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THE ECUADORIAN CIVILIAN SPACE PROGRAM: NEAR-FUTURE MANNED RESEARCH MISSIONS IN A LOW COST, ENTRY LEVEL SPACE PROGRAM.

Abstract

The Ecuadorian Civilian Space Program was presented on August 29 2007, to date; big steps have been taken by this Civilian program endorsed by the Ecuadorian Air Force and the Ecuadorian Civilian Space Agency. We will discuss the creation of microgravity facilities for training and research from scratch and the joint microgravity research missions made with the Ecuadorian Air Force, the development of tailored astronaut training programs alongside with the Gagarin Cosmonaut Training Center and the training of the first Ecuadorian as a professional astronaut, the planned use of would-be available commercial spacecrafts as a low cost alternative to the ISS for microgravity research manned missions and briefly discuss the building of a ground station for a national satellite program and the ramifications to climate monitoring in the country.
The methodology and training components unique to the Ecuadorian Space Program (ESP) will be outlined and how those training components were used in other sub-programs of the ESP like the Microgravity Induction Regime during the parabolic flights for reducing the discomfort in the flight participants and improving their work performance in microgravity research work. The mission planning and training methodology and components will be outlined as well as the list of proposed experiments for the 1rst stage of the manned space program, known as the ESAA-01 phase. We will also discuss the impact in the Ecuadorian society and in the region of the Ecuadorian Space Program.

Introduction: EXA is the Ecuadorian Civilian Space Agency, a civilian NGO created in 2007, in charge of the administration and execution of the Ecuadorian Civilian Space Program – ECSP.

But before its creation, there was a previous initiative called Project ESAA (Ex Sominus Ad Astra) which goal was to start the Ecuadorian space age, a new era of inspiration and progress for our nation, Project ESAA achieved the training of an Ecuadorian citizen as a professional astronaut in June of 2007, the project started in 2004 as a personal initiative of Ronnie Nader, and was rapidly and decisively sponsored by the Ecuadorian Air Force General Command, tapping him as the first official Ecuadorian astronaut candidate, under the Advanced Suborbital Astronaut Training Program or ASA/T Program, which was undertaken from 2004 to 2007, under an agreement with the Gagarin Cosmonaut Training Center, who provided the training facilities and validated the ASA/T training program.

The ASA/T training program: The main reason behind developing a low cost manned space program for a nation that has not had a scientific tradition was just that: To wake up the country to the need to start producing its own technology and scientific development, as an urgent need for the nation's march into this century. But obviously, until 2006, the country has not had any practical contact with space technology or science, so taking the first step was to develop a low cost manned mission and a low

cost astronaut training program, and this was the ESAA-01 mission and Advanced Suborbital Astronaut – ASA/T program, planned by the Ecuadorian Air Force and the Gagarin Cosmonaut Training Center - GCTC, this last one was chosen by us for its open minded policy and worldwide recognition as the leading cosmonautics training center by its obvious merits and tradition.

The Russian Ambassador at that time, Mr. Valentin Bogomazov was key in facilitating the contact with the GCTC and the launching of the ECSP.

The goal of the ASA/T program was to produce an entry level, yet professional, fully Ecuadorian astronaut, able to serve both a as a mission specialist and a mission commander if the nature of the mission called for it, a professional able to both command an space mission and do science in space aimed to practical needs of technology development. The profile of an ASA/T astronaut requires qualifications in science, engineering and command aptitude.

The ASA/T program was divided in 3 phases or 'Legs', follows a short resume of the program, more information can be found at http://www.exa.ec:

L1: This phase's goal was to develop the physical training and knowledge acquisition to properly train a candidate with no previous experience in microgravity to be able to orientate and work properly during µG conditions

L2: Phase goal was to train the candidate in both the knowledge of cosmonautics related sciences and a more extensive physical and mental conditioning to high and very low gravity environment. It included multiple excessive in the TsF-18 Centrifuge and EVA simulation in the GCTC Hydrolab.

The syllabus for this phase was:

-Differential Calculus
-Orbital Mechanics
-Astronomy and Astrometrics
-Astronavigation
-Rocket propulsion theory
-Russian language

Physical training and exercises includes:

-General physical testing and conditioning
-Blood stream displacement conditioning
-Otholytic system conditioning
-EVA mission simulation
-Centrifuge simulation
-Parabolic flight training
-Mirage F1 high gravity training
-Kfir CE high gravity training

Centrifuge training in the TsF-18 on GCTC

L3: Phase goal is to complete the ASA/T program by getting the candidate to complete a short version of an orbital cosmonaut training program, adding high gravity and high altitude training and testing in combat jets.

