The Ecuadorian Civilian Space Program:
Manned research missions in a low cost space program

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The Ecuadorian Civilian Space Program

- Background
- ASA/T training program
- Manned Missions Program
- CS/MS training program
- Conclusions

The ECSP Background

- 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.

- The ECSP is a young and modest space program, based on indigenous technology, national effort, government and private funding and international cooperation.

- Since 2007 to date, the EXA has reached the following milestones:

The ECSP
Project DAEDALUS

In 2008 Project DAEDALUS tested and flown the first Latin American microgravity plane, the FG-1 CONDOR, an in-house modified T-39 Sabreliner, we flown 8 missions in this plane until achieving research quality microgravity.

We also achieved a Microgravity world record.

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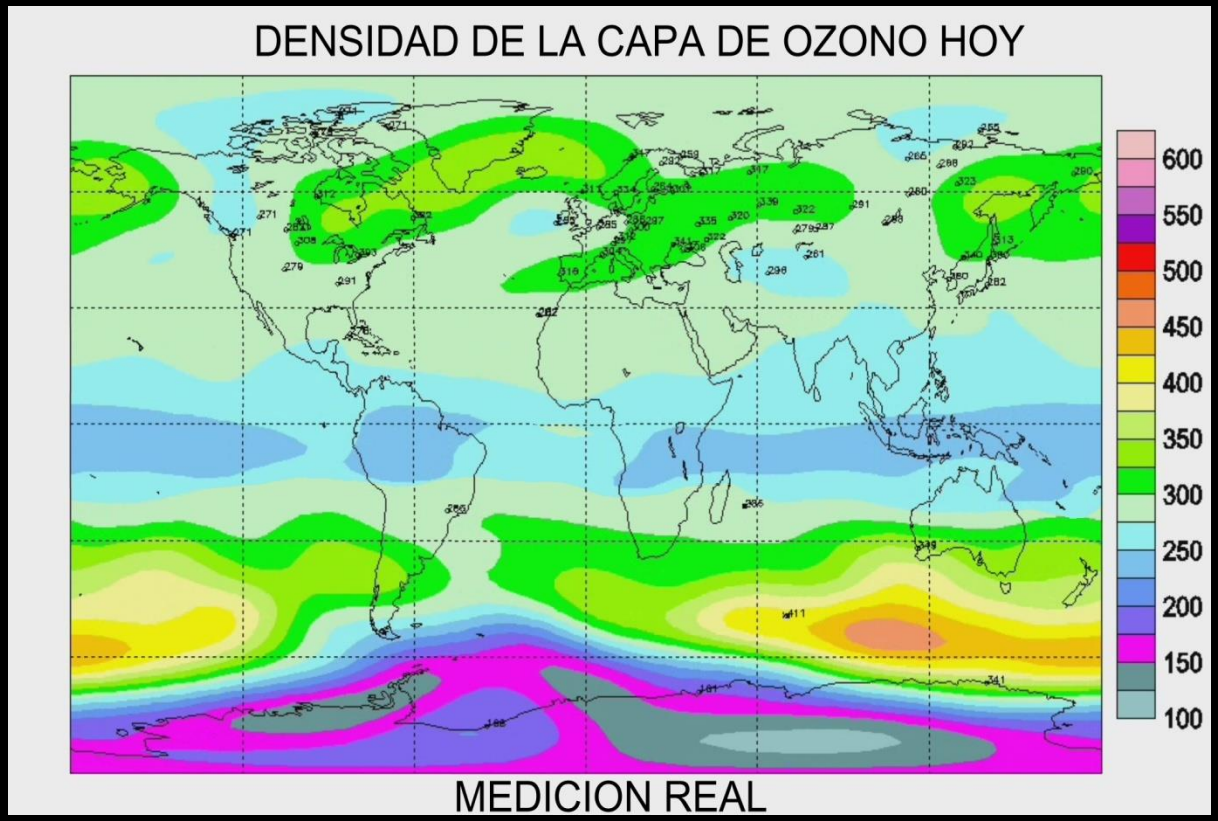
The ECSP Project DAEDALUS

The ECSP HIPERION

- In October 2008 EXA published the HIPERIÓN Report, a resume of a scientific study proving the weakening of the ozone layer over the equatorial region of the planet
- 28 years of data from 10 satellites and 242 days of direct measurements from 10 different points in the country with a 5 minute resolution of UV data were analyzed
- The report clearly showed that UV levels in the country exceeds by far those recommended by the UV Index established by the UN-WMO and the UN-PNUMA
- As a direct result of this investigation, population and government were able to take measures to protect the people by informing the UV index daily, every 5 minutes to avoid the risk of UV overexposure



The ECSP HERMES

- In 2009 EXA built the HERMES ground station based on the MINOTAUR array, in order to acquired the experience need for the Project PEGASUS
- HERMES became the first ground station able to connect orbiting spacecrafts directly to the Internet
- HERMES was presented at the 2009 UN-OOSA Small Satellite Symposium in Austria, were it was remotely operated by engineers of 34 countries

