68th International Astronautical Congress (IAC), Adelaide, Australia, 25-29 September 2017.


IAC-17,E1,IP,14,x37364

# AFFORDABLE ACCESS TO SUB-ORBITAL RESEARCH FOR LATIN AMERICAN COUNTRIES

**Msc. Jaime Jaramillo[a]*, Erika Wagner[b], Cdr. Ronnie Nader[c]**

[a] *Space Operation division, Ecuadorian Civilian Space Agency (EXA), Av. República del Ecuador y Av. Naciones Unidas, Quito, Ecuador, jaimej@exa.ec.*
[b] *Blue Origin, 21218 76th Ave S, Kent, WA, USA, Phone: +1-253-437-9300, ewagner@blueorigin.com.*
[c] *Space Operation division, Ecuadorian Civilian Space Agency (EXA), Km 3.5 via a Samborondon, Guayaquil, Ecuador, rnader@exa.ec.*
* Author

## Abstract

With the rise of affordable suborbital launch vehicles, new opportunities are arising for regions that Otherwise struggle to access space and its micro gravity environment. In the case of the Latin American region, there are many institutions, both governmental and private, that seek space access to conduct scientific research and technology development. We see a valuable opportunity to train the next generation of space researchers in our region through hands-on projects culminating in spaceflight research missions. To that end, the Ecuadorian Civil Space Agency (EXA) is working with Blue Origin to fly a dedicated Payload Locker of Latin American micro gravity research experiments in 2019 (LATCOSMOS-B). Through an international proposal process, we will select 12 organizations to build and fly NanoLabs on the New Shepard space vehicle. These small format payloads will experience three to four minutes of free fall within the New Shepard crew capsule, offering opportunities for life and micro gravity sciences, as well as multi-body interactions, liquid physics, and technology demonstrations. To help facilitate broad sharing of this experience across and beyond the region, we will encourage teams to submit and execute outreach plans with their science. Future opportunities for human-tended research will also be briefly discussed. This paper will focus on the project plan and objectives propose a draft mission plan for a model Mission and discuss the implications for the region.

**Keywords:** (Suborbital, Microgravity, Latin America, Education)

## 1. Introduction: Microgravity science in Latin American Region, Prospective and future.

Space exploration triggers the imagination of the people. Since the first human space flight in 1961, more than 500 explorers from different nations have ventured into space, motivated by curiosity, the impetus of knowledge and a certain belief that space exploration could benefit people on Earth.

Unfortunately, the unequal development of the space industry worldwide has created a difference between space nations and non-space nations, in much the same way that differentiates developed and undeveloped countries.

Historically, the LAC region has always been lagging behind in the space sciences and technology area.

This differences lies in three aspects:

- Access to space
- Education
- Funding

For example, in the Latin American region up until May 2008 there was no way to access a microgravity research facility that can offer more than 4, or at most 5, seconds of high quality microgravity conditions. In answer to this came in 2009 the DEDALUS PROJECT [1], which is until now the only initiative for microgravity flights in the region.

In this field, with a few honorable exceptions [2], things have not changed so much.

The lack of interest in space development by the Latin American Governments, with some exceptions as Brazil, Argentina and few others recently, is reflected in a lack of funding and therefore limited research, development and achievements.

Access to space in the region is not just limited to microgravity science, but also to the opportunities to launch satellites because we do not have a regional launch vehicle that can give us this permanent access to orbit. Despite this great obstacle, there have been many successful projects in this area [3,15]

Indigenous space technology development is likewise limited because government-sponsored technology acquisition from space nations often comes without technology transfer programs that can foster the

domestic development of such technologies such as R&D and testing facilities, university careers, startups, etc.

In the education axis, the lack of a permanent program for access to space technologies in the region has resulted in a limited number of secondary schools or universities incorporating space science and research on their curriculum at a permanent basis, with some notable exceptions [16] that only confirm the rule.

Limited access to space environment laboratories is also an obstacle to overcome for those who choose the path to develop their own space technology in the region.

Finally, one of the biggest obstacles, if not the main one, is the lack of budget for this emerging industry in the region., Until now the only civilian space agency in the region is EXA, and with governments in the region trying to solve other political and economic problems, space development tends to be marginalized from the hemisphere's political agenda. To this, we have to add the lack of interest from investors or even lack of knowledge of the real opportunities in Space technology development that can be turned into advances for industrial and commercial ventures

***What is the good News?***

The good news for the Region comes from the IAF-GRULAC group and its LATCOSMOS space development plan [17], which plans to intervene in the three axes of the problem.

This paper is focused on the LATCOSMOS-B initiative: "Your Experiment to Space" (YES) which intends to create a permanent program for Affordable Access to Suborbital Research for Latin American Countries in alliance with U.S. commercial space company, Blue Origin.

