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A Small Box That?s a Big Deal: How Latin American Countries Are Using CubeSATs and Why it Matters

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Kevin Freese

Introduction

The Army is the Defense Department's largest space user and is heavily dependent upon space capabilities to achieve land dominance,**[1]** so the space domain is an essential part of the current and future operational environment. That domain is getting more crowded, not just in terms of the numbers of objects in space, but in terms of the variety of actors. Many countries that were previously not space-capable are now actively pursuing domestic space programs. A relatively new satellite technology – the CubeSAT – is now making it easier for such countries to launch their space programs.

Four Latin American countries, Costa Rica, Ecuador, Peru, and Uruguay, are among those whom have benefited from CubeSAT technology. Their respective space programs share much in common. Their entry into space using CubeSATs as a gateway has much larger implications for the future operational environment. By facilitating traditionally non-spacefaring nations to develop space programs, CubeSATs will give such nations a greater voice in international space policies and laws. For the United States, this will mean increased necessity to take the interests of other nations into consideration when operating in space.

Background

Cube Satellites, or CubeSATs, are standardized-configuration small satellites, with masses less than 10 kg (22 lbs). Sometimes they are classified as picosatellites [mass <1 kg (2.2 lbs)] or nanosatellites [mass 1-10 kg (2.2-22 lbs)]. Not all small satellites are CubeSATs, but the CubeSAT platform is popular because its standardized, modular 1000 cm^3 box frame can be used to mount diverse payloads in a structure that is easy to lift and deploy in large numbers. Many CubeSATs combine multiple frames to form larger, but still small, satellites. Researchers at the California Polytechnic State University at San Luis Obispo and Stanford University first conceived of CubeSATs in 1999 with the first CubeSAT deployment in 2003. The original purpose was to be a platform for secondary payloads. The CubeSAT design was meant to reduce risk to the primary payload, but over time it became a standardized platform.**[2]** CubeSAT frames are commercially available and can even be purchased over the internet. The target consumers for CubeSATs are educational institutions and amateur radio promoters; the majority of CubeSAT missions have been launched by universities and schools.[3] However, the CubeSAT platform's low cost to build, low-weight (meaning low cost to lift), and standardized frame make CubeSATs accessible platforms for nascent space programs.

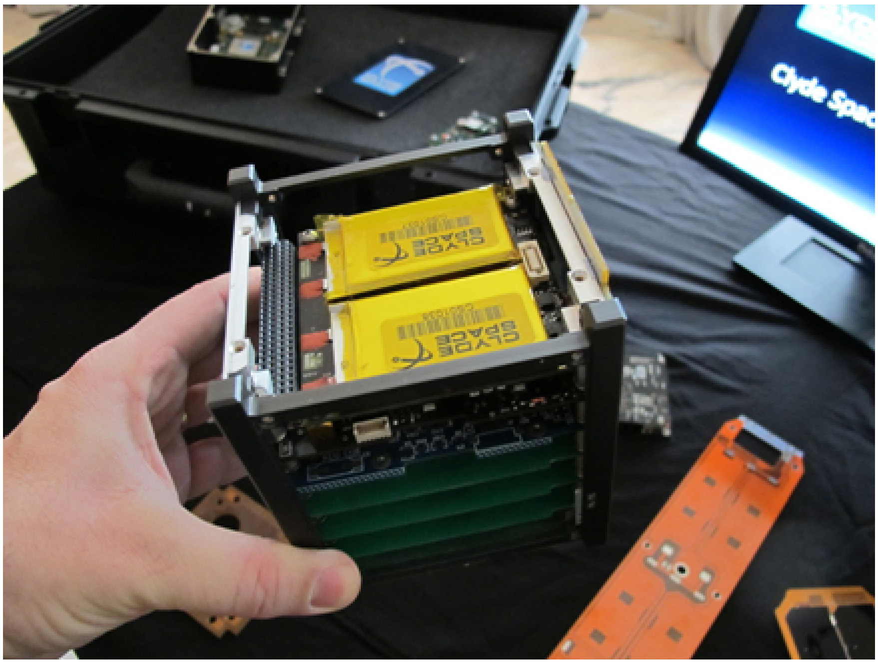

Image 1. 1U cubesat structure without outer skin (source: Wikimedia Commons user Svobodat, "1U cubesat structure without outer skin," Wikimedia Commons , 26 January 2011, https://commons.wikimedia.org/wiki/File:CubeSat_in_hand.jpg accessed 31 March 2016. Photo in public domain.)