The ECSP PEGASUS

- In 2010 EXA began the design and construction of the first Ecuadorian satellite, the NEE-01 PEGASUS.
- PEGASUS and its twin KRYSAOR were completely built in the country with indigenous technology, fabrication methods, tools and testing facilities that were developed exclusively for the EXA-USP (Unmanned Space Program)
- Facilities as the Space Environment Simulation Chamber or the GOLEM Magneto Acoustical Vibration Facility were also build for testing and development of indigenous satellite technology

The ECSP
Exporting our technology

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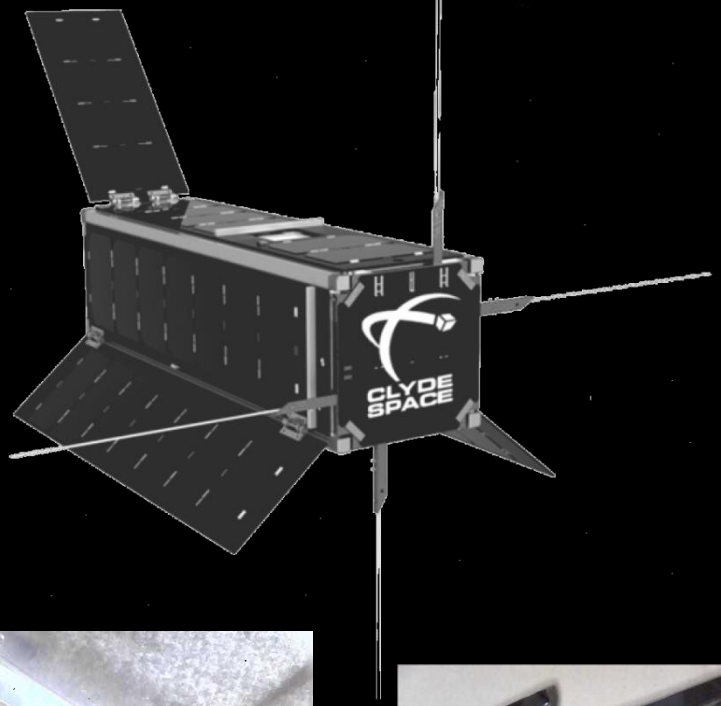
UKube-1

- In 2011, EXA participated in the development of Ukube-1, first cubesat from United Kingdom with the manufacturing of 8 custom made parts of titanium for the flight model
- The parts provided were 10 times lighter and 5 times stronger than those commercially available
- To our knowledge, it was the first time in history that a country from Latin America exported space technology to a country of the G7 group



The ECSP PEGASUS

On April 25 2013 at 23h13m LCL time the Chinese vector LM2D departed from the Jiu Quan Cosmodrome, where an small delegation of Ecuadorian officials was present

Local operations to capture initial telemetry in Ecuador were in charge of the EXA's Mission Director, Cmdr. Ronnie Nader

President Rafael Correa and Vice-president Jorge Glass both attended the launch operations in person at the CCVE in Samborondon sitting behind EXA's crew.

