New Spacefaring Nations Prepare Next Generation To Explore the Universe

by Marsha Freeman

A highlight of the 65th annual International Astronautical Congress (IAC), held in Toronto, Canada Sept. 29-Oct. 3, was the optimism expressed by the students and young professionals, who, along with leaders of the BRICS countries, are preparing their nations for the future. These young scientists and engineers are enthusiastically developing the knowledge and skills, through initially small, university-based projects, to inspire the youth of their countries, and encourage their governments to support tomorrow's scientific breakthroughs. Many of the new, first-time space projects presented this year were described by young people from the smaller nations in Ibero-America.

NASA

Tiny university satellites, or nanosats, being deployed from Japan's Kibo module on the International Space Station.

A report released in February by Euroconsult, "Profiles of Government Space Programs," documented the accelerating push toward the future by new space nations. In 2003, there were 10 countries just starting out in space investment, spending between $10 and $100 million. Last year, there were 30 such nations. And, the study reports, last year, 22 additional countries identified plans for investment in space. No nation intends to be left behind. By contrast, in the U.S., for both civilian and military space programs combined, spending in 2012 was $38.7 billion—*an $8.8 billion reduction* from the peak pre-Obama budget year of 2009.

This year's IAC provided an opportunity for developing nations to present their programs, discuss cooperation and regional integration, and spread the optimism that is prerequisite for a future.

Creating the Next Generation

For the past few years, the International Astronautical Federation has shown a determined effort to encourage participation from students and young space professionals. As the pioneers who created the last 50 years of space exploration pass from the scene, new blood and fresh ideas must be incorporated into the world space community. This policy has been very successful, as more than a quarter of the abstracts submitted for the Toronto Congress were from students from around the world.

In most cases, student projects start small, with limited budgets, and many hours of volunteer work, with the help of faculty and advisors. But no matter how small a project is, it is a challenge. In order to send any spacecraft into orbit, it must be able to withstand extreme temperature variations and radiation bombardment. It must survive the vibration environment of launch and have a power source to animate its instruments. It must also have a way of communicating with the Earth.

Over the past few years, much of the activity, and the most of the media's focus on emerging space nations, have been in Asia. But students from Central and South

EXA

The young people of Ecuador followed with great interest and pride, the progress of their Pegasu small satellite, as seen here in exhibits, educational activities, photographs, and bumper stickers.

America presented their work at the Toronto Congress, bringing a new dimension to global space development.

Natalia Vargas-Cuentas, from the Military Engineering School of Bolivia, reviewed her nation's space activity, which began with the December 2013 launch of the Túpac Katari communications satellite. The satellite was built by, and launched from, China, and included the training of Bolivian professionals. The Bolivian Space Agency, created to implement the satellite project, has announced that Bolivia hopes to purchase a remote sensing satellite "in the near future." But, Vargas-Cuentas stressed, "Bolivia must move from being a country dependent on others, to being a country applying learned theory, a country with [the] capacity to do research activities, and to be able to develop its own technology." She proposed that a small satellite be developed at a university, whose main objective is education.

To promote this policy, and organize support within the government, the students at the Military Engineering School helped organize the First Bolivian Congress in Aerospace Technology, which took place this past July. Over 150 attended from other Ibero-American nations and international aerospace firms. There was discussion of a broad range of space technologies, as well as the possibility of creating a Latin American space agency.

Vargas-Cuentas and her colleagues are intent on organizing support from the Bolivian government for the small satellite project. This is already on the mind of the nation's leadership, as reflected in the recent scientific offensive of President Evo Morales for nuclear power.

Central American Integration

For the smaller nations of Central America, cooperation and integration multiply the resources and ef-

fectiveness of each country's still-modest efforts. The Central American Association for Aeronautics and Space (ACAE) was founded in 2009. A predecessor organization had been founded in 1989 by Ronald Chang-Díaz, the brother of former NASA astronaut Franklin Chang-Díaz, who has long promoted the formation of a Latin American Space Agency. ACAE representative Carlos Alvarado-Briceño presented a paper in Toronto, in collaboration with people from the Costa Rica Institute of Technology. Their aim is to create the first Central American satellite, designed and built completely by Costa Rican students and faculty, to build capacity in Costa Rica, and be a model and inspiration for their neighbors.