Costa Rica

Costa Rica is home to the Central American Association for Aeronautics and Space (ACAE). Founded in 2010 as a successor to the 1990 Costa Rican association for Space Research and Advancement and the First Space Congress of the Americas, ACAE's mission is to promote and develop Central American aerospace talent with a vision to be the lead entity for Central American participation in the space field at the global level. ACAE is organized as a non-governmental organization, but it is associated with the Costa Rican government's National Council for Space Research and Development (CONIDA), also founded in 2010, as well as other government agency, educational, and industry partners.[4] CONIDA is subordinate to Costa Rica's Ministry of Science, Technology, and Telecommunications, with a mission to be the referential and consultative government agency for Costa Rican aerospace development.[5]

As of March 2016, ACAE has announced a program to develop its first domestically-built satellite, a 1-unit CubeSAT identified as Project Irazú. If successful, the satellite will deploy from the International Space Station in 2017 and will measure carbon dioxide levels for comparison with data from Central American rain forests for six months. Irazú will have an expected total cost of $(USD) 500,000, with the final $(USD) 75,000 for construction, testing, and deployment raised by a crowd-sourcing campaign.[6] Project personnel include international professors, researchers, students and subject matter experts, but the core team are Costa Rican citizens. The project will also involve a ground station at the Costa Rica Institute of Technology; the infrastructure development will facilitate future space projects. The Costa Rican government has declared that the Irazú project is a Public Interest.[7]

Even if successful, Costa Rica's Iruzú CubeSAT will only be in orbit for a short time. However, the infrastructure, relationships, and expertise will last much longer. Costa Rica will have made itself the Central American pioneer in space.

Ecuador

Ecuador's space agency is the Ecuadorian Civilian Space Agency (EXA), founded in 2007. EXA's mission is to administer and execute Ecuador's civilian space program, research planetary and space science, and advance science in Ecuador's educational system. EXA works closely with the Ecuadorian Air Force, as well as international, industry, and educational partners. In addition to developing national satellite programs, EXA's long-term goals include manned space flight.**[8]**

Ecuador has two satellites; both are CubeSATs. The first was NEE-01 Pegasus, a 1-unit CubeSAT launched by China in April 2013. Its primary mission was to pave the way for future satellite missions, but it also supported student projects and had a camera. At 3kg, it was considerably heavier than other 1-unit CubeSATs, because it was built with additional radiation shielding.**[9]** Built and primarily funded by EXA, the NEE-01 Pegasus cost $(USD) 80,000 to build and $(USD) 700,000 for testing, security, logistics, and launch. Less than one month after launch, the satellite was struck by debris from a 1985 Russian rocket launch. Its signal was lost, but the Ecuadorian government is still tracking the satellite.**[10]**

Ecuador's second satellite is identified as NEE-02 Krysaor. Launched from Russia in November 2013, NEE-02 is also a 1-unit CubeSAT. It includes an Earth-imaging camera. **[11]** Like NEE-01 Pegasus, NEE-02 Krysaor weights 2.1kg. EXA tracks the satellites from a ground station near Guayaquil, Ecuador.**[12]** In January 2014, NEE-02 Krysaor received and relayed a signal from NEE-01 Pegasus.**[13]**

NEE-01 Pegasus and NEE-02 Krysaor will provide Ecuador benefit far longer than their technical missions, because Ecuador will be able to use them to refine and improve its ground-based infrastructure. This will make future satellite programs – including larger satellites – more affordable and more likely to succeed. Additionally, by using one satellite to reacquire signal from the other, EXA has demonstrated an ability to overcome technical challenges related to satellite operation, improving the agency's standing in the international community.

Peru

Peru's space agency is the National Commission for Aerospace Research and Development (CONIDA). CONIDA was established in 1974, conceptualized as a civilian organization to work with foreign partners in support of Peru's national space objectives. CONIDA has had a close relationship with the military from its inception. Peru has initiated several space programs, ranging from ballistic missile programs to partnerships with Indian, Russian and North Korean space agencies, and has joined the Asia-Pacific Space Cooperation Organization. However, most CONIDA projects have not been completed. In 2006, the Peruvian congress passed a law declaring that creation of a satellite imagery center was a national priority. Peru's government issued its first national space policy in 2009.**[14]** CONIDA's official mission is to promote, research, develop, and advance space science and technology in support of the national interests, as well as to generate varied and unique services promoting national development.**[15]**