We will review the LATCOSMOS-B in detail in section 3 of this paper, and we will also link it to LATCOSMOS-C initiative: "Latin Americans in Space", the human spaceflight component of the LATCOSMOS initiative.

The last part of section 3 will be dedicated to a executive review of the LATCOSMOS-D: "Get Funded", which will establish the flow of funding that will allow this program become a reality.

After the trial of LATCOSMOS program is finished, IAF-GRULAC intends to convert it in a permanent program for Latin America, which will put our Region in a world-class position of access to suborbital and microgravity missions.

## 2.- New Shepard Flight Opportunities

Blue Origin's New Shepard vehicle began suborbital test flights in 2015, demonstrating operational reusability of both booster and capsule. Three missions in 2016 included pathfinder research payloads from the United states and Germany, exploring basic and applied fluid physics, as well as low-gravity collisions with applications to planetary science.

With a parabolic trajectory cresting at over 100 km (62 miles), the New Shepard payload capsule experiences over 3 minutes of free fall before returning to Earth under parachutes and soft landing with a retro thruster system. The interior of the capsule is kept at a "shirt-sleeve" environment, simplifying hardware development and operations (Fig. 1).

New Shepard's current Research and Education Missions (REM) program supports payloads in a variety of sizes, ranging from small NanoLabs to standardized Locker formats to large-format custom payloads over 200 pounds (Fig. 2).

NanoLab payloads are specially designed to provide students of all ages with a low-cost, reduced-complexity format for accessing the microgravity environment. Up to 12 NanoLabs are housed together within the capsule in a Locker-scale facility provided by NanoRacks, the NanoRacks Feather Frame (NFF).

A NanoLab consists of a small customer-provided box and its payload. Maximum external dimensions are 10x10x20 cm, and maximum total mass is 0.5 kg. Multiple such units can be grouped together for a larger experiment. The NFF provides appropriate interfaces to the capsule and, starting about five minutes before launch, 5V of power at 0.9A and key mission parameters via a USB interface (Fig. 3).

Standard experiments should be flexible to orientation, able to be loaded into the rocket ~4 days before flight and removed ~12 hours after flight. (Late load and early recovery may be available as a special service.) NanoLabs should contain no significant hazards (biological, chemical, stored energy, etc.). Flight environments, interface details, and concept of operations are provided in a NanoLab Payload User's Guide.[18]

What can student accomplish in this sort of short spaceflight? The answers are wide ranging:

- Release balls of colored liquids to explore fluid dynamics
- Explore the collisions of simple objects like beads or rubber balls
- Watch brine shrimp or other simple organisms respond to changing gravity levels
- Melt a low temperature polymer or wax in the absence of convection
- Create zero-G art or musical compositions
- Explore the basic physics of a mass on a spring under variable G-loads
- Examine capillary action with liquids of different properties

- Test technologies for a future ISS mission or CubeSat
- Or whatever else they may dream up!

The process from contracting to flight can be as short as six months or modified to meet an academic calendar. Student teams are supported through pre-flight design and safety reviews, flight, and return of their experiment.

## 3. The EXA-BLUE Latin American Initiative: Your Experiment to Space (YES)

*3.1 Program Overview*

The LATCOSMOS-B: "Your Experiment to Space" (YES), is part of the working program of the IAF-GRULAC, and consists of a commercial initiative between the EXA and Blue Origin, that will fly a dedicated Payload Locker of Latin American micro gravity research experiment in 2019.

- The **goal** of this program is to allow high school children to fly their experiment to suborbital space and expose it to microgravity in order to inspire the excitement and the life changing experience of participating in a real space mission on a real rocket, from an early age.

- The **means** of this program is to send a 500 grams payload into suborbital space using the Blue Origin's New Shepard launch vehicle and teach them how to design real space science experiments, how to prepare real space payloads, collect data and analyze it to produce real scientific results.

- It is based on the NanoLabs platform that has already more than a dozen payloads in development and getting ready to fly on board the New Shepard launch vehicle.

- The **result** that we want achieve here is to demonstrate to the students that dealing with space hardware and space missions is not only achievable for them, but actually is an exhilarating experience, therefore empowering them with the courage to follow their vocation as our future space engineers.

*3.2.- Draft Mission Plan and Road Map*

The YES Program is a complete initiative that will help institutions to send experiments to space for the first time. The initiative will be operated by EXA-Blue Origin alliance, and managed trough IAF-GRULAC and its allies in the LAC Region.

