brehme Dnapoli Reis de Mesquita,§ Diego Mauricio Jiménez, Avid Roman-Gonzalez,†† Giancarlo Villena de la Cruz,‡‡ Natalia Indira Vargas Cuentas§§ and Federico Perazzo*****

Abstract

This chapter addresses the past and current efforts of the South American region in the space area. The space activities in the region date back to 1967, and since then South American countries have achieved a relative modest capability through their national programs and sometimes international collaboration, with

---

* Presented at the Forty-Ninth History Symposium of the International Academy of Astronautics, 12–16 October, 2015, Jerusalem, Israel. Paper IAC-15-E4.2.7.

† JSPS Research Fellow ISAS/JAXA and Regional Coordinator South America SGAC, Japan.

* Regional Coordinator South America SGAC, China.

† National Point of Contact SGAC, Chile.

‡ São Paulo State University and National Point of Contact SGAC, Brazil.

§ Federal Institute of Education, Science and Technology of Maranhão and member of the Space Generation Advisory Council, Brazil.

** National Point of Contact SGAC, Colombia.

†† Image Processing Research Laboratory (INTI-Lab), Universidad de Ciencias y Humanidades (UCH) and National Point of Contact SGAC, Peru.

‡‡ National Point of Contact SGAC, Peru

§§ National Point of Contact SGAC, Bolivia.

*** INVAP and National Point of Contact SGAC, Argentina.

the space activities in the region led primarily by the Brazilian and Argentinian space programs. In an era where missions explore the solar system and beyond, this chapter focuses on the participation of a region that is still at the early stages of its space technology development, but has a considerable amount to offer in terms of material, specialized personnel, launch sites, and energy. In summary, this work presents a historical review of the main achievements in the South American region, and by analyzing past and present efforts, it aims to project a trend for the future of space in South America. The chapter also contests current efforts of regional integration, such as the South American Space Agency proposal.

I. Introduction

Since the late 1950s, space has become another dramatic arena for countries to prove their technological superiority, military firepower and, by extension, their political-economic system. From 1967, in South America, Brazil started the first space activities in the region with the launch of Sonda I. Since then, South American countries have been developing space capacity individually to provide basic space-based services and small autonomy in this area.

As the countries in the South American region develop their activities, the most significant steps have been initiated by Brazil, Argentina, Peru, and Bolivia, among others. Brazil currently has a well-established institute of space research, one astronaut sent to the International Space Station (ISS) and ongoing efforts to develop its own launch capability. Argentina, on the other hand, is currently working on the construction of Tronador II, a light payload satellite injector, based on previous models Tronador Ia and Ib successfully launched from Puerto Belgrano naval base. In Peru, the national aerospace research and development commission (CONIDA) launched the first space Peruvian probe, Paulet, from Punta Lobos air force base in Pucusana in 2006. Bolivia is also making its mark in the sector; with its first telecommunications satellite in 2013 and recent efforts to develop a remote-sensing satellite. In 2011, Chile put into orbit its Earth Observation satellite SSOT/FASat-Charlie that provides the best resolution in the South American region.

The space programs in South America not only address a technological gap, but also offer a chance to inspire people and bring to their attention the potential and benefits of the space sector. This chapter provides a historical review of the evolution of the space activity in South America and its relation with historical and political aspects, as well as important steps that need to be taken to further develop the space sector in the region. This chapter directly addresses the outcomes of the Defense Ministers meeting of the Union of South American Nations (UNASUR), in November 2011, where the representatives collectively deemed to prioritize the creation of a South American Space Agency and its collaboration through UNASUR.

Section II discusses the South American Space Agency and the UNASUR. The following sections from III to VII present, individually, a historical review of the main accomplishments of each country. Section IX considers past achievements and approaches to project future trends and collaborations. And the final section discusses the main points of this chapter, outlining the most significant aspects.

II. The South American Space Agency

The Union of South American Nations is an intergovernmental union targeted to better integrate the South American region integrating. In essence, the union joins two already established customs unions: the Mercosur and the Andean Community of Nations (CAN). The UNASUR Constitutive Treaty[1] was signed on 23 May 2008, with Uruguay ratifying the agreement on 1 December 2010 as the last remaining country. The enrollment of the entire region gave the union full legality with the Constitutive Treaty reaching force on 11 March 2011, thus making UNASUR a legal entity.

The VI Conferencia Espacial de las Americas (CEA), held in Pachuca, Mexico, in November 2010, approved the Pachuca Declaration, in which the creation of a Space Technical Consulting Group brought together representatives of the national agencies or government bodies in charge of space affairs. This working group aimed to support the CEA and its executive secretariat. It was, in part, based on the works of this group that in November 2011 the defense ministers of Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Surinam, Venezuela, and the deputy-minister of Uruguay agreed on the creation of a South American Space Agency during a meeting of the Defense Council of UNASUR. Goals for this agency will be to focus efforts, to place satellites into orbit using a regional launch vehicle, and to reduce costs and increase technological capabilities. In accordance with the United Nations Outer Space Treaty,[2] all the activities will be for peaceful uses.

Inside the framework of the agency, Argentina proposes the intention to use a regionally developed launch vehicle, which aligns with the national Tronador project. However, some of the South American countries are resistant to the proposal. Nevertheless, the goal of technological cooperation on the satellites area seem to attract more attention of the Member States. The Argentine Defense

Ministry indicated, in the November 2011 meeting, its interest in developing a space agency project with UNASUR. Brazil has positioned with caveats on the proposal, due to the costs involved in creating new structures as well as the non-military characteristics of the Brazilian space program, different from what was proposed. The main Brazilian argument is the disparity of the South American space capabilities would reduce the country's advantages. However, the development of the Alcantara Launch Center is a strong motivation, which would allow Brazil to develop a regional center for final assembly, testing, launch, control, and tracking.

Nowadays, there is a group of people in different governments pushing for the creation of this regional space agency. However, at the present day, the heads of the government have yet to agree or dedicate funding for its creation. The South American Space Agency remains a goal that is being pursued in the region.