CONIDA used CubeSATs to pioneer Peru's satellite program. Peru has built four CubeSATs: PUCP-SAT 1, Pocket-PUCP (technically not a cube satellite), UAPSAT-1, and Chasqui-1.**[16]** Russia launched Peru's first satellites in November 2013. One was a 1-unit, 1.2kg cube satellite identified as PUCP-Sat 1; it carried and later deployed an even-smaller "femto-satellite" identified as Pocket-PUCP. At 97g, Pocket-PUCP was one of the smallest satellites ever launched. Students and faculty from the Ponftificia Universidad Catolica del Peru's Institute for Radio Astronomy designed them. The culmination of a threeyear project, these were Peru’s first domestically-built satellites. The PUCP-Sat 1 collected and transmitted temperature information from Pocket-PUCP, with the purpose of using information to help design future satellites. Because of the small size of the satellites and their proximity to other small satellites, it took several weeks for the faculty to acquire its signal, but they eventually succeeded.[17]

Peru’s third satellite was UAPSAT-1, a 1-unit configuration CubeSAT built by faculty and students from Alas Peruanas University. The satellite parts for UAPSAT-1 cost $(USD) 500,000 and the launch cost $(USD) 160,000; the labor cost $(USD) one million.[18] The project began in 2010 and NASA launched the satellite in January 2014, deploying it a few days later from the ISS via a robotic arm. UAPSAT-1’s mission was to collect space weather information for a period of eight months.[19]

In August 2014, a Russian cosmonaut manually deployed Peru’s fourth satellite into orbit while on a space walk from the International Space Station. Identified as Chasqui-1, it was a 1-unit cube satellite built by engineers from Peru’s National Engineering University and tested by experts from Russia’s Southwest State University. Chasqui-1 was actually launched in February 2014, but remained aboard the space station until its scheduled deployment. Chasqui-1’s mission was to collect visible and near infrared imagery for a two-month period.[20] No signals were ever received; Chasqui-1 deorbited on 15 January 2015.[21]

Image 2. Chasqui 1 being deployed by hand from ISS. (Source: Jerry Wright, ed., "Station Spacewalkers Deploy Nanosatellite, Install and Retrieve Science," NASA TV , 17 August 2014, http://www.nasa.gov/content/station-spacewalkers-deploy-nanosatellite-install-and-retrieve-science accessed 31 March 2016. Photo in public domain.)

Although CONIDA initiated its space program with CubeSATs, Peru’s space ambitions do not end with secondary launches by international partners. CONIDA is developing and testing its own domestically-produced rocket systems. Peru’s goal is to have a rocket capable of reaching orbital altitudes as early as 2020.[22] By using CubeSATs, Peru has established its ability to operate in space; if eventually able to launch its own satellites, Peru will become a true space-faring nation and a regional space leader.

Uruguay

Uruguay’s space agency is the Space-Aeronautics Research and Advancement Center (CIDA-E). Founded in 1975, CIDA-E's mission is to study and promote the study of space and aeronautic topics, to advance research results, and to help create public awareness of space and aeronautics. CIDA-E falls within Uruguay's National Directorate of Civil Aviation and Aeronautic Infrastructure. CIDA-E's tasks include research, education, publication, and building networks with international partners.[23]

Uruguay's only satellite is no longer operational but is still in orbit. It was a 2-unit configuration cube satellite with an electro-optical and infrared camera, named ANTELSAT. Launched by Russia in 2014, it was a collaborative project between the University of the Republic's engineering faculty, the state engineering faculty, and ANTEL, Uruguay's telecommunications provider. The satellite's mission was Earth imaging and amateur radio communications for education.[24] The project began in 2006 and involved 60 individual participants, half of whom were students and all of whom were Uruguayan (although California Polytechnic State University conducted tests). The total cost for the satellite until the launch was $(USD) 695,000.[25] ANTELSAT unexpectedly stopped communicating in April 2015. It had completed more than 4,000 orbits and sent more than 750,000 transmissions and 60 images.[26]

Ecuador is not currently operating its own domestically-produced satellites in space, but ANTELSAT really did complete its mission. Ecuador has a space program, including ground infrastructure and human expertise. Even if CIDA-E continues by focusing on education, Ecuador is positioned to grow in science and space capability.