The IAF-GRULAC using the academic and research network of itself and its allies, will organize a Kick-Off event for all the institutions interested in this initiative. In this event will be reviewed potential research topics, such as life and microgravity sciences, multi-body interactions, fluid physics, and technology demonstrations. Participants will be given a short introduction to the program and the technology that will be used (NanoLabs), so that the institution will understand the restrictions for their experiments. In this Kick-Off event, IAF-GRULAC will launch its Call for Experiments for the YES Program. This ***Call for experiments*** process will be oriented to Schools, High Schools, Universities and Research Institutes in the LAC Region.

The YES program will select twelve experiments from the ***Call for Experiments***, and initiate with those institutions the consulting process to lead them to space (Fig. 4).

A Technical Advisory process will help schools to formulate the experiment in a standard New Shepard Research and Education Mission (REM) format. After the experiment is correctly formulated, the institution will receive consulting to design it.

Next, the functional proof of concept (PoC) of the experiment will take place in the Laboratories of the institution or in laboratories of IAF-GRULAC allies if the institution does not have the facilities for the PoC implementation. Each institution will have to designate a Technical responsible party for the PoC. The technical team of the YES program will advise the PoC.

Each sponsored institution will need to submit periodical progress reports while building the payload to monitor the effectiveness of the program, and a final report detailing how grades improved in the participating students.

When the PoC is ready, it will have to be miniaturized to the NanoLabs Form Factor. This process will be in the hands of EXA, in close work with the PoC responsible in each institution. It can be done in the institution laboratories or in the EXA (and allies') laboratories, as required. Once this is finished we will obtain ***Prototype 1*** (Fig. 5) of the experiment.

The NanoLab Prototype 1 will be certified for the New Shepard flight in the EXA labs; testing will include: vibration, audible noise, electromagnetic radiation emission, hazardous material revision protocols, pressure levels, and heat generation. Once the certification process is finished and the experiment obtains the certification report, we will have ***Prototype 2*** (Fig. 6) of the experiment.

EXA will lead the REM Payload Integration with Blue Origin and NanoLabs to obtain the experiment permissions to flight in the New Shepard. After successful completing of these reviews, EXA will perform the Launch Site Integration with the PoC, and its institutional working group.

NanoLabs will be launched and recovered at Blue Origin's West Texas Launch Site, and we will obtain the Data collected on the flight (Fig. 7).

Finally, with the Data obtained from the mission, the institution will receive additional advice to publish their results in technical and scientific media, with the help of the IAF-GRULAC network and its allies (Fig. 8).

*3.3 The Next Step: The Crewed Latin American Missions (Overview)*

Beyond the non-crewed space program of LATCOSMOS is the "Latinamericans in Space" initiative which intends to train and fly the first Latin American suborbital missions (Fig. 9)

- The **goal** of this program is to allow Latinamerican professionals to be trained as payload specialists and fly a suborbital space mission as crew with the objective of operating an experiment in microgravity to inspire the whole region by demonstrating regional capabilities in a dedicated human space mission crewed only by Latinamericans
- The **means** of this program is to train a crew of 5 payload specialist and 1 mission commander using a shorter version of the Advanced Suborbital Astronaut Training Program (ASA/T) developed by EXA/GCTC (Gagarin Cosmonaut Training Center) and then fly a technical research mission in suborbital space reaching more than 100 km above Earth's surface, onboard the Blue Origin's New Shepard launch vehicle.
- It is based on the first U.S. human space mission of 1961 flown by Alan Shepard by the means of the Mercury Redstone 3 launch vehicle onboard the Freedom 7 capsule on a vertical takeoff and capsule landing suborbital flight profile.
- The **result** we want to achieve is not only to **demonstrate** that the region can produce its own astronauts, but to acquire the talent and workforce that the region needs.

## 4.- Programatics

In accordance with Blue Origin and OrbitMuse the initial flow for this program will be as show in Fig. 10

## 5.- Conclusions.

LATCOSMOS-B: Your Experiment in Space (YES) program is the first sustainable initiative for affordable access to suborbital research for Latin American countries. Once consolidated as a permanent program, it will operate in the three aspects that generate the gap between LAC Region and more active space nations:

- **Access to space:** LAC Region will have permanent access to space through suborbital missions of Blue Origin, in its New Shepard spacecraft.
- **Education:** This initiative promotes connectivity through all levels of education in LAC Region, but especially Schools and High Schools; i.e., it is oriented to the New Generation of LAC Region.
- **Funding:** For the first time in LAC Region, an initiative like this starts with the funding source inside it, and with a new means of reach financing sources: crowdfunding. It means that we will not have to see the initiative die looking for governmental and military funding.

The impact on the LAC Region will be huge and could be measured in the near future as the new generations of Latin Americans join humankind's effort to expand beyond this planet in order to survive.

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## 7. Figures

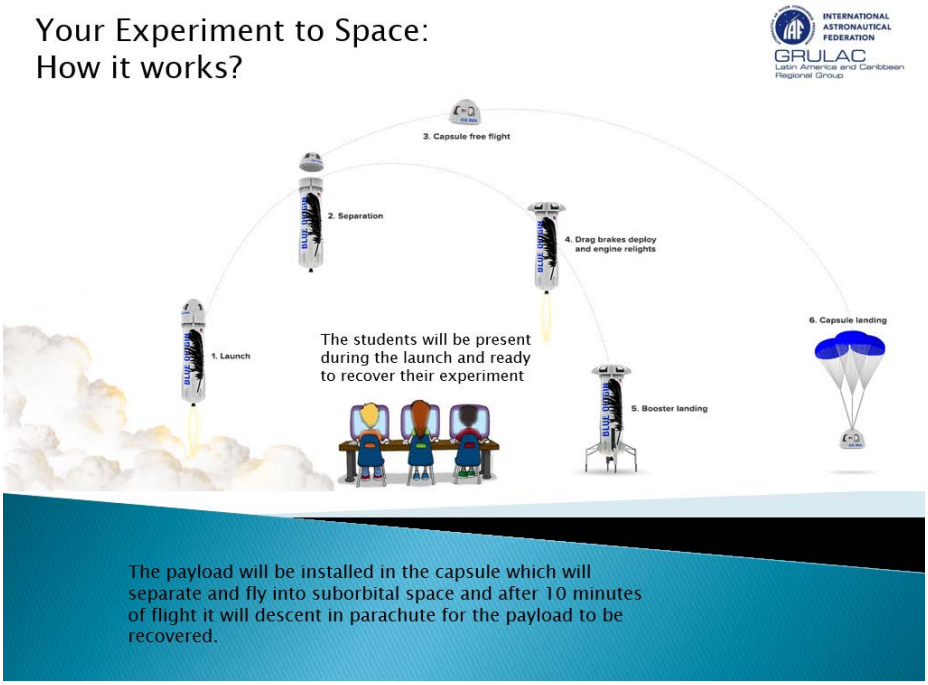
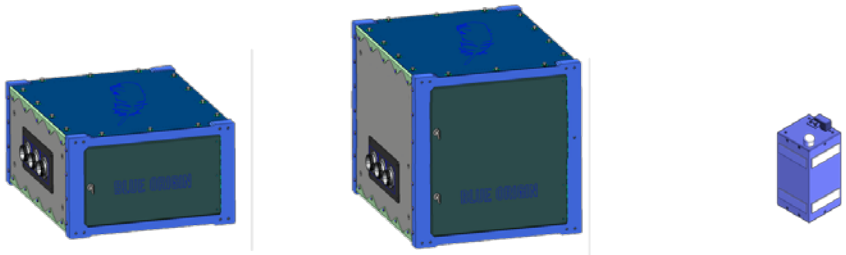



*Figure 1 – New Shepard Trajectory (courtesy of blue origin)*



| Single Payload Locker | Double Payload Locker | NanoLab |
|---|---|---|
| 20.6 x 16.3 x 9.5 inches | 20.6 x 16.3 x 19 inches | 3.9 x 3.9 x 7.9 inches |
| 25 lbm payload | 50 lbm payload | 1.1 lbm payload |
| 26 +/- 4 VDC<br>200 W peak power<br>Flight data via Ethernet | 26 +/- 4 VDC<br>200 W peak power<br>Flight data via Ethernet | 5 VDC<br>4.5 W peak power<br>Flight data via USB |

*Figure 2 - Standard Sizes and Interfaces for New Shepard Payloads (courtesy of blue origin)*


*Figure 3 – The NanoLabs Platform (courtesy of blue origin)*

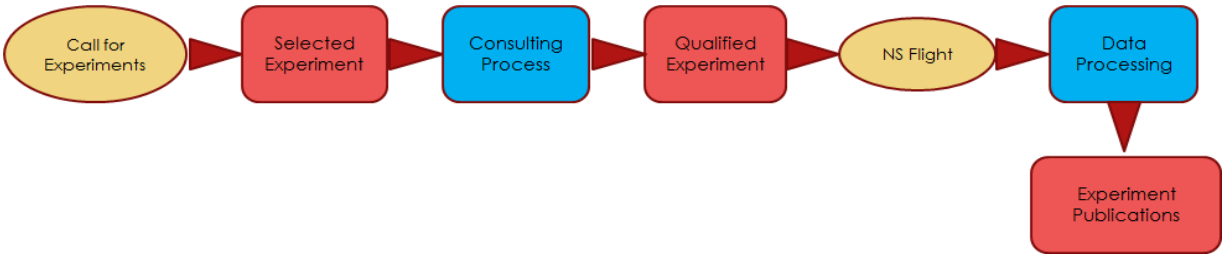



*Fig. 4. General Process for the experiments in the YES Program*