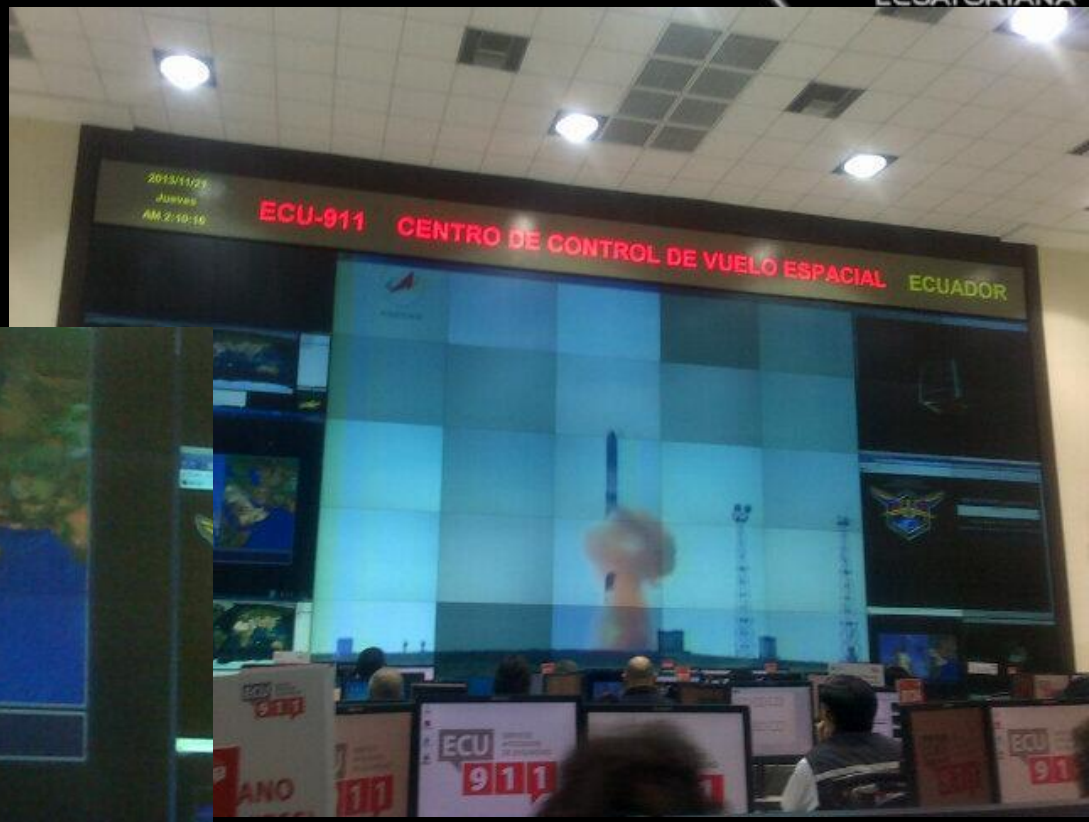
The ECSP PEGASUS

On May 5 2013, first contact with the NEE-01 was established with HERMES-A ground station in Samborondon.

PEGASUS became the first cubesat to transmit live video from orbit, and, using the HERMES Internet-to-orbit relay capabilities, the video feed from the satellite is received directly by people around the world, even in their smart phones, live from space.

The ECSP KRYSAOR

On November 21 2013 el NEE-02 KRYSAOR reached its target orbit on board the Russian Dnepr RS20B



The ECSP PERSEUS

In January 2014 the NEE-02 KRYSAOR flying formation with the NEE-01 PEGASUS was able to retransmit its signal, lost 6 months before due an orbital debris incident when HERMES ground control activated the PERSEUS device, achieving the first rescue operation for this type of spacecraft

The ECSP
Exporting our technology

- In December 2015, a group of 4 U.S. High Schools selects EXA to provide parts for a fleet of 12 cubesats to be launched along 12 years. EXA will provide the SEAM/NEMEA anti radiation MLI, the deployable solar arrays, titanium structure and the high energy density battery arrays for this fleet. EXA gets the second biggest contract for this project.

- The U.S. Government provides the funding for this program.

- EXA participates in this project besides big names as NASA JPL, MIT, SORLOX, Brown University, CalPoly, Montana State University, Tyvak and others.

- This is the technology developed for project PEGASUS. To our knowledge, it is the first time in history that a Latin American country exports its indigenous and original space technology to the United States of America.

The ECSP
Aerospace Operations

- To this date, EXA operates a fleet of six drones, multi-rotor and fixed wing.
- The FEROX class multi-rotor can fly up to 120 minutes using a system of energy recovery from the engines, invented at the EXA.
- We have 3 trained pilots operating the drones OLS (Out of Line of Sight) from command stations, using VR head gear to distances up to 32 km.
- This fleet has been built using the technology and experience developed for the PEGASUS program, and the pilot training program used elements from the ASA/T program.
- To summarize, EXA currently operates a fleet of 6 drones and 2 satellites.

The ECSP Publishing

- Until this date EXA published 55 papers accepted for oral presentation in international workshops and congresses of IAF, IAA, and institutions like the Universities of Harvard, Utah, CalPoly, The Austrian Academy of Sciences and the ITU. Some papers have been published in Acta Astronautica.

- The work of EXA and the history of the ECSP is included in the official national school textbooks and in private ones too.

- To date, the EXA has been honored and decorated 10 times, by various government ,official institutions and universities, including the National Assembly medal for Scientific Merit, the highest national honor in the sciences area.

The EXA MSP RATIONALE

- Developing countries need science and technology to boost their develop process.
- Access to space for our countries has always been exclusive and elusive due to costs, technology and some times political constrains. Human access to space is still more difficult to achieve for our societies.
- One solution is to develop an indigenous, entry-level manned space program bearing a low cost and a relatively high yield with a fast turn around.
- The answer lies in the very beginnings of the cold-war era space race: SUB ORBITAL SPACE FLIGHT.
- It is said that exploring space is mankind’s endeavor, yet developing countries are still looking from the sidelines: We must engage in this endeavor too, because we are mankind too.

The EXA MSP Background

- In August 29, 2007 the Ecuadorian Civilian Space Program is announced and the Ecuadorian Civilian Space Agency is created.
- 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 Cosmonaut, able to serve both a as a mission specialist and a mission commander depending on what the nature of the mission demanded.

The EXA MSP
WHAT IS AN ASTRONAUT

- "Astronaut is a person that crews an spacecraft or is trained to do so" accordingly to Merriam –Webster dictionary
- NASA and ESA declares astronauts once a 2-year basic training program has been completed by the candidate.
- ROSKOSMOS declares cosmonauts once the basic training program has been completed by the candidate, which can take from 18 months to 26 months.
- Only after the completion of the basic training program a mission is assigned to the newly minted astronaut or cosmonaut. It can take many years for an astronaut or cosmonaut to actually crew a mission.
- Astronauts/Cosmonaut are declared upon completion of basic training BEFORE reaching space, not the other way around.