Comparison

The CubeSAT programs in Costa Rica, Ecuador, Peru, and Uruguay share several things in common. First, in all four countries, there was a deliberate effort to domestically produce as much as possible – even when foreign experts had be consulted for testing and launch was provided by international partners. Producing their own satellites was considered a national achievement and a source of national pride by each country. Second, each country has taken a collaborative approach, with much of their effort and expertise being provided by state-funded universities, with input and guidance from their respective national governments through government agencies. Third, using CubeSATs helped each country keep costs relatively low. All of the various programs were well below $(USD) two million. Furthermore, the satellite component of the costs was a minority of the investment for each country involved – the majority of expense was for ground infrastructure and developing expertise. Fourth, and most importantly, even though each satellite has had a different primary mission, each country viewed paving the way for future space activities to be at least as important as each satellite's individual mission.

Implications for the Future

Space is a global commons, so no one nation controls the space domain. Individual countries have their own laws about space technology, research, and exploration, but international laws, treaties, and customs govern space activities at the international level. These are really in their infancy, akin in some ways to international maritime laws centuries ago, which changed as technology and politics evolved. In fact, besides some non-binding but generally-adhered-to United Nations resolutions, there have only been five major space treaties. Of particular interest is the 1979 Agreement Governing Activities of States on the Moon and Other Celestial Bodies, not because of the treaty's content, but because none of the major space actors ratified it – rendering it effectively dormant.[27]

The impotence of the Moon Treaty implies that, in matters relating to international space law, the opinions of spacefaring countries matter more than the opinions of countries who do not have space programs. Hitherto, the United States has benefited from being primary among a few space actors, thus having a leading voice. Now, the world is rapidly changing into one in which there are dozens of stakeholders in outer space. Some have more robust programs than others, but all of them will have a voice in shaping the international laws and policies in space.

In the case of Costa Rica, Ecuador, Peru, and Uruguay, this is not just theoretical. Two shared traits of all of their respective CubeSAT programs, and their space programs in general, are the emphasis upon using the programs to build international networks and advancing national interests. They see themselves as part of an international community of space actors. While none of these countries are enemies of the United States, respective national interests do not always align from country to country. Since space law is still in its infancy, it is likely to evolve dramatically. Consequently, in the future operational environment in space, the United States is increasingly likely to be constrained or restrained by rules that are put into place by countries indifferent to United States interests, especially regarding military activities in space.

Conclusion

Costa Rica, Ecuador, Peru, and Uruguay are just four countries, highlighted here because they are emblematic of a larger trend. Traditionally non-space-faring countries are increasingly perceiving space as a domain in which they need to operate. CubeSATs are making it easier for countries with limited resources to use a comparatively low-cost platform for the orbital component of their space programs, while they develop their ground infrastructure, expertise, organization, and enterprise relationships to enable future space endeavors. More importantly, CubeSATs are enabling more countries to join the club of countries that operate in space, meaning that other space-faring nations will have to lend greater heed to their perspectives. CubeSATs might be small, but they have big implications for the future of the operational environment in the space domain.

The views expressed in this report are those of the author and do not necessarily represent the official policy or position of the Department of the Army, Department of Defense, or the U.S. government. The Foreign Military Studies Office (FMSO) assesses regional military and security issues through open-source media and direct engagement with foreign military and security specialists to advise army leadership on issues of policy and planning critical to the U.S. Army and the wider military community.

End Notes

[1] LTG David Mann, “On Space Programs,” *Statement before the Committee on Armed Services Strategic Forces Subcommittee, U.S. Senate, 2nd Session, 113th Congress*, 12 March 2014, http://www.armed-services.senate.gov/imo/media/doc/Mann_03-12-14.pdf accessed on 31 March 2016.

[2] Unattributed author(s), “CubeSat History,” *Innovative Solutions in Space*, no date given, http://www.isispace.nl/cms/index.php/cubesats/cubesat-history accessed on 29 March 2016.

[3] Pierre Galeone, “Cubesats and Education: The Fly Your Own Satellite! Programme,” *European Space Agency*, no date given, http://www.esa.int/Education/CubeSats_and_Education_the_Fly_Your_Satellite!_programme accessed on 30 March 2016.

[4] Unattributed author(s), “The Association,” *Asociación Centroamericana de Aeronáutica y del Espacio*, no date given, http://www.acae-ca.org/index.php/acae accessed 31 March 2016.

[5] Unattributed author(s), “Consejo Nacional de Investigación y Desarrollo Aerospacial (CONIDA),” no date given, *Ministerio de Ciencia y Tecnología*, http://www.micit.go.cr/index.php?option=com_content&view=article&id=6114&Itemid=1497 accessed on 22 March 2016.