III. Argentina

Argentina's first activities in the space field date back to 1961, when the National Commission for Space Research, Comisión Nacional de Investigaciones Espaciales (CNIE), was first established within the Argentine Air Forces. A civil engineer, Mr. Teofilo Tabanera, conducted the beginnings of the new entity as its first president. National Commission for Space Activities (CONAE) Space Center in the province of Córdoba has been named in his honor. CNIE, working with local and international partners, carried out the first southern hemisphere scientific atmospheric physics using rockets and stratospheric balloons. Together with the Argentine Institute of Aeronautics and Space Research, CNIE designed and constructed a family of one- and two-stage sounding rockets, the Orion, Rigel, and Castor, which were launched from Chamical, in the Province of La Rioja.

The first Latin American course on space survey matters was organized by CNIE at the Bariloche Atomic Center, located in the Province of Rio Negro. NASA scientists and experts from Harvard, Iowa, and Rice Universities lectured as part of the course, which was amply attended by Argentine professionals as well as by Brazilian, Chilean, and Colombian colleagues. In 1991, the Argentine government decreed the creation of CONAE as a civil entity reporting directly to the President. Since 1996, this specialized agency accomplishes its mission governed by the Ministry of Foreign Affairs. The progress has continued through to today with the development of new satellite technologies within the government and private sector, reinforcing that Argentina is indeed an actor in the international space community. Therefore, it's important to bring new players and dedicated individuals to collaborate and develop new ties with the international space community.

Table 8–1 shows the chronology of the major events of the Argentinean Space Program.

Year	Event
1996	Launch of the SAC B satellite
1998	Launch of the SAC A satellite
2000	Launch of the SAC C satellite
2011	Launch of the SAC D satellite
2014	Launch of the ARSAT 1 satellite
2015	Launch of the ARSAT 2 satellite

Table 8–1: Main space-related events in Argentina (1996–2015).

IV. Bolivia

February 10, 2010, marked the day Bolivia officially began its journey into the space era, initiated by the promulgation of Supreme Decree 0423.

The Bolivian Space Agency, Agencia Boliviana Espacial (ABE), has aims to manage and execute the implementation of the satellite project, Tupac Katari, allowing Bolivia to enter the space sector with a communications satellite, constructed in China. The satellite simply acts as a large mirror, forwarding and amplifying the signals of Internet, telephony, and television to call centers around the country. The Internet and telephony are transmitted by the VSAT antennas, and the television is only transmitted through DTH antennas.

Additionally, the ABE has the following specific functions:[3]

- Promote the development of new satellite and space projects.
- Promote technology transfer and training of human resources in space technology.
- Promote the implementation of the satellite applications for use in social programs, productive programs, defense programs, environment programs, and others.

In August 2010, with the issuance of Supreme Decree 0599, ABE became a Strategic National Public Enterprise with legal personality, of an indefinite duration, with its own assets, autonomy of administrative, financial, legal, and technical management, under the custody of the Ministry of Public Works, Services and Housing. On 23 December 2010, the Bolivian government and the Development Bank of China signed a contract to build the Bolivian satellite.

At 12:45 pm on Friday, 20 December 2013, the Tupac Katari satellite was successfully launched reaching an altitude of 10,000 kilometers above the Earth to enter its first orbit.

In Bolivia, technicians of Amachuma, the Earth station in the city of El Alto, reported the first satellite signals were received, commenting that "Bolivia enters at the space age." Bolivia had officially entered the small privileged group of nations with its own satellite. Thanks to the Bolivian International Media, the public of Bolivia could appreciate this historic launch. As of March 2014, the satellite began operations to provide services to Bolivian and foreign companies.

The Tupac Katari space program has three fundamental building blocks that are interconnected:

1. Geostationary satellite.
2. Two ground stations of control and operation in Amachuma (La Paz) and La Guardia (Santa Cruz).
3. Thousands of telecenters at the national territory.

Among the main uses and benefits of the Tupac Katari satellite provides basic tele-education—higher level (video conferencing) and educational channel (TV)—as well as telemedicine services. By the end of 2014, Bolivia had the goal of installing 2,500 telecenters in small rural towns across the country, where there was no means of communications infrastructure. Each telecenter will consist of a VSAT antenna of 1.8 meters in diameter, five computers, a television, and a telephone. To operate the satellite Tupac Katari, the top 64 young professionals from Bolivia were selected, 20 electronic engineers, 18 telecommunications engineers, and 16 systems engineers; all of whom received scholarships for intensive theoretical and practical training in the construction and management of satellites in China, at the CAST Shenzhou Institute.

Table 8–2 presents a historical summary of Bolivia's main space achievements.

Year	Event
2010	The Bolivian Space Agency is created. Contract with the satellite designer is signed.
2012	A group of 64 professionals are sent by the Bolivian government to be trained in the design and operation of the satellite in China.
2013	Tupac Katari communications satellite is launched.
2014	Tupac Katari starts operations.

Table 8–2: Main space-related events in Bolivia (2010–2014).

V. Brazil

"My earnest desire is to see true Aviation Schools in Brazil. See the airplane—today powerful weapon of war, tomorrow through great transport—covering our vast regions, populating our sky, where, first, looked up..."*[4]

This quote, translated from Santos-Dumont at the beginning of the 20th century, shows one of the first initiatives of starting activities related to the aviation sector, later leading to the development of space activities in Brazil. The region referred to in the extended quote (Valley of Paraíba in state of São Paulo), later received important schools, institutes of research, and industries that correspond to the main center for aerospace activity in Brazil. Among some of them are the National Institute for Space Research (INPE), Embraer, and several other industries of the aeronautical and aerospace sector, such as Technological Institute of Aeronautics (ITA) and Institute of Aeronautics and Space (IAE).