The EXA MSP ASA/T Program

- The ASA/T training program had a net duration of 16 months, accomplished among 3 years.
- It was divided in 3 phases and included scientific, technical, military and physical training

The EXA MSP ASA/T Program

The ASA/T training program executed:

- 8 EVA simulation sessions
- 10 centrifuge sessions, minG= -4.5G, maxG= 8.6G
- 3800 hours of theory sessions
- 2800 hours of physical preparation
- 140 sessions of medical tests
- 800 hours of Russian languages
- 200 hours of combat jet flight training
- 60 hours of microgravity flight
- 6 sessions at the hypobaric chamber
- 6 wilderness and sea survival sessions
- 4 Soyuz TMA simulation sessions
- 10 Astronavigation simulator sessions

The EXA MSP ASA/T Program

- NEEDS FOR THE PROGRAM:
- A professional able to both command an space mission and do science in space aim to practical needs of technology development.
- The profile of an ASA/T cosmonaut requires qualifications in science, engineering and command aptitude.
- The ASA/T Program objective is to produce the crew for the ESAA suborbital research manned missions.

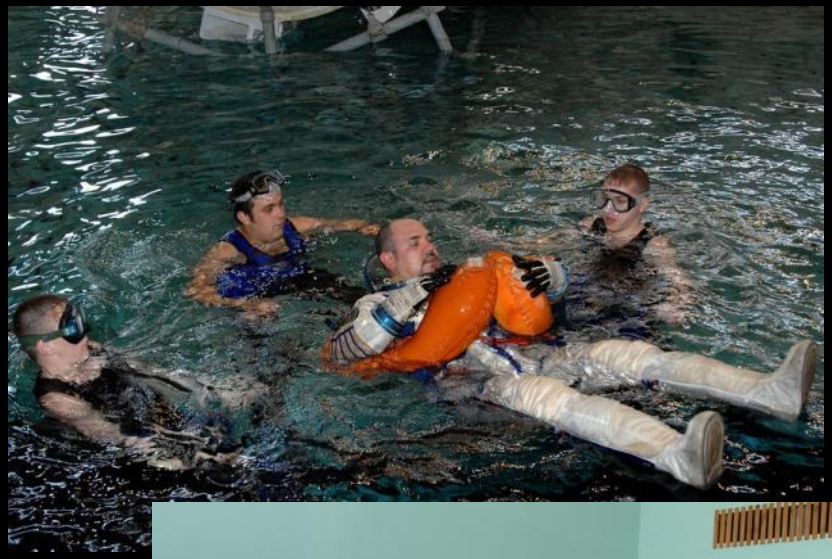
The EXA MSP ASA/T Program

- This type of mission profile is very similar to the U.S. first suborbital missions in space, an astronaut manning a vertical takeoff – vertical landing capsule, performing science observations and experiments in space for a short period of time.

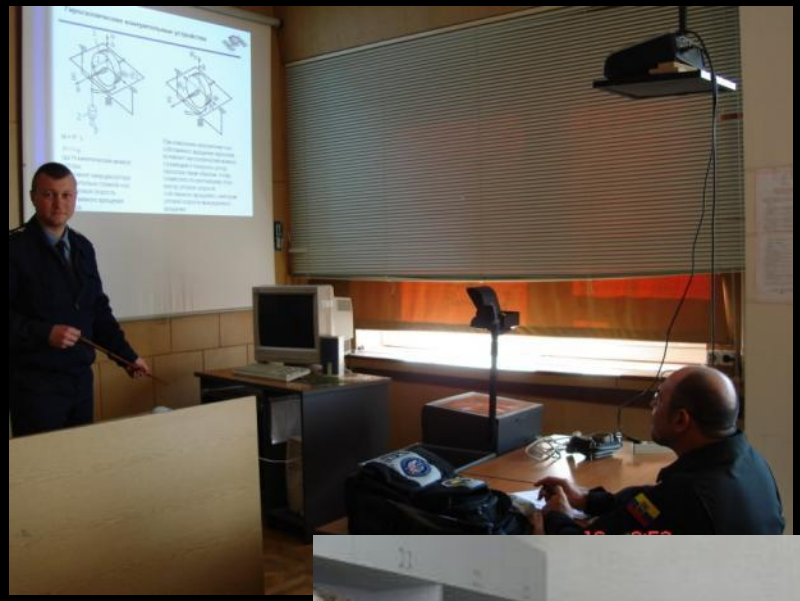
- The reason for choosing this type of mission is that it is a very low cost and can be sustained over time, and provides direct opportunities to Ecuadorian researchers for developing professional space exploration skills.