[6] L. Arias, “Costa Rica’s first satellite project enters decisive stage,” *The Tico Times*, 16 March 2016, http://www.ticotimes.net/2016/03/16/90296#comments-90296 accessed on 29 March 2016.

[7] Unattributed author(s) from the Central American Association for Aeronautics and Space, “Irazú Project: The First Satellite Made in Costa Rica,” *Kickstarter*, no date provided, https://www.kickstarter.com/projects/irazu/irazu-project-the-first-satellite-made-in-costa-ri accessed on 29 March 2016.

[8] Unattributed author(s), “What is the EXA?”, *The Ecuadorian Space Agency*, no date given, http://exa.ec/exa-en.htm accessed 19 March 2016

[9] Iván Martínez, “Ecuador y su primer satélite artificial,” Diario Turing, 01 August 2013, http://www.eldiario.es/turing/Satelite-Pegaso-Ecuador_0_158884782.html accessed on 04 March 2016.

[10] Unattributed author(s), “Se oficializa desaparición del primer satélite ecuatoriano NEE-01 Pegaso,” *Ecuavisa*, 05 September 2013**, http://ecuavisa.com/articulo/noticias/actualidad/40151-se-oficializa-desaparicion-pegaso** accessed on 04 March 2016.

[11] Unattributed author(s), “EXA puso en órbita a Krysaor, el Segundo satélite ecuatoriano,” *El Diaro*, 21 November 2013, http://www.eldiario.ec/noticias-manabi-ecuador/294045-exa-puso-en-orbita-a-krysaor-el-segundo-satelite-ecuatoriano/ accessed 07 March 2016.

[12] Unattributed author(s), “Ecuador already has its second satellite in space, NEE-02 Krysaor,” *Andes Agencia Pública de Noticias del Ecuador y Suramérica*, 21 November 2013, http://www.andes.info.ec/en/news/ecuador-already-has-its-second-satellite-space-nee-02-krysaor.html accessed 07 March 2016.

[13] Unattributed author(s), “Nader: EXA recupera contacto con Pegaso usando a Krysaor,” *Expreso*, 25 January 2014, http://expreso.ec/expreso/plantillas/nota_print.aspx?idArt=5634364&tipo=2 accessed 07 March 2016.

[14] Robert C. Harding, *Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier*, (Abingdon-on-Thames and New York: Routledge, 2012) 156-58.

[15] Unattributed author(s), “Comisión Nacional de Investigación y Desarrollo Aeroespacial,” *Oficina Nacional de Gobierno Electrónico e Informática*, no date given, http://www.peru.gob.pe/directorio/pep_directorio_detalle_institucion.asp?cod_institucion=85 accessed 28 March 2016.

[16] Unattributed author(s), “Peru,” *Space Generation Advisory Council*, no date provided, http://spacegeneration.org/sgac-regions/south-america/peru.html accessed on 02 March 2016

[17] Unattributed author(s), “La PUCP lanza al espacio primeros satélites hechos integramente en el Perú,” *Gestión*, 21 November 2013, lanzan-satelites-hechos-integramente-peru-construidos-pucp-2081686 accessed on 02 March 2016; Rachel Chase, “First Peruvian Satellites Launched into Space,” *Living in Peru*, 21 November 2013, http://www.peruthisweek.com/news-first-peruvian-satellites-launched-into-space-101517 accessed 01 March 2016; and Unattributed author(s), “Satélites: PUCP-Sat-1: Especificaciones del Satélite,” Instituto de Radiostronomía INRAS-PUCP, no date provided, http://inras.pucp.edu.pe/proyectos/pucp-sat-1/especificaciones-del-satelite/ accessed on 02 March 2016.

[18] Unattributed author(s), “La NASA lanzó satélite peruano UAP SAT-1 de US$ 1.6 millones,” *Gestion*, 9 January 2014, http://gestion.pe/tecnologia/nasa-lanzo-satelite-peruano-uap-sat-1-us-16-millones-2085804 accessed on 02 March 2016.

[19] Unattributed author(s), “NASA envoi al espacio satélite peruano UAP-SAT1,” La Prensa, 09 January 2014, http://laprensa.peru.com/tecnologia-ciencia/noticia-nasa-envio-al-espacio-satelite-peruano-uap-sat-1-18596 accessed on 02 March 2016

[20] Unattributed author(s), “Entró en órbita el satélite peruano Chasqui 1 desarrollado por la UNI,” *América Noticias*, 19 August 2014, http://www.americatv.com.pe/noticias/actualidad/satelite-peruano-uni-chasqui-1-ya-esta-orbita-n149621 accessed on 03 March 2016.