Syllabus:

-Orbital Mechanics
-Astronomy and Astrometrics
-Astronavigation
-Psychological training
-Basics of Space medicine
-Space Ship Control Systems
-Space Ship Life Support Systems
-Space suits theory
-Emergency systems
-Photography theory
-Security systems
-Survival and rescue theory
-Mission Planning theory
-Mission Control theory
-Russian language

Helicopter rescue training exercise on the GCTC Hydro lab.

Training:

-Hypobaric chamber testing and training
-Astronavigation training
-Soyuz operation and simulation training
-Sokol KV2 suit training
-Orlan-M suit training
-EVA mission simulation
-Centrifuge simulation
-MiG-29 high gravity training
-MiG-31 suborbital launch simulation
-Survival and rescue training in land and water
-Parabolic flight training

Parabolic flight training exercise

Completing the 3 phase took 16 months, mainly of academic and physical training, The estimated cost of this training was approximately US$800.000,oo

On June 8, 2007 the then Sub Commander Ronnie Nader completed the ASA/T program and became officially the firs Ecuadorian citizen to be trained as a professional astronaut.

Russian Ambassador congratulates the 1st Ecuadorian astronaut.

To his return to the country, both the President and the Russian Federation Ambassador praised the achievement as the beginning of a new era for the country.

In August 29, 2007 the Ecuadorian Civilian Space Program - ECSP was outlined by Ronnie Nader, with the presence of the Russian ambassador, Mr. Valentin Bogomazov, and the Air Force General command , it proposed 3 phases for manned space flight:

Phase 1 – Manned Suborbital flights

Phase 2 - Manned and Unmanned Orbital flights

Phase 3 – Manned and Unmanned Lunar flights

This paper will focus in the Phase 1 of the ECSP.

ECSP Phase 1: Manned Suborbital flights: 3 missions have been outlined for this phase: the ESAA-01, ESAA-02, and ESAA-03 missions. The main objective of to get an entry level experience to phase 2 and the testing of in-house developed equipment and technologies, like the Space Environment Attenuation Manifold – SEAM/NEMEA, the CYCLOPS real time video transmission system and the ARGOS amplification prototype, this 2 systems are currently in development and bet testing, the SEAM/NEMEA shield is now in production capability.

The approach to the Phase 1 is to lease low cost, vertical launch manned suborbital rockets like the ones being tested by the Armadillo Aerospace Corporation and many others around the world, yet, the full experience of a professional space mission

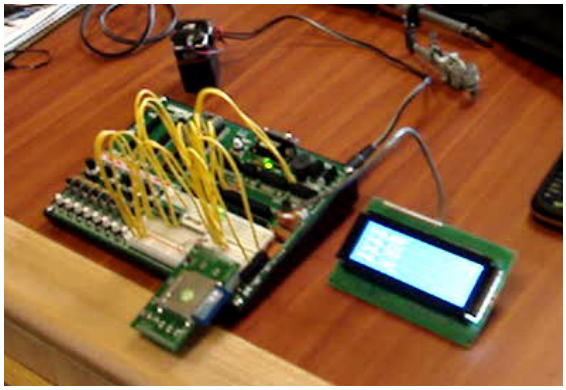
had to be developed, and then it came the DAEDALUS Project.

The ECSP has a key educational and academic component where the objective is to provide low cost access to space research facilities and tools to bolster the scientific production and inspire new generations of engineers and scientists in the country. The first task in order to accomplish this objective was to have access to a microgravity research plane, as missions developed with that plane will be very similar to actual suborbital missions command structure.

In November 2007, EXA Astronaut Ronnie Nader, currently Aerospace Operations Director at EXA, was a freshman from the Advanced Suborbital Astronaut - ASA/T training program, developed for the EXA at the Gagarin Cosmonaut Training Center – GCTC, in the Russian Federation, being a Systems Engineer and having extensive training experience on µG parabolic flights, he proposed the idea of a national µG plane.

The plan was to modify an existing plane with a device capable of sensing in real time the variations of the Z acceleration vector and inform the pilot a prediction of the next most probable value of the computed vector, so the pilot could take immediate action. Such device would have to be tailor-tuned for the possible response time of the human pilot hand-eye coordination response in order to be accurate enough to produce µG variations of hundredths of G. Such device was called Multi-Vector Gravimetric Computing Platform or MGCP

The project was proposed to the Ecuadorian Air Force – FAE (for its spanish acronym), and it was accepted. The responsibilities of the project were shared: EXA would have to build and test the MGCP, provide mission planning and mission command services, FAE would provide logistics, fuel, planes and pilots.