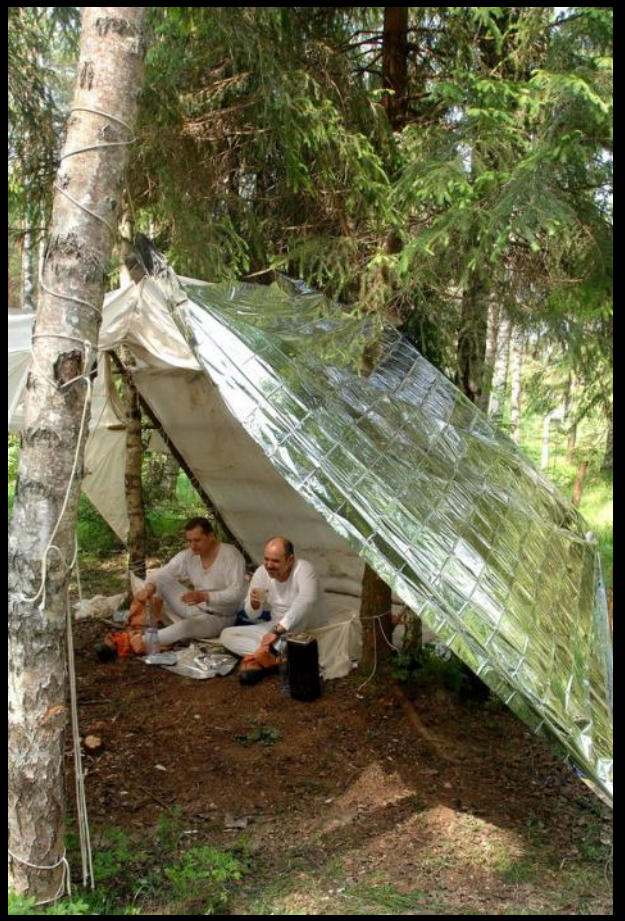
- And allows us to truly inspire our people trough science and achievement.