[21] Unattributed author(s), “CHASQUI-1,” *N2YO.com*, no date provided, http://www.n2yo.com/satellite/?s=40117#results accessed on 03 March 2016.

[22] Unattributed author(s), “Peru launches first homemade rocket,” *Space Travel*, 19 June 2013, http://www.space-travel.com/reports/Peru_launches_first_homemade_rocket_999.html accessed 30 March 2016.

[23] Unattributed author(s), “Centro de Investigación y Difusión Aeronáutico-Espacial,” Dirección Nacional de Aviación Civil e Infraestructura Aeronáutica, no date given, http://www.dinacia.gub.uy/comunidad-aeronautica/2013-11-01-16-45-49/centro-de-investigacion-y-difusion-aeronautico-espacial-cida-e.html accessed 31 March 2016.

[24] Unattributed author(s), “ANTELSAT,” *N2YO.com*, no date provided, http://www.n2yo.com/satellite/?s=40034, accessed 01 March 2016.

[25] Unattributed author(s), “Se pone hoy en órbita el primer satélite uruguayo,” *El Pais*, 19 June 2014, http://www.elpais.com.uy/vida-actual/se-pone-orbita-satelite-uruguayo.html accessed on 01 March 2016.

[26] Unattributed author(s), “Se apagó satélite uruguayo AntelSat,” *República.com.uy*, 16 July 2015, http://www.republica.com.uy/se-apago-antelsat/526384/ accessed on 01 March 2016.

[27] Matthew J. Kleiman, “Space Law 101: An Introduction to Space Law,” American Bar Association Young Lawyers Division, no date given, http://www.americanbar.org/groups/young_lawyers/publications/the_101_201_practice_series/space_law_101_an_introduct
accessed 31 March 2016.

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{8} http://www.ticotimes.net/2016/03/16/90296#comments-90296
{9} https://www.kickstarter.com/projects/irazu/irazu-project-the-first-satellite-made-in-costa-ri
{10} http://exa.ec/exa-en.htm
{11} http://www.eldiario.es/turing/Satelite-Pegaso-Ecuador_0_158884782.html
{12} http://www.eldiario.ec/noticias-manabi-ecuador/294045-exa-puso-en-orbita-a-krysaor-el-segundo-satelite-ecuatoriano/
{13} http://www.andes.info.ec/en/news/ecuador-already-has-its-second-satellite-space-nee-02-krysaor.html
{14} http://expreso.ec/expreso/plantillas/nota_print.aspx?idArt=5634364&tipo=2
{15} http://www.peru.gob.pe/directorio/pep_directorio_detalle_institucion.asp?cod_institucion=85
{16} http://spacegeneration.org/sgac-regions/south-america/peru.html
{17} http://www.peruthisweek.com/news-first-peruvian-satellites-launched-into-space-101517
{18} http://inras.pucp.edu.pe/proyectos/pucp-sat-1/especificaciones-del-satelite/
{19} http://gestion.pe/tecnologia/nasa-lanzo-satelite-peruano-uap-sat-1-us-16-millones-2085804
{20} http://laprensa.peru.com/tecnologia-ciencia/noticia-nasa-envio-al-espacio-satelite-peruano-uap-sat-1-18596
{21} http://www.americatv.com.pe/noticias/actualidad/satelite-peruano-uni-chasqui-1-ya-esta-orbita-n149621
{22} http://www.n2yo.com/satellite/?s=40117#results
{23} http://www.space-travel.com/reports/Peru_launches_first_homemade_rocket_999.html
{24} http://www.dinacia.gub.uy/comunidad-aeronautica/2013-11-01-16-45-49/centro-de-investigacion-y-difusion-aeronautico-espacial-cida-e.html

{25} http://www.n2yo.com/satellite/?s=40034
{26} http://www.elpais.com.uy/vida-actual/se-pone-orbita-satelite-uruguayo.html
{27} http://www.republica.com.uy/se-apago-antelsat/526384/
{28}
http://www.americanbar.org/groups/young_lawyers/publications/the_101_201_practice_series/space_law_101_an_introduct
{29} http://smallwarsjournal.com/comment/reply/48923#comment-form