In 2012, ACAE announced its intention to develop a small satellite with a unique function: It would receive environmental data daily from a system of sensors located in different test areas of the country, and link the sensors together, re-transmitting the data on atmospheric variables and forestry information for use by the government. The satellite, DSpace, was approved by the government this year, and the preliminary design of the small cubesat is in progress. Franklin Chang-Díaz's AdAstra Rocket Company is helping to underwrite the project.

Alvarado explained that this project is "not an isolated effort." The purpose is "to plant a seed." Asked about funding, he said that the Institute of Technology will request $300,000 next year, and that the National Forest Finance Fund may contribute in the future. The Institute team, he said, is made up of 15-30 young people.

Optimism and Fortitude

An example of the enthusiasm, and fortitude, needed to make these small, educational projects successful, was presented in Toronto by Margot Solberg, an American who is teaching in Ecuador. She spoke in place of Commander Ronnie Nader, the head of the Ecuadorian Civilian Space Agency (EXA), who was unable to attend.

EXA was created in 2007, with support from the Ecuadorian Air Force, and in 2010, received approval to build the nation's first satellite. Ecuadorian Space Ship-01, Pegasus, is a cubesat, or nanosatellite, weighing less than 10 kg. The raw materials to build the satellite components were imported, but the fabrication and testing were done in EXA facilities, for a cost of $30,000. Pegasus was launched on a Chinese rocket on April 25, 2013. But less than a month later, it flew through a cloud of orbital debris and was damaged. Not willing to give its first satellite up for lost, the EXA team devised a bold recovery plan.

FIGURE 1

Fortuitously, a second small satellite, Krysaor, was being readied for launch. A micro repeater device was quickly designed and added to Krysaor, which could communicate with the damaged Pegasus, and act as a relay for communication with Earth. Krysaor lifted off on Nov. 21, and two months later, the entire nation heard Pegasus identify itself as the first Ecuadorian satellite, as it transmitted the national anthem. The country "exploded in joy," EXA reported.

Solberg described the "profound loss for the country" felt by her students when communication was lost with Pegasus, and their joy upon recovery. The authors of the paper state: "The sincere hope is that the information conveyed here will contribute to inspire others with the same goal, to live up to the stature of their dreams, as we intend to do."

Ecuador is pushing forward to create the ability to produce its own, indigenous satellites. During a vist to China in July, Defense Minister María Fernanda Espinosa told the press, "Ecuador is not very interested in acquiring a satellite, but in the transfer of technology, so as to develop national facilities to strengthen our own capabilities." China Great Wall Industries will advise Ecuador on a satellite project, and train Ecuadorian aerospace personnel.

Second-Generation Small Satellites

The simplest, although still challenging, mission for a nation's first satellite is generally as a telecommunica-

tions relay for telephone and television. More difficult, is an Earth remote-sensing system, which, in addition to all of the subsystems any satellite requires, includes cameras and often other instruments, to collect data to reveal various characteristics about the Earth's surface. This requires not only a technical staff to manage the satellite system, but the development of knowledge in an array of scientific disciplines, including hydrology, geography, topology, meteorology, and agriculture, to interpret the received data.

ESA

Students from the University of Liège in Belgium and experts from the European Space Agency inspect the OUFTI-1 cubesat.

Following the successful mission of Colombia's first indigenous satellite, the tiny 1-kg Libertad-1, in 2007, students at the Aerospace Program at the University Sergio Arboleda, began developing Libertad-2, which weighs 4 kg. With the inclusion of solar cells for power, it will be possible to recharge its battery, extending the lifetime of the mission. The camera, which is the payload for the satellite, will be acquired. The proposed launch date is in the first half of 2016.

At the Congress, Dr. Jorge Soliz Torrico, from the University, explained that the purpose of the satellite is educational. The "ground station" which receives the satellite telemetry is on the roof of a building at the university! He said that the initiative is from private universities, and receives no government funding. The government, he said, recently announced its plan to buy a commercial remote-sensing satellite. But this would be for government applications and commercial purposes, not for education.

Small Sats for Space Science

In 2010, the von Karmen Institute in Belgium, funded by the European Union, proposed the QB50 project, a network of 50 nanosatellites, each weighing 2 or 3 kg, to study a remote part of the atmosphere, called the thermosphere. This is an ionized layer of the atmosphere, important for the propagation of radio signal communication. The object of the mission is to study the equatorial electro-jet, which is a high concentration of electrically charged particles, to understand how changes there affect radio communications and other phenomena on Earth. In Peru, the National University San Antonio Abad of Cusco intends to participate in the satellite constellation.