The EXA MSP
ASA/T Program

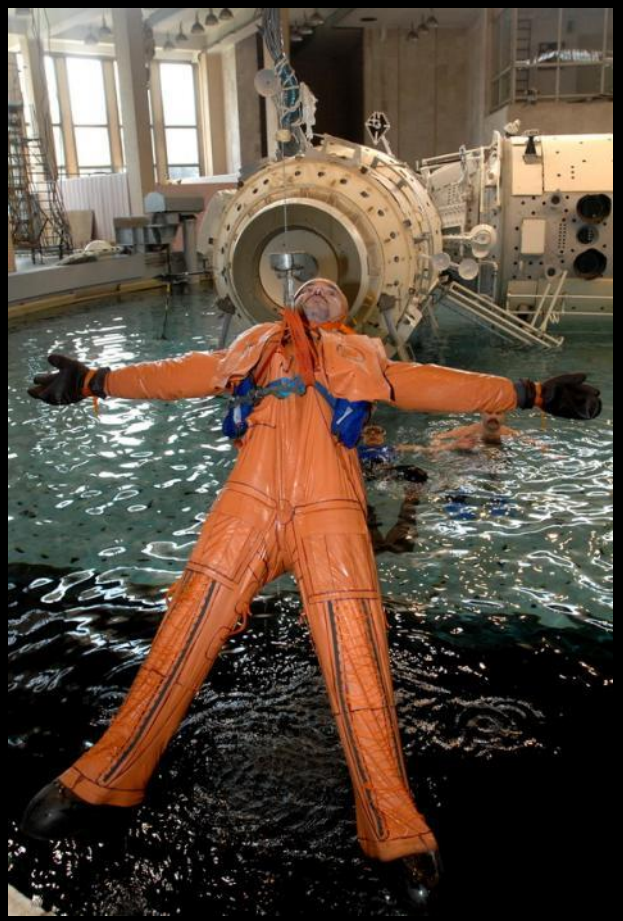


The EXA MSP
ASA/T Program



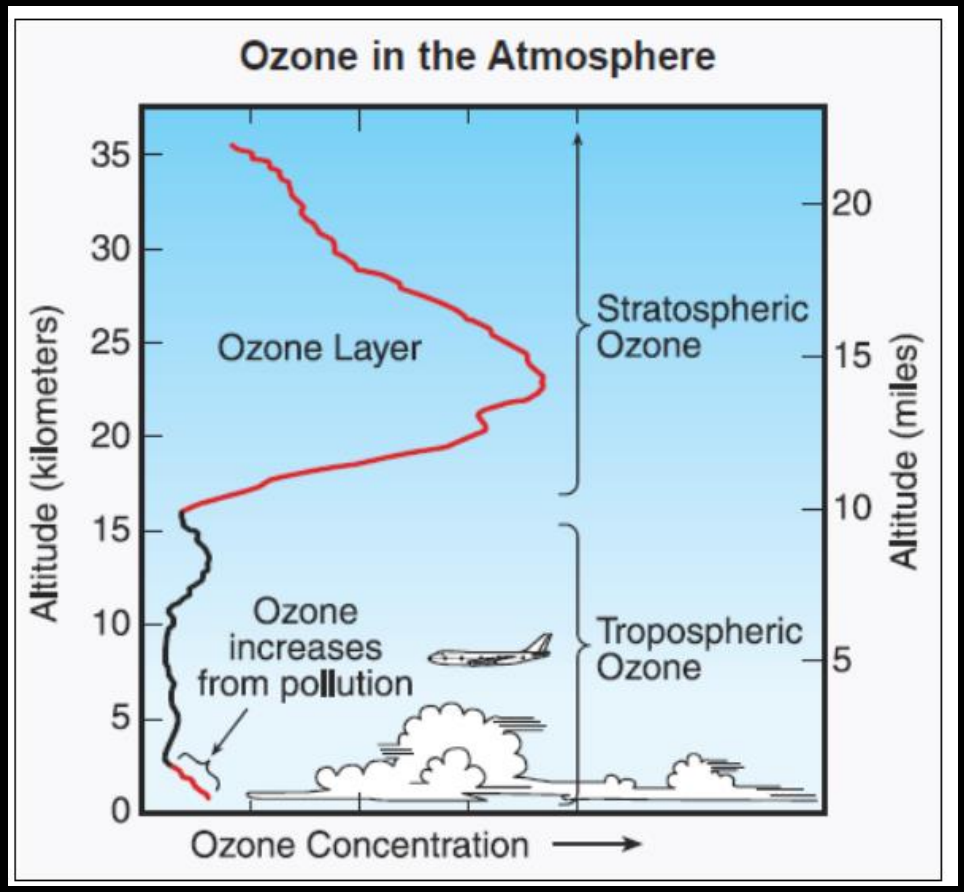


The EXA MSP ASA/T Program



The EXA MSP
Sub-Orbital Phase

- 3 missions have been outlined for this phase: the ESAA-01, ESAA-02, and ESAA-03 missions.
- The primary objective is HIPERION II: To obtain a direct sample of the ozone layer between 15 and 60 kilometers and direct measurements of its dimensions like density, temperature, composition, mixture with other gas species while in flight.
- The secondary objective is the use of 2 systems that are currently in use in our unmanned space program, onboard our 2 satellites NEE-01 and NEE-02



The ECSP
Manned Mission Program

- The approach to the Phase 1 is to lease low cost, vertical launch manned suborbital spacecraft like the ones being tested by XCOR and/or Blue Origin.

- Yet, the full experience of a professional space mission had to be developed, and then it came the DAEDALUS Project.

- In November 2007, EXA 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.

The ECSP
The DAEDALUS Program

On April 10 2008, Mission EXA/FAE-01 is executed by Mjr. Xavier Coral and Cmdr Nader achieving 301 seconds of µG on 21 parabolas, the MGCP-MK1 acquired the flight parameters as expected, while providing the mission commander with guiding data about µG conditions achieved.

The ECSP
Manned Mission Program

- Once the nation acquired the capability of parabolic flight, EXA and FAE were able to plan and execute astronautics training missions

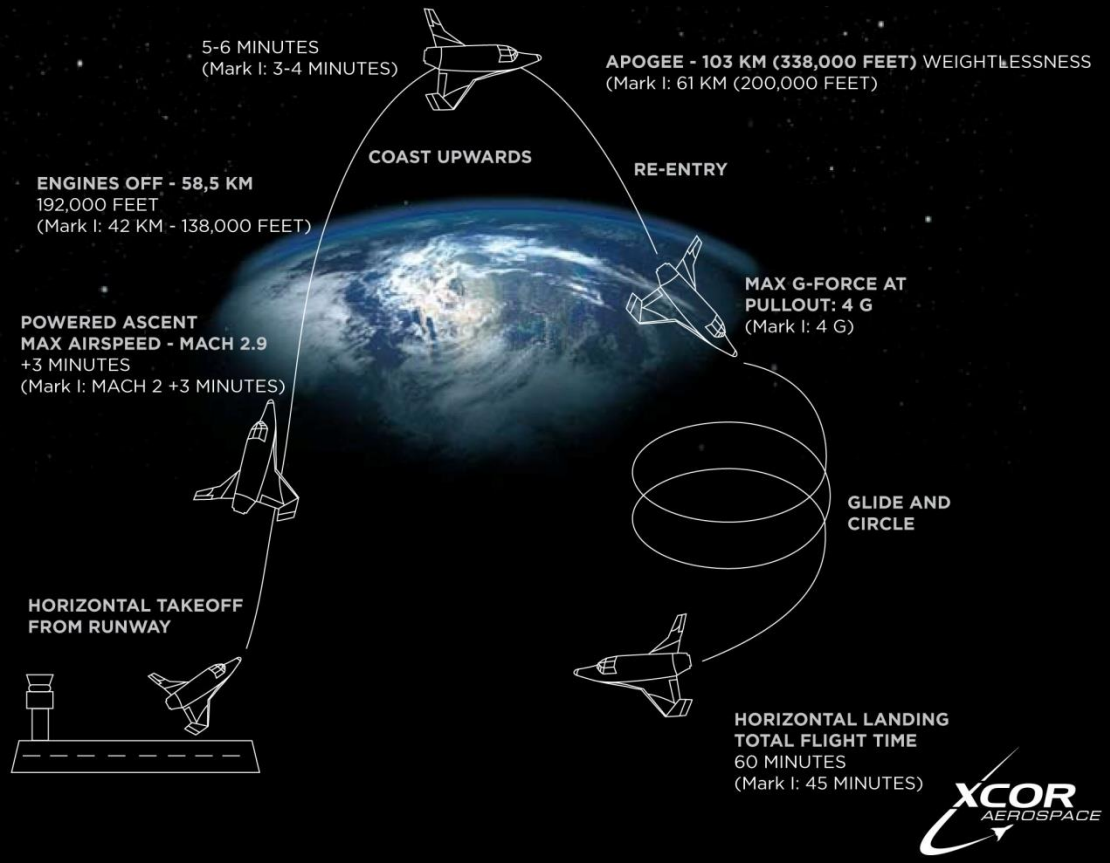
- From that point 7 research missions were flown and many other training missions, a command structure and mission protocols were developed, the best feature of this missions is they are very similar to the short term suborbital missions planned for Phase 1.