The first prototype of the MGCP, 2 were built, the depicted MK0A and the MK0B

On February 2008 the MGCP was ready and tested and the mission planning phase began; 2 missions were designed by the EXA's Aerospace Operations division, the EXA/FAE-01with the objective of field testing the MGCP and gather real data on the plane capabilities, and the EXA/FAE-02 mission with the objective of producing the µG target conditions in a plane capable of transporting passengers.

The first mission was flown successfully on April 10 2008 on a Mirage F1JE by Major Xavier Coral and Astronaut Ronnie Nader as the mission commander in charge of operating the MGCP and thus directing the parabolic flight operations: 301 seconds of µG were obtained in 21 parabolas.

The EXA team that designed and developed the MCGP-MK1, which can be seen in the hands of Eng. Hector Carrion, second from the left, moments before mission EXA/FAE-01

The second mission was flown on a Sabreliner T-39 on May 6 2008 by Lt Col Tirso Guerra and Lt.Col Marcos Chiluiza as pilots, Sgt. Jorge Nolivos as flight engineer, Major Xavier Coral as observer and

Astronaut Ronnie Nader as mission commander in charge of parabolic flight and MCGP operations: 165 seconds of µG were obtained in 18 parabolas. The plane was nicknamed FuerzaG-1 CONDOR and at the date of this paper publishing it remains as the first and only microgravity plane in Latin America.

From that point 7 research missions were flown and many other training missions, a command structure and mission protocols were developed the best feature of this missions is they are very similar to the short term suborbital missions planned for Phase 1. Astronaut Nader gained command experience and the EXA and FAE teams gained mission experience.

Cmdr. R. Nader floats in µG holding a blob of water while Capt. C. Mino assists, the MCDU can be seen in the back, near the MC helmet front.

It is to be mentioned that in the course of this missions, many developments were made, like the RIM/G induction regime, that allowed us to almost eliminate the so called short-term exposure space sickness and the achievement of a world record in microgravity, validated by both Guinness World Records and the World Records Academy, as a result of project POSEIDON.

All this advances in the project DAEDALUS and POSEIDON were the direct result of the ASA/T training program and the knowledge gathered in the GCTC, combined with new, ingenious approaches to the challenges at hand.

The mission patch for the ESAA-01 mission.

The first Ecuadorian manned mission to space will be the ESAA-01, scheduled for the 4th quarter of 2012 on board the Armadillo suborbital capsule, which is now on beta testing, Cmdr. Nader will fly a solo mission carrying a SEAM/NEMEA experimental testing device aimed to gather data to build a prototype that will allow us to perfect a version of this shielding to be used in manned missions.

The trajectory will be suborbital, ascending up to H=110kms, taking of vertically allowing up to 10 minutes of µG and then descending via controlled vertical powered descent.

The ESAA-02 mission will attempt testing the CYCLOPS system and the ESAA-03 will test the ARGOS prototype.

The Armadillo PIXEL engine prototype during testing

These missions are very low cost, the actual cost for renting the ships is US$102.000, but a whole research

mission can get up to US$200.000 taking into account the engineering and supporting crew for the payload to fly and the specific mission training needed for each mission, the testing equipment and flight hardware for the payload and many other factors that come into play in a manned space mission.

As for budget constraints in the first 3 missions the ship will be manned by one astronaut only, in this case, our only astronaut, Cmdr. Nader, who will have to perform both mission command and mission specialist role.

Artist concept of the Armadillo powered capsule

After these first missions we plan to enforce this low cost space research platform either by alliances with launching companies or by establishing our own spaceports and inviting launching entities to operate and to continue this very economical, yet efficient research program.

The manned suborbital research program will be sustained until the orbital manned program can overtake its functions, accordingly to our schedule, for the year 2014, however, before that date some unmanned orbital mission could take place, whenever budget allows it.

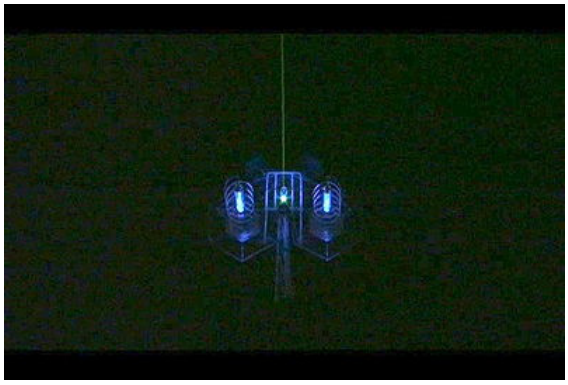
Suborbital Mission Planning: From the operation of the FG1-CONDOR plane we are interpolating the mission planning and the command structure for our first manned space mission.