The period when the space sector started to obtain more interest from the Brazilian government was during the period of military rule, which began in 1964 and continued for 20 years. In this period, Brazilian space activities were at preliminary stages and were under military supervision,[5] like other activities of the country. After the end of this period, the expansion of the activities of the INPE[6] (now attached to the Ministry of Science, Technology, and Development) and the creation of undergraduate and postgraduate studies in nonmilitary institutions, the creation of the Brazilian Space Agency (AEB), the Brazilian Aerospace Association (AAB), and the Brazilian Association of Aeronautical and Space Law (ABDAE) contributed significantly to the expansion of space activity in Brazil. Today, there is greater freedom within this sector than in the period of military supervision, allowing its greater expansion and technological development, due to more interactions and contributions from academia and the industries.

More recently, Brazil has two launch sites, Alcantara Launch Center and Barreira do Inferno Launch Center, the latter of which manufactures, assembles, and tests sounding rockets, satellites, and rocket engines. Brazil is currently also developing a launch vehicle nationally and a second launcher family in collaboration with the Russian Federal Space Agency. With support from IAE and the aerospace industry, Brazil has designed and produced a successful set of probe vehicles. These rockets have provided the realization of numerous scientific and technological experiments. The field of probe rockets technology formed the ba-

* Meu mais intenso desejo é ver verdadeiras escolas de aviação no Brasil. Ver o aeroplano - hoje poderosa arma de guerra, amanhã meio ótimo de tranporte - percorendo as nossas imensas regiões, povoando nosso céu, para onde, primeiro, leventou os olhos..." Santos- Dumont.

sis for the development of a Satellite Launch Vehicle (SLV), an artifact of four stages, with about 50 tons at take-off, capable of launching satellites from 100 kg to 350 kg in altitudes of 200 km to 1,000 km.[7] The operational vehicles of this class of probe rockets are used for suborbital space exploration missions and are capable of launching payloads composed of scientific and technological experiments. The rockets are adequate for the current national research needs and have a history of successful launches. These projects began in 1967, when the rocket Sonda I, Brazil's national rocket performed its inaugural flight in Barreira do Inferno Launch Center. During a period of 12 years, over 200 rocket experiments of this type have been performed. The incentives to involve universities and research centers in the space program are resulting in an increased demand for these vehicles, which has led to the continuation of its production.

Satellites developed under this program were the SCD-1 and 2 (the Data Collection Satellite), launched in 1993 and 1998, respectively.[8] Moreover, China and Brazil signed a cooperation agreement for the development project known as Satellite China-Brazil Earth Resources Satellite (CBERS) in July 1988.[9] The CBERS satellites are intended to monitor climate change, water resources management, and images for licensing, among other applications. Their images are used in Brazil by private companies and institutions, such as IBAMA, INCRA, Petrobras, Aneel, Embrapa, and government administrations.[10] Three satellites are being developed by INPE, responsible for implementing the projects Amazonia-1, which will be used for imaging of the Amazon region, Sabia-Mar developed in cooperation with Argentina for ocean studies, and GPM-Brasil, for meteorological studies.[11] The operations of SCD and CBERS satellites also are performed by INPE.

Table 8–3 shows the chronology of the major events of the Brazilian Space Program until July 2015.

Year	Event
1961	Creation of Organizing Group of the National Commission on Space Activities (GOCNAE).
1963	The GOCNAE becomes the National Commission on Space Activities (CNAE).
1965	Inauguration of the launch center of Barreira do Inferno (CLBI).
1967	Launch of the rocket Sonda I at CLBI.
1969	Launch of the rocket Sonda II at CLBI.
1971	Extinction of CNAE and establishment of the Institute for Space Research, today the National Institute for Space Research (INPE); creation of the Institute for Space Activities Center, at CTA, today DCTA.
1983	Inauguration of Alcantara Launch Center (CLA).

1988	Brazil and China sign cooperation agreement for the development of Chinese-Brazilian Earth Resources Satellite (CBERS).
1993	Launched the first Brazilian satellite, the Data Collection Satellite (SCD-1) with a mission to collect environmental data.
1994	Creation of the Brazilian Space Agency (AEB).
1997	First test flight on the satellite launch vehicle of Brazil (VLS-1) at CLA.
1998	Launched of the Brazilian satellite SCD-2.
1999	CBERS-1 satellite is launched; flight of the second prototype of the VLS-1; launch of scientific microsatellites SACI 1 and SACI 2.
2003	Accident with the third VLS-1 prototype at CLA; launch of CBERS-2.
2006	Realization of centenary mission in honor of the centenary of the first manned flight of an airplane, the 14-BIS by Santos-Dumont. The main objective was to send the first Brazilian astronaut, Marcos Pontes, into space by a Soyuz spacecraft to conduct experiments aboard the International Station Space (ISS).
2007	Launch of CBERS-2B.
2013	Launch of CBERS-3.
2014	Launch of the first Brazilian nanosatellite, the NanosatC-Br1; launch of CBERS-4.
2015	Launch the first CubeSat fully developed in Brazil, the AESP-14.

Table 8–3: Main space-related events in Brazil (1961–2015).

It is important to include two additional innovative and successful activities being performed in the Brazilian space sector:

1. The ASTER mission,[12, 13] the first Brazilian deep space mission that intends to send a spacecraft to investigate a triple system formed by three asteroids (2001SN263). The program also seeks cooperation with the Russian Federal Space Agency and is budgeted to be a few tens of millions of dollars, but there is yet to be fundraising. If this mission is successful, Brazil will become the fifth space power to send a spacecraft to an asteroid, behind the United States, European Union, Japan, and China, and the first to send a spacecraft to a triple asteroid system.

2. The work of IAE and the national industry producing a set of suborbital vehicles,[14, 15] including the Sonda series and the VS series. The main characteristics that distinguish sounding rockets and other vehicles to access space is low development costs, ease of launch, speed in accomplishing the mission, reusability of rocket experiment, and recovery and flexibility of the launch site. For this reason, these vehicles serve the wide variety of applications, as well as providing a microgravity environment for several minutes, which provides research opportunities in a wide variety of disciplines, such as materials science, fluid physics,

biology, astronomy, geophysics, atmospheric sciences, among others. It is estimated that the Sounding Rockets Program of the National Aeronautics and Space Administration (NASA) and ESA Microgravity achieve more than 50 launches of suborbital vehicles per year, supporting scientific and technological research.