- Cosmonaut Nader gained command experience and the EXA and FAE teams gained mission experience.

- FAE put their equipment and human resources, EXA did the same and added the experience gained during the ASA/T program in Russia.

The ECSP
Manned Mission Program

- The first Ecuadorian manned mission to space will be the ESAA-01 carrying the HYPERION II payload mark-1.
- The second mission, ESAA-02 will carry the HYPERION II payload mark-3.
- The third mission ESAA-03 will carry the HYPERION II payload mark-5.
- The trajectory will be suborbital, ascending up to H=105 km, and payload operation will start on H=15 km until H=70 km.
- On descent payload operation will begin again at H=70 km until H=15 km



The ECSP
Manned Mission Program

- The actual cost for leasing the XCOR spacecraft is US$150.000.
- But a whole research mission can get up to US$400.000 factoring in 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.
- The ozone samples have to be processed almost immediately, as O3 survives less than 30 minutes in non-cryogenic environments, however the HYPERION-II payloads carry cryogenic preservation systems and XCOR Lynx provides cryogenic feed lines.
- The data recorded for the HYPERION-II payload as well as the sensor matrix and crew control interface have already been developed and we have tested prototypes for the Mark-1 and the Mark-3

The ECSP
Manned Mission Program

- XCOR Lynx provides 3 payloads bays to hold scientific payloads, HYPERION II is cubesat 3U form factor that can be mounted in payload bay A or payload bay C in the back of the spacecraft

- EXA has payload capacity available in its program flights for 3rd parties to allocated their experiments, if interested, contact us.

- Payload could be 1U to 3U cubesat form factor, they can be automatic or operated by our crew.

- A RFI can be sent to spaceops@exa.ec

CS/MS TRAINING SYSTEMIC APPROACH

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CS/MS TRAINING PROGRAM

Physiological Component

Fitness Training

Space Suit Training

Flight Skills

Centrifuge

High G Training

Zero - G Training

Academic Component

Theory Classes

Specific Training

Space Craft Systems

Simulator Training

Payload Component

Payload Des, Ops, Int

Survival Component

Survival Training

Emergency Drills

Operations Component

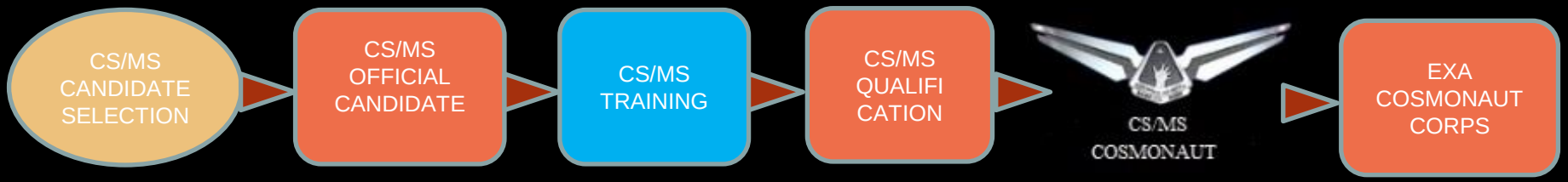
Ground Control

Flight Planning/ Control/Ops

Fist Class CS/MS Training Track 1: Basic and Advanced Suborbital Training (BAST)

- Once the candidate is accepted, in the **CS/MS** program, he becomes a **CS/MS OFFICIAL CANDIDATE** The CS/MS official candidate trains for a period of 2.5 years in **Basic and Advanced Suborbital Training** (**BAST**), including:
    - Academic Classes.
    - Payload Training.
    - Physiological Training.
    - Survival Training.
    - Flight Skills Training.
    - Flight Planning Control & Operations Training.

- After the **BAST CS/MS Training** is completed, the candidate obtains the **CS/MS Cosmonaut function** in EXA cosmonaut corps.



First Class CS/MS Training Program: Candidate Requirement

Candidate requirements are:

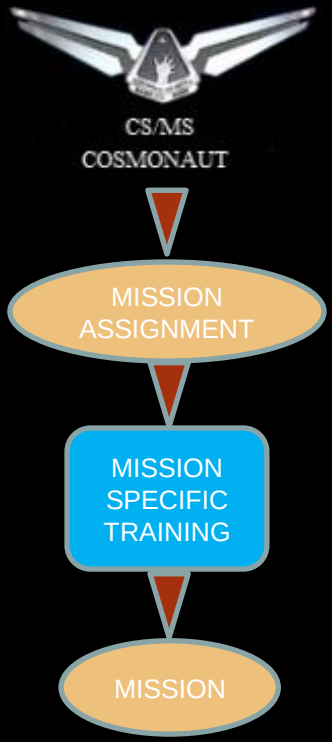
- Being Ecuadorian of birth.
- Age between 35 and 45 years.
- Have at least a bachelor degree of Systems Engineering, Telecommunications, Electronics or related field with a minimum duration of 5 years
- At least 5 years of professional experience in the career or in related projects.
- Lab experience or applied engineering experience.
- Ability to perform work in flight environment.
- At least 4 papers of career related research, published in symposiums or in indexed publications, at least 2 must be English.
- Conversational fluency in English, an acceptable level of Russian language is desired also.
- Good health with no disqualifying conditions.
- height between 1.65m and 1.80m

Fist Class CS/MS Training Track 2: Suborbital Specific Training (SST)

- The **CS/MS Cosmonaut** is assigned with a mission and will receive the **Suborbital Specific Training (SST)** of about 6 months. This means that the First Class complete CS/MS Training Program last for 3 years.

- The default assignment will be to serve as a backup for the ESSA missions.

- After the first mission is completed, EXA will evaluate mission performance and results, depending on which the **CS/MS** could be assigned to the **ASA/T COSMONAUT** training program in order to apply to command functions, and if so, under graduation from the ASA/T program he will hold the function of sub commander of the EXA Cosmonaut Corps.

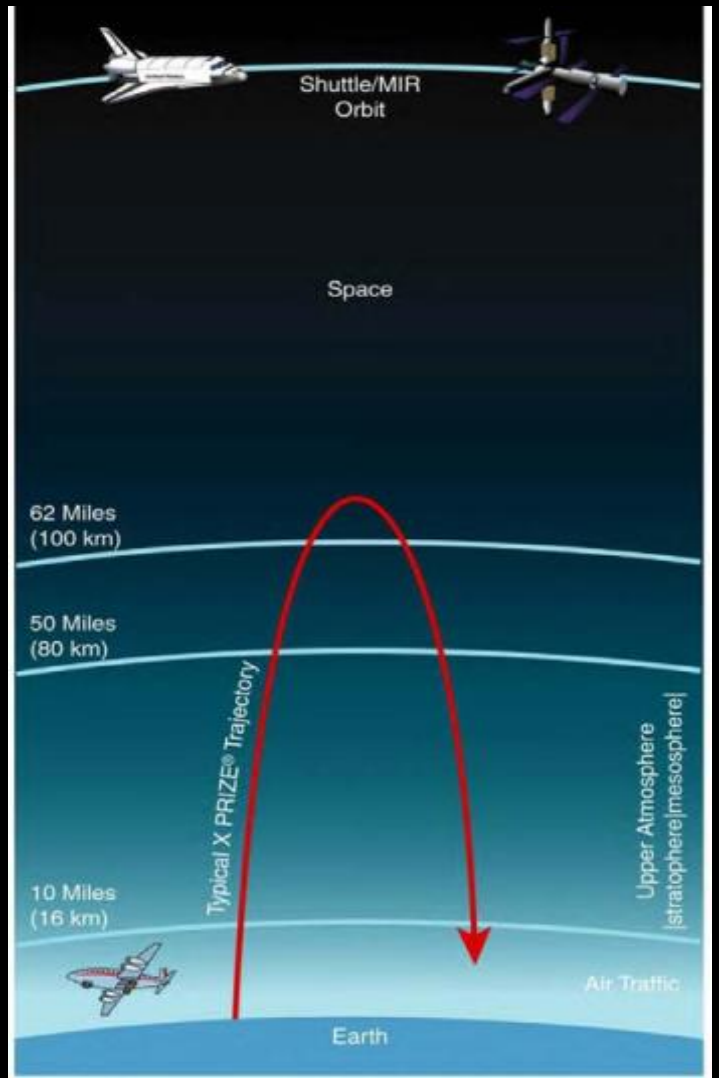


CS/MS Training Curriculum

COMPONENT	TRAINING - TOPIC	CS/MS TRAINING			SPECIFIC TRAINING
		BASIC TRAINING		ADVANCED TRAINING	
		Module I	Module II	Module III	Module IV
ACADEMIC	Theory classes				
PHYSIOLOGICAL	Fitness Training				
	Physiological/Space Suit Training				
SURVIVAL	Survival training				
	Emergency drills				
FLYING SKILLS	Human Centrifuge				
	High-g training				
	Zero-g training				
OPERATIONS	Flight Planning, Control and Operations				
	Ground control/coordination				
SPECIFIC TRAINING	Simulator training				
	Mission Specific Training				

The ECSP
Manned Mission Program

- 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
- This shift will depend on budget and available TRLs commercially available



The ECSP
Conclusions

- The ECSP is supported by our government, but run by civilians and where the Armed Forces collaborate as close partners of the program supporting the citizens.
- The structure of the Manned Space Program allows flexibility both in costs and turnaround mission time, producing results fast with a modest investment.
- The ECSP is our own way to walk the path that other nations have walked before and that has taken them to greatness and progress

We will walk in that same direction, but we have chosen to follow our own path.

The ECSP Conclusions

- The ECSP is a young but sovereign space program, we are still in our beginnings.
- We look forward for international cooperation and development
- We also look forward to integrate into the international community and to contribute with our experiences, technology and resources to the concerted effort for constructing a truly inclusive space faring society.

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One day, not far away
We will touch the sky...

...In the name of Ecuador.