Our methodology is to prove a concept and once it works we will used as tried-and-true, then we are proving this concepts in every aerospace mission we perform.

More information about Command structure and mission planning can be found on the paper Paper ID: 3358 IAC-09-A2.I.2 of the IAC Congress 2009

Ground Station Development: As a part of the ECSP, a ground station had to be built from scratch, as a first step toward developing national satellite building capability.

This was project HERMES, which rendered a ground station not only able to efficiently work satellites from HF to K band, but also became the first internet to orbit gateway, enabling the nation to acquire many capabilities such as space traffic monitoring and even the capability to relay live scientific satellite signals to any point in the world.

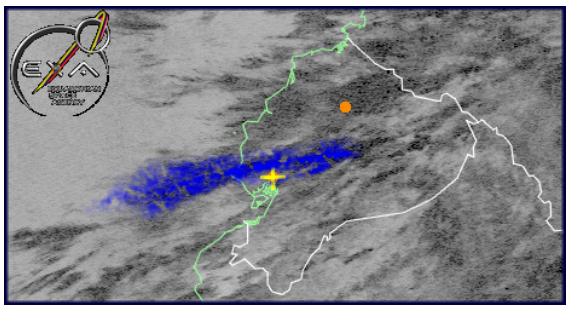


The MINOTAUR array during night operation

One remarkable program is the A SATELLITE IN CLASSROOM program, based on the DELTA operation mode of the HERMES-A/MINOTAUR array, which enable school kids to receive live scientific satellite signals to their classrooms and decode them in real time, taking education to a new highs in the country.

The HERMES-A Ground station has rendered best than expect results and it is also a powerful laboratory that allow us to experiment and learn for ourselves about satellite technology from firsthand experience. And also serves other international institutions abroad like the JAXA, The Michigan State University, the Graz Technical University, the

Swiss EPFL and it is sometimes used for national security purposes when monitoring possible spacecraft collisions on its range of 6000kms, like the event of February 5 2010 between a Iridium 33 debris and the EPFL SwissCube.



The image of the ash cloud spewed by the Tungurahua volcano in 2010, the image was downloaded and processed by the HERMES-A ground station.

Results and impact: The ECSP is, to our knowledge, the only civilian space program in the world: It is not run by the government, but by civilians and where the National Armed Forces collaborate as close partners and not rulers of the program alongside the citizens, it is truly the purest expression of the Ecuadorian desire to reach to the future and progress.

The ECSP is our very own way to walk the path that many other nations have walked before and that has taken them to greatness and progress, we will walk in the same direction but we have chosen our own path.

This unusual collaboration structure has rendered amazing results if it is taken into consideration that before 2006, Ecuador was a country with no presence whatsoever in the astronautics and space sciences community worldwide and now, only 4 years later, the concrete results can be outlined as follows:

-On June 8, 2007, Ecuador trains its first astronaut, with the help of the Russian Federation.

-On August 29 2007, The Ecuadorian Civilian Space Program for the next 10 years is published and the creation of the Ecuadorian Civilian Space Agency is announced.

-On November 1 2007, the Ecuadorian Civilian Space Agency, EXA is created. It becomes the first ever space agency in the history of the country.

-On May 6 2008 EXA and FAE jointly fly the EXA/FAE-02 microgravity research mission, second and final mission for Project DAEDALUS, giving to Ecuador the first and still the only microgravity plane of Latin America.

Cmdr. Ronnie Nader receives the Ecuadorian flag on the maiden mission of the FuerzaG-1 Condor and the salutation of his crew.

-On June 19 2008 EXA and FAE jointly fly the EXA/FAE-06 microgravity research mission for the Project POSEIDON, establishing the World Microgravity Record for the youngest human being, a 7-yeard old child, a delegate from Guinness World Records is present on the premises and declares the record at 11h47 am local time.

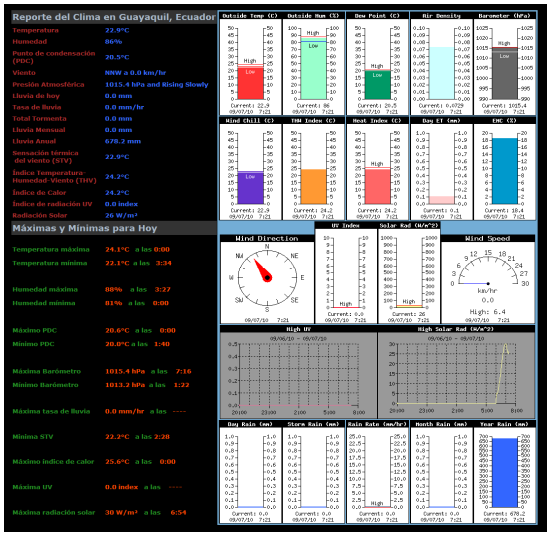
-On the same month EXA and FAE establish the PEVM/G - Ecuadorian Microgravity Flight Program, aimed to encourage the scientific interest in the young students and to continue the biomedical research in microgravity conditions

-On September 29 2008 the General Assembly of the International Astronautical Federation, meeting in Glasgow, UK during its 59th Congress adopts EXA as a new member with the status of Space Agency, representing Ecuador.

-On October 22 EXA publishes de HIPERION report, a 1 year field study analyzing the latest 28 years of data from 10 satellites and more than 200 ground stations around the world and 2 ground stations on Ecuadorian territory, the study concludes

that the ozone layer over the tropics is damaged and as result extreme levels of UV radiation are hitting Ecuadorian territory.

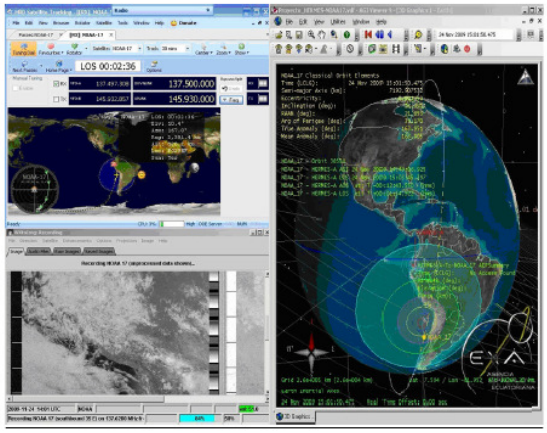
-EXA also implements the Reactive Alert Network HIPERION, a real time alert system protecting more than 4 million people by giving them real time and accurate information about UV radiation levels.



The HIPERION Reactive alert Network interface

-On March 2009 EXA starts the HERMES project, the first Internet-to-Orbit gateway and the most sensible ground station in the region, the station is named HERMES-A//MINOTAUR.

-On September 8 2009, the UN-OOSA invites the EXA to present Project HERMES into the Small Satellites for Sustainable Development Conference and it officially becomes the first Internet-to-Orbit gateway.



The HERMES Virtual Ground Station client interface

-On November 19 2009, EXA presents the A SATELLITE IN CLASSROOM program, based on the Delta operation mode of the HERMES-A/MINOTAUR gateway, the first program in the world that puts a real satellite in the classrooms of elementary schools, making possible for the first time that school children can download images from weather satellites in real time. The Academia Cotopaxi in Quito and the Ecomundo in Guayaquil becomes the first schools in the world to be able to work satellites in their classrooms in a daily basis.

2nd grade children capturing a NOAA-18 satellite image by themselves in real time, thanks to the A SATELLITE IN CLASSROOM program

-On June 29 2010, the construction of the NEE-01 PEGASUS begins, when launched, it will become the first Ecuadorian satellite, completely build in Ecuador without foreign help and with our own technologies and capabilities.

Conclusions: To date, our country has become a productive member of the international space community and a reference point for the space technology development efforts in the Latin American region, as a direct result of the ECSP.

And all this fast development began with the idea of a low cost manned space program: Clearly, the Project ESAA achieved its goal: To spawn a new era of progress for our country and to inspire a whole generation of Ecuadorians to reach for the future with their own hands.

Acknowledgements: The Ecuadorian Civilian Space Agency wishes to thank The Ecuadorian Air force for its support and participation, To the former Air Force General Commanders, Gen. Jorge Gabela, and Gen. Rodrigo Bohorquez, to the actual Air Force General Commander Gen. Leonardo Barreiro for their vision and support to the Ecuadorian Civilian Space Program and to our nation all.

We both, the EXA and the Ecuadorian Air Force have a special regard to the Russian Federation, to all the trainers and directives of the Gagarin Cosmonaut Training Center, who believed in this project joyfully and to whom our country has a debt of profound gratitude.

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