According to the National Program of Space Activities, the objective of development of space research in a strategic scenario for the next decade includes the following topics:[16] the program for the development of critical technologies; the actions of technological absorption in the development of the Geostationary Satellite Defense and Strategic Communications (SGDC); the new directions for the Sectoral Funds; the National Defense Strategy (END); actions of the Sectoral Technological Schedule (ATS) in the context of "Plano Brasil Maior"; the special role of the Science Without Borders program for space research; legislative initiatives for the unburdening of the sector, among other government actions.

VI. Colombia

The following represents a summary of the space-related activities in Colombia. The country has always worked with organizations developing aeronautic technologies, and more recently, efforts have been made in the development of the space sector. The developments are provided in a chronological manner, and the main milestones are summarized in Table 8–4.

In November 1971, Colombia signed the United Nations Outer Space Treaty, which was recognized by the Colombian Supreme Court in November 2013. Colombia also signed the agreement to register satellites in orbit in November 1974, whose approval by the Colombian Supreme Court took place in April 2013.[17]

In 2006, the Colombian government created the Colombian Space Commission (Comisión Colombiana del Espacio—CSC) whose main goal is to provide access to space technologies in telecommunications, remote sensing, and navigation. The CSC has seven work groups to achieve its objectives, among which are satellite navigation, remote sensing, astronautics and astronomy, knowledge management, telecommunications, space policy, and geospatial database.[18]

In 2007, the Sergio Arboleda University launched the Libertad I, the first Colombian satellite in orbit. The Libertad I is a picosatellite of approximately 1 kg, and its main goal was to perform technological demonstrations of the Colombian capabilities in space systems.[19] The mission successfully accomplished all its goals and until now remains the only Colombian satellite in orbit.

The Colombian presidency created the Presidential Program for Space Development in November 2013, aiming to lead the projects to promote universities and companies to enroll in the space development in the country.[20] This commission continued working toward the acquisition of a remote-sensing satellite,[21] until the government cancelled the Presidential Program for Space Development in 2014, arguing that it was cheaper to buy remote-sensing data from third parties instead of buying and operating its own satellite.[22]

In December 2014, Bolivia launched two high-altitude balloons with four scientific experiments onboard, three of which were conducted by the University of Antioquia and one by a group of primary school students from a public school from Medellín.[23] This mission was designed and executed by the local Columbian company, Ideatech.[24]

The University Sergio Arboleda is currently leading its second nanosatellite design and development, which will be called Libertad II,[25] and the same university projects further developments in the near future. At the same time, other universities around the country are considering devoting part of their budgets and working hours to develop their own nanosatellites.[26]

In 2015, Ruta N (Medellín's Science, Technology, and Innovation Foundation) launched the program Medellín Espacial (Medellín in Space), which will support startups and university research projects working on business ideas in the aerospace industry based in the city of Medellín.[27]

Year	Event
1971	Signature of the Outer Space Treaty.
2006	Creation of Colombian Space Committee.
2007	Launch of first Colombian nanosatellite—Libertad I.
2013	Creation of Presidential Program for Space Development.
2014	Cancelation of the Presidential Program for Space Development and the Colombian Remote Sensing satellite.
2014	Launch of two high-altitude balloons carrying four scientific payloads.
2015	Medellin in Space Program is created.

Table 8–4: Main space-related events in Colombia (1971–2015).

Colombia is still at a very early stage in its space-development projects, since the country still lacks having one operational satellite like other Latin American countries have now. This fact shows the urgent need to transform the Colombian Space Committee into a formal Space Agency that promotes the development of equipment and space technologies acquisition.

On the other hand, the academic and private sectors have been the actors who have focused on the development of space technologies in Colombia, which highlights the need to make the Colombian government more actively involved managing in financially supporting these types of initiatives.

VII. Chile

From the late 1950s, Chile has played a role in the space activities of other major countries providing ground support. There is not much published information about the developments of activities in Chile, hence this section's author has used what was available and benchmarked it with its knowledge from work at the Agencia Chilena del Espacio (Chilean Space Agency) during 2010. The developments are provided in a chronological manner, and the main milestones are summarized in Table 8–5.

In 1957, two ground stations were installed, the first in Salar del Carmen (near Antofagasta) and the second in Peldehue (north of the capital Santiago). Both stations were part of the US Army's Minitrack Network.[28] This is considered the first milestone for Chilean involvement in space activities. With the launch of Sputnik I, on 4 October 1957,[29] the station capabilities were verified. With the creation of NASA in 1958, these ground stations were passed to civilian operators (for Chile, this was the University of Chile). Technological developments in 1963 saw the station at the Salar del Carmen closed, while Peldehue reached a peak of about 200 employees during the 1970s. It remains open with fewer personnel to date, after being sold to the Swedish Space Corporation in 2009.[30]

Later in 1968, the national telecommunications company Entel started to operate its Longovilo ground station for telephone and data via satellite. This was the first of its kind in South America, and it allowed Chile to receive the signals of the Moon landing in 1969.[31]

In 1973, Chile joined the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), and its counterpart has always remained at the Foreign Affairs Ministry. Chile has participated in UN COPUOS sessions and has signed and ratified all five space treaties.[32]

In 1980, the Committee for Space Matters (Comite de Asuntos Espaciales) was created under the Defense Ministry with the objective of proposing a text for the National Space Policy as well as the law to create a space agency. This committee had evolved over the years with different names, becoming the Presidential Advisory Commission, known as the Chilean Space Agency in 2001.[33] It remained under the defense sector until 2009,[34] when it was moved to the Under

Secretariat of Economy (a civilian ministry with the idea of fulfilling Chile's obligations under UN COPUOS). In December 2011, the agency dissolved as no budget was allocated for its functioning.

Following the developments of the US Space Shuttle program in 1985, the Mataveri agreement was signed. Under this agreement, NASA enlarged the Easter Island airport runway to be used as backup for emergency Shuttle landings from near polar missions/orbits. However, the site was never used for the landing of the Shuttle.

During the 1990s, an agreement was signed with the German Aerospace Center (DLR) to support the operations of its antenna located in Antarctica, 30 meters from the Chilean Army's base, O'Higgins. Under this agreement, the radar images from ERS-1 and ERS-2 were downloaded at the station.

On 31 August 1995, FASAT-ALFA, the first Chilean satellite developed by the Air Force at the University of Surrey was launched into orbit. Unfortunately, issues with the separation mechanism didn't allow it to deploy. After this failure, and using the insurance, the development of FASAT-BRAVO was immediately started. This was successfully launched on 10 July 1998 and successfully fulfilled its mission of contributing to the scientific development of the country.[35] After the launch of FASAT-BRAVO, satellite developments took a long break until the process for procuring the third Chilean Satellite, SSOT, in 2007.

In July 2008, the contract for the construction of SSOT, also known as FASat-Charlie, was signed with EADS (now Airbus group). The satellites were launched with a delay of two years on 16 December 2011. With its resolution of 1.45 meters in panchromatic and 5.8 meters in multispectral, the optical satellite offered the highest resolution in South America.

After a period without a space agency, a high-level body was created in 2014 by the Ministerial Council with the tasks of promoting and developing space activities.[36]

The Defense Minister as well as the Ministerial Council has announced the process for replacing the Earth Observation Satellite, which is coming to an end of its orbital lifetime toward the end of 2016. Also, a new space agency should be created under the "new" Science and Technology Ministry to be created next year.[37, 38] There are also discussions regarding a communications satellite, which are fueled by the experienced loss of communications during the 2010 earthquake in Chile.

Year	Event
1957	First ground support stations installed in Chile as part of the Minitrack network.
1968	National telecommunications company started operations of its ground station for telephone and data via satellite (first of its kind in South America).
1973	Joined UN COPUOS.
1980	Creation of committee for space matters.
1985	Mataveri agreement for use of Easter Island runway as backup for US Space Shuttle polar mission emergency landings.
1995	Launch of first Chilean satellites FASat-ALFA, built at University of Surrey (unsuccessful deployment).
1998	Successful launch of FASat-BRAVO.
2011	Launch of SSOT/FASat-Charlie.
2015	Discussion on the replacement of SSOT.

Table 8–5: Main space-related events in Chile (1957–2015).

Since 1980, with the creation of different committees, several attempts to form a national space agency have failed. The defense side of space, has been covered by three satellites being already procured using its own budget, however the civilian side continues to remain limited. Hence the main mission is to gather political support to allocate a long-term budget to be administered by a civilian space agency with a mid- to long-term strategy.

The latest developments, new satellite process, and reactivation of the agency under the Science and Technology Ministry, point in the right direction. The key for the successes of this endeavor will be to attract young professionals, who with the appropriate political and monetary support could lead the country to develop its full potential in terms of space applications and research.

VIII. Peru

The following represents a summary of the space-related activities in Peru, which has recently experienced an important growth in the space sector. Peru has a long history in aerospace activities.

In 1895, the Peruvian engineer and scientist Pedro Paulet designed and built the first liquid fuel engine. At the beginning of last century, Paulet proposed a futuristic, for his time, spacecraft propelled by rockets called the Torpedo Plane.

The National Commission of Investigation and Aerospace Development (CONIDA) plays the role of the aerospace agency in 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. The major tasks of CONIDA are as follows:

- Promote in Peru the development and peaceful research in the space field.
- Organize studies, theoretical and practical research, about space topics with national and foreign entities.
- Conclude cooperation agreements with similar national and international institutions.
- Encourage the exchange of technology and support and execute the training of national specialists.
- Administrate the national law and legislation applicable to space.
- Support national and educational space projects.[39]

On 4 July 2015, Peruvian Defense Minister Jakke Valakivi announced the construction of the National Satellite Imagery Operations Centre, Centro Nacional de Operaciones de Imágenes Satelitales (CNOIS). CNOIS is being built at the Peruvian Air Force's Punta Lobos logistics base in the Pucusana district, about 40 miles (64 km) south of Lima. CNOIS is part of a PEN600 million (US$188 million) government-to-government contract with France signed in 2014.[40]

On 12 June 2013, Peru successfully launched its first rocket built with 100 percent Peruvian technology with the capacity to reach the stratosphere, at the scientific base of Punta Lobos in Pucusana, south of the country's capital, Lima. The manufacturing of Paulet 1-B was a milestone in Peru's aerospace industry, because it was the first time that a device built solely with Peruvian technology was launched into space.[41]

The Peruvian Institute of Radio astronomy of Pontificia Universidad Catolica del Peru University developed two satellites (one pico and one nano) with academic and research in space science and engineering purposes. The PUCP-Sat 1 and Pocket-PUCP were launched into orbit from the Russian Baikonur Yasny, with academic and research in science and space engineering purposes, the construction of which was attended by teachers and students of the specialties of physics, mechanical engineering, electrical engineering, and telecommunications engineering.[42]

On 4 February 2014, during the 181st spacewalk for assembly and maintenance of the International Space Station (ISS), Russian cosmonauts Alexander Skvortsov and Oleg Artemyev released by hand a 1-kg Peruvian nanosatellite, dubbed Chasqui 1. Students at the National University of Engineering in Peru built the satellite for gaining experience in satellite manufacturing and Information and Communication Technology (ICT). The satellite was designed for

Earth observation and will deliver pictures of Earth to a designated ground station.[43]

NASA launched a cube-shaped satellite designed by students and faculty from Peruvian university Universidad Alas Peruanas. The satellite, known as UAP SAT-1, was sent into space inside Orbital Sciences' Antares rocket from NASA's Wallops Flight Facility in Wallops Island, Virginia, about 1300 (Peru time) Thursday, 9 January 2014. The UAPSat-1 weighs less than a kilogram and is programmed to return data regarding its status and environment by means of amateur radio broadcasts. The project has been underway since 2010 and represents an investment of over US$500,000.[44]

Table 8–6 presents a historical summary of Peru's main space achievements.

Year	Event
1895	Peruvian engineer and scientist Pedro Paulet (1874–1945) designed and built the first liquid fuel engine.
1974	Foundation of the National Commission of Investigation and Aerospace Development of Peru (CONIDA).
2013	Launch of CONIDA—PAULET 1-B Rocket. Launch of PUCP-SAT satellite, built at Pontificia Universidad Catolica del Peru.
2014	Launch of satellite Chasqui-1, built at Universidad Nacional de Ingenieria. Launch of UAPSat-1 satellite, built at Universidad Alas Peruanas.
2015	Construction of National Satellite Imagery Operations Centre (CNOIS).

Table 8–6: Main space-related events in Peru (1895–2015).

IX. Conclusions and Future Trends

The success of Europe in space following the success of the United States and the former USSR motivated South American nations to institute long-term space technology efforts for both space access and utilization. Today, space access is available to virtually any nation willing to purchase a launch, and competitively offered by more than eight nations that are able to provide a launch vehicle for payload delivery. Launch suppliers today include the United States, Russia, Ukraine, China, Japan, India, ESA Member countries (France and Italy), and several additional nations following closely behind with their own government-sponsored launch vehicles.

Today, worldwide launch rates are appreciable and sustained. It is worth noting that the mix of missions among the three major types is shifting toward an increased diversity of missions, sponsors, and providers. In looking closer at this mix, we can identify noteworthy trends about an emerging international industrial base for space products and services manufactured in South America.

Even though some countries can rent a launching site, or share a compartment with the payload, especially in the case of nano and pico satellites, like in the most recently launching of Tita, the third Argentinian nano satellite, using a Russian rocket that also carried another 30 satellites from different countries. Despite space activity in the South American region not being strong,[45] the idea of possessing a launching site for LEO and GEO orbits, could bring the same benefits that they have brought for other countries in the world.

Space Launch Infrastructure and Activity

One of the biggest challenges for South America is undoubtedly to develop a launching site. ETO-launch providers include governments and corporations located on three of the seven continents of the world (North America, Europe, and Asia), and are the product of aggressive R&D from national space agencies. Both new and derivative models of launchers have evolved per individual nation's space policies and strategies. Their respective launch sites are located close to the equator on land, coastal areas, and even on the ocean itself. A review of this diversity of capability is an integral part of understanding South American trends and the possibility to rely on its own regional launch capability. As South America continues to shape up as a hotbed for the satellite industry, Venezuela is looking to become a more relevant player in this market. With two satellites already launched, and more ambitious space projects in the pipeline, the country is quickly becoming a pioneer for developing a space-based capability in Latin America.[46]

Peru launched the Mars desert research station[47] as an activity to simulate life on Mars, promoting a new culture and involving different sectors of the academy in this ambitious idea. The ARSAT-1 was the first satellite constructed with local technology in Latin America[48] in 2014. Bolivia's long-awaited first foray into space took place in China, when the Asian superpower launched the Andean nation's Tupac Katari the first telecommunications satellite.[49] One of the most significant events that shocked the space community was when Brazil opted to unilaterally cancel the bilateral accord reached with Ukraine in 2003 to build a joint center for launching satellites at Brazil's Alcantara aerospace base.[50]

Economic Incentives for Cooperation

A space project in the region requires a large budget and effort to be reached. UNASUR has a clear ambition to reach an integral level of cooperation on multiple levels among its member countries, based on the social dimension of integration and the local needs of each of the member countries.

One of the objectives of UNASUR is to promote a better integration between space agencies in South America. The region undergoes an important moment of democratic stability and social progress, which is a consequence, among other factors, of the benefits resulting from the political coordination among the countries. The organization has proved to be possible in order to strengthen integration and find consensus, respecting plurality.

The group's ability to cooperate is affected by the disproportionate size of Brazil's economy, which accounts for about 60 percent of UNASUR's total economic output. World Bank data shows that Brazil is a country with the strongest internal market in South America and the least trade-dependent economy in UNASUR, as seen in Figure 8–1.

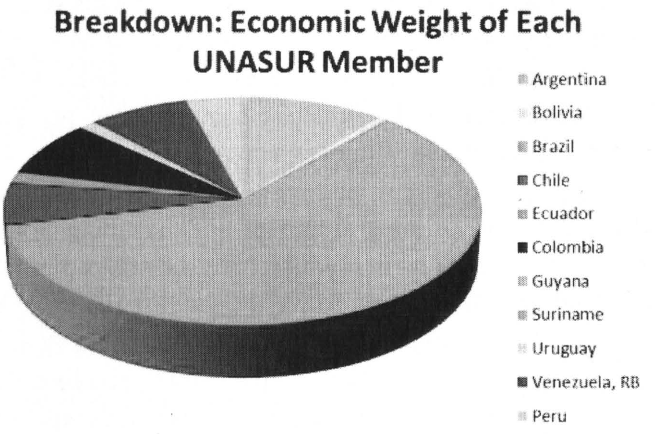

Figure 8–1: World Bank world development indicators database figures for 2011.[51]

Shared Vision for Space Utilization

The socio-techno-political expansion in South America[52] may reflect the industrial space age depending first on the national strategic and economic interests of prospective participants. Unfortunately, the enabling technological infrastructure for future collaboration appears to not be maturing rapidly and strengthening until now. More ambitious and long-term endeavors on spaceflight will rest on government resources, yet here too, there appear to be more options for government customers in terms of suitable launch vehicles and launch sites around the world. National governments and their respective space agencies need to make concerted efforts to leverage South American experience and knowledge in exploring space and exploiting technology to serve UNASUR constituent's needs on Earth. A more detailed examination of the space services market place (access and utilization) is possible in terms of the success and failure of cooperatives, the pace of development of new space access capability (either private or governmental), or the operations and sustainment of such capability, where multiple geographically dispersed parties are involved. The maturation of the space sector is occurring at a rapid pace with many actors playing a role.

There is no doubt that the internationalization of space is enjoying a period of ascendancy.[53] "Earth is the cradle of humanity, but one cannot live in a cradle forever," per Konstantin Tsiolkovsky.

Acknowledgments

The authors would like to thank Minoo Rathnasabapathy for her valuable inputs and text revisions and the Bolivian authors who helped finalized the section: Reynaldo Lopez Aramayo, Niels Omar Saavedra Tapia, Neila Alejandra Arteaga Vargas, Sanny Anghela Lizarro Quiroga, Náyade Karla Franco Valeriano, and Shaghayegh Almasian Bellido.

References and Notes

[1] UNASUR, "South American Union of Nations Constitutive Treaty," 1 April 2009. [Online]. Available: http://studentorgs.law.smu.edu/getattachment/International-Law-Review-Association/Resources/LBRA-Archive/15- 2/SMB213.pdf.aspx.

[2] United Nations Office for Outer Space Affairs, "Treaty on Principles Governing the Activities of States in Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies," Official Records of the General Assembly, Twenty-First Session, agenda items 30, 89 and 91, document A/6431, 1966. [Online]. Available: http://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html#fn1.

[3] Specialized magazine Bolivian delivered by the Ministry of Government in January 2014 in a public ceremony held at the Government Palace.

[4] R. V. de Moraes; A. P. M. Chiaradia, "Instituições e Agências Brasileiras," Chapter of book "A Conquista do Espaço: do Sputnik à Missão Centenário," pp. 123–150, 2007.

[5] A. L. do A. Villas-Bôas; L. C. Borges, "O Estado Brasileiro e a Questão das Tecnologias Espaciais: do GOCNAE à AEB," Anais do XII Encontro Regional de História - ANPUH-RJ, 2006. [Online]. Available: http://rj.anpuh.org/resources/rj/Anais/2006/conferencias/Ana%20Lucia%20do%20Amaral%20VillasBoas%20e%20Luiz%20C%20Borges.pdf. [Accessed: 10-Jul-2015].

[6] G. Câmara, "A pesquisa espacial no Brasil: 50 anos de INPE (1961-2011)," Revista USP, n. 89, março/maio, pp. 234-243, 2011.

[7] T. da S. Ribeiro, "Veículos Lançadores de Satélites - Cenário Atual e Futuro," Parcerias Estratégicas, v. 4, n. 7, pp. 235–248, 2009.

[8] V. Orlando; H. K. Kuga, "Os satélites SCD1 e SCD2 da Missão Espacial Completa Brasileira," Chapter of book "A Conquista do Espaço: do Sputnik à Missão Centenário," pp. 151–176, 2007.

[9] National Institute for Space Research, "History of CBERS," [Online]. Available: http://www.cbers.inpe.br/.

[10] C. E. Santana; J. R. B. Coelho, "O Projeto CBERS de Satélites de Observação da Terra," Parcerias Estratégicas, v. 4, n. 7, pp. 203–210, 2009. [Online]. Available: http://seer.cgee.org.br/index.php/parcerias_estrategicas/article/viewFile/89/82. [Accessed: 10-Jul-2015].

[11] National Institute for Space Research, "Plano Diretor 2011 – 2015." [Online]. Available: http://www.inpe.br/noticias/arquivos/pdf/Plano_diretor_miolo.pdf. [Accessed: 10-Jul-2015].

[12] E. E. N. Macau; O. C. Winter; H. F. Campos Velho; A. A. Sukhanov; A. G. Vicente de Brum; J. L. Ferreira; A. Hetem; G. M. Sandonato; R. Sfair, "The Aster Mission: Exploring for the First Time a Triple System Asteroid," Proceedings of the 62nd International Astronautical Congress, v. 5, pp. 3669–3677, 2011.

[13] E. Macau; O. Winter; H. de Campos Velho; A. Sukhanov, "Missão Áster: indo aonde ninguém jamais foi," Ciência Hoje, vol. 50, pp. 20–25, 2012.

[14] Instituto de Aeronáutica e Espaço, "Foguetes de Sondagem do Brasil voam algo na Europa," Revista Espaço Brasileiro, no. 15, Jan–Jun, pp. 20–21, 2013.

[15] A. R. de S. Carvalho; L. M. S. Urbina; J. H. de S. Damiani, "The Interaction Between the Institute of Science and Technology and Industry: The Strategic Context for Development Projects," Proceedings of the 9th International Conference on Information Systems and Technology Management, 2012. [Online]. Available: http://www.tecsi.fea.usp.br/envio/contecsi/index.php/contecsi/9contecsi/paper/view/3474/1976. [Accessed: 10-Jul-2015].

[16] Brazilian Space Agency, "National Program of Space Activities: PNAE 2012-2021" [Online]. Available: http:// http://www.aeb.gov.br/wp-content/uploads/2013/01/PNAE-Ingles.pdf. [Accessed: 10-Jul-2015].

[17] Cancilleria Colombiana webpage [Online]. Available: http://www.cancilleria.gov.co/comision-nacionesunidas-uso-pacifico-del-espacio-ultraterrestre-copous. [Accessed: 01-Jul-2015].

[18] Comisión Colombiana del Espacio. [Online]. Available: https://www.cce.gov.co/alcance. [Accessed: 02-Jul-2015].

[19] Universidad Sergio Arboleda [Online]. Available: http://www.usergioarboleda.edu.co/proyecto_espacial/libertadi.html. [Accessed: 02-Jul-2015].

[20] Decreto Presidencial "Programa Presidencial de Desarrollo Espacial" [Online]. Available: http://wsp.presidencia.gov.co/Normativa/Decretos/2013/Documents/NOVIEMBRE/15/DECRETO%202516%20DE L%2015%20DE%20NOVIEMBRE%20DE%202013.pdf=P49401092481348748141551. [Accessed: 04-Jul-2015].

[21] Periodico El Tiempo "Colombia no comprará satelite" [Online]. Available: http://www.eltiempo.com/politica/gobierno/colombia-no-comprara-satelite/14539258 [Accessed: 04-Jul-2015.

[22] Periodico El Tiempo "Gobierno frena compra de satelite" [Online]. Available: http://www.eltiempo.com/politica/gobierno/gobierno-frena-compra-de-satelite/14533968. [Accessed: 04-Jul-2015].

[23] Ruta N "Misión Aurora" [Online]. Available: http://rutanmedellin.org/es/actualidad/noticias/item/medellin-dasus-primeros-pasos-para-conquistar-el-espacio. [Accessed: 05-Jul-2015].

[24] Ideatech webpage [Online]. Available: www.ideatech.com.co. [Accessed: 05-Jul-2015].

[25] Revista Semana "Acreditación de alta calidad" [Online]. Available: http://www.semana.com/especialescomerciales/especial-de-educacion/articulo/acreditacion-de-alta-calidad/381447-3. [Accessed: 05-Jul-2015].

[26] Revista Semana "Colombia sin un lugar en el espacio" [Online]. Available: http://www.elespectador.com/noticias/actualidad/vivir/colombia-sin-un-lugar-el-espacio-articulo-416346. [Accessed: 06-Jul-2015].

[27] Ruta N webpage "Medellín Espacial" [Online]. Available: http://rutanmedellin.org/es/ciudadanos/item/medellin-espacial. [Accessed: 05-Jul-2015].

[28] C. G. Pattillo Barrientos, "Desarrollo Espacial en Chile," Santiago, 2013.

[29] S. G. (NASA), "Sputnik and The Dawn of the Space Age," 2007. [Online]. Available: http://history.nasa.gov/sputnik/.

[30] SSC, "Sweedish Space Corportation" [Online]. Available: http://www.sscspace.com/about-the-ssc-group/ssccompanies/ssc-chile. [Accessed: 04-Jun-2015].

[31] ENTEL S.A., "Servicios Satelitales" [Online]. Available: http://personas.entel.cl/PortalPersonas/appmanager/entelpcs/personas?_nfpb=true&_pageLabel=P494010924813487 48141551. [Accessed: 04-Jun-2015].

[32] COPUOS, "Status of international agreements relating to activities in outer space as at 1 January 2015," 2015.

[33] Chilean Presidential Commission, "Crea Comision Asesora Presidencial Denominada Aagencial Chilena del Espacio."

[34] "Decreto Supremo # 144 del 29 de diciembre de 2008."

[35] Fuerza Aerea de Chile, "Actividad Espacial en Chile" [Online]. Available: http://www.ssot.cl/antecedentes.php. [Accessed: 01-Jul-2015].

[36] *CREA COMISIÓN ASESORA PRESIDENCIAL DENOMINADA CONSEJO DE MINISTROS PARA EL DESARROLLO DIGITAL Y ESPACIAL.* MINISTERIO DE TRANSPORTES Y TELECOMUNICACIONES; SUBSECRETARÍA DE TELECOMUNICACIONES, 2014.

[37] C. González Isla, "Chile relanza carrera para llegar al espacio," La Tercera, 2015.

[38] C. González Isla, "Chile creará agencia espacial y priorizará uso civil de nuevo satélite," La Tercera, 2015.

[39] J. Martin Canales Romero, "First Steps to Establish a Small Satellite Program in Peru," Lima-Peru, 2010.

[40] IHS Jane's 360, "Peru Begins Production of Satellite Support Infrastructure" [Online]. Available: http://www.janes.com/article/52856/peru-begins-production-of-satellite-support-infrastructure. [Accessed: 22-Jul-2015].

[41] CCTV, "Peru Launches First Homemade Rocket" [Online]. Available: http://english.cntv.cn/20130613/101650.shtml. [Accessed: 22-Jul-2015].

[42] GESTION, "La PUCP lanza al espacio primeros satélites hechos íntegramente en el Perú" [Online]. Available: http://gestion.pe/tecnologia/lanzan-satelites-hechos-integramente-peru-construidos-pucp-2081686. [Accessed: 22-Jul-2015].

[43] LA INFO, "Peru and Russia Allies to Launch Satellite into Space Chasqui I" [Online]. Available: http://lainfo.es/en/2014/02/05/peru-and-russia-allies-to-launch-satellite-into-space-chasqui-i/ [Accessed: 22-Jul-2015].

[44] ANDINA PERU, "Nasa Launches Peruvian Satellite into Space" [Online]. Available: http://www.andina.com.pe/agencia/noticia-nasa-launches-peruvian-satellite-into-space-489387.aspx [Accessed: 22-Jul-2015].

[45] Space Launch Report, http://www.spacelaunchreport.com/log2015.html.

[46] "Venezuela: Latin America's Next Space Pioneer?," http://www.satellitetoday.com/publications/2013/08/23/venezuela-latin-americas-next-space-pioneer-2/.

[47] The Mars Society, https://www.facebook.com/TheMarsSocietyPeru.

[48] "Argentina Launches Its First Home-Built Satellite," http://phys.org/news/2014-10-argentina-home-builtsatellite.html.

[49] http://latino.foxnews.com/latino/news/2013/10/17/bolivia-enters-space-race-launches-its-first-satellite-from-china/.

[50] "Brazil Cancels Pact to Build Satellite-Launching Center with Ukraine," http://www.efe.com/efe/english/technology/brazil-cancels-pact-to-build-satellite-launching-center-withukraine/50000267-2672914.

[51] Explainer: What Is UNASUR?, http://www.as-coa.org/articles/explainer-what-unasur.

[52] Nicholas S. Keim` and Peter E. Zeender, "Global Trends in Space Access and Utilization."

[53] Grey, J., "Commentary — The New Global Space Scene," *Aerospace America*, Vol. 46, No. 2, Feb. 2008.