The Peruvian project is titled: "Study of the Thermosphere: Acquisition and Data Analysis of Satellite Missions (QB50 Project)." The primary goal is to receive, analyze, and study the data collected by the array of satellites. The Peruvian proposal is to use two ground stations in Cusco to form the heart of a network in Peru, to retrieve the satellite data, and then develop the ability to do scientific analyses of the characteristics and changes in the ionosphere.

A second Peruvian project, which was approved last December, is directed more locally at the design and construction of a camera for optical studies of cloud cover in the Cusco region. The importance of both of these space science projects, the paper stresses, is that "the Universidad Nacional San Antonio Abad del Cusco (UNSAAC) does not want to be left behind" as neighboring countries move forward. These two projects will be important for "developing different skills in the students and professionals of Cusco, and also [for] an impact in the entire country."

Another participant in the European QB50 project, is a Turkish team from the Space Systems Design Laboratory of Istanbul Technical University, and the High Energy Astrophysics Detector Laboratory at Sabanci University. The X-ray detector that the team is developing is being designed by the Technical University and

FIGURE 2

NUSAAC

The National University San Antonio Abad of Cusco in Peru is planning to participate in the QB50 small satellite constellation, by receiving satellite data and developing the scientific capability to analyze changes in the thermosphere.

the Turkish Air Force Academy, to fly on one of the 50 small satellites in the constellation. The paper presented by the Turkish university team states that small satellites can "include many novel missions," which will help in "creating a living civilization in Earth orbit, and then in the Solar System."

Imaginative student papers using very small spacecraft for science missions were also presented by university teams from the U.S. One—a group of researchers from California Polytechnic University, the University of Michigan, and the University of Texas, working under internships at NASA's Jet Propulsion Laboratory—aims to inspire—hence its name. This Interplanetary mission, NanoSpacecraft Pathfinder in Relevant Environment (INSPIRE), would be the world's first attempt to send a nanospacecraft, weighing just a few kilograms, to heliocentric orbit, on an Earth-escape trajectory, headed to deep space. The authors of the paper describe INSPIRE as "the first spacecraft in a new generation of explorers." The object of the mission is to demonstrate the ability to place two tiny spacecraft into deep space, while "creating a cadre of partner universities experienced with the challenges of interplanetary missions."

Leaving the 'Old World' Behind

In stark contrast to the uplifting contributions from the next generation, the first day of the Congress demonstrated the bankruptcy of both the economies and the geopolitics of the trans-Atlantic nations.

The members of the first panel of a Congress are always the heads of the world's major space agencies. But, in Toronto, the heads of the space agencies from Russia and China were denied visas by the Canadian government, due to what is generally believed to have been pressure by the United States. According to Russian attendees, out of the 10-person delegation from Roscosmos, the Russian civilian space agency, only two people were given visas—two translators! It is estimated by attendees that less than half of the delegates from Russia's space research institutes were allowed to attend. Included in the group of "refusniks" who were denied visas was Sergei Krikalov, the first cosmonaut to fly on NASA's Space Shuttle, who later worked in Mission Control in Houston.

While space agencies in Europe, Russia, India, and numerous developing space nations are pursuing cooperation with China, the United States has banned cooperation in manned space flight. Ironically, one reason given for the ban, by politicians and political pundits, is the secrecy of the Chinese space program. But the scientists from China who wanted to come to discuss what their country is doing in space, were barred from participating!

At a press conference following the panel of space agency heads, Canadian Space Agency director Walter Natynczxk said that he became aware of the visa problems only 48 hours before the opening of the Congress. While this could be the case, as if to underline Canada's slavish following of America's Russia sanctions policy, on the last day of the Congress, the Canadian government announced that the M3M commercial communications satellite, which was originally to be launched in July on a Russian Soyuz, would instead be delayed a year, and will possibly launch on an Indian rocket. (This "offer" now poses a dilemma for India, which is anxious to garner the fee for the launch, but has refused to join the attack on Russia over Ukraine.) The incongruity of this decision was demonstrated by the fact that a Sino-Canadian space cooperation agreement was signed during the Congress.

Meanwhile, the BRICS nations of China, Russia, and India are pushing full-steam ahead. This will be described in a subsequent article on the International Astronautical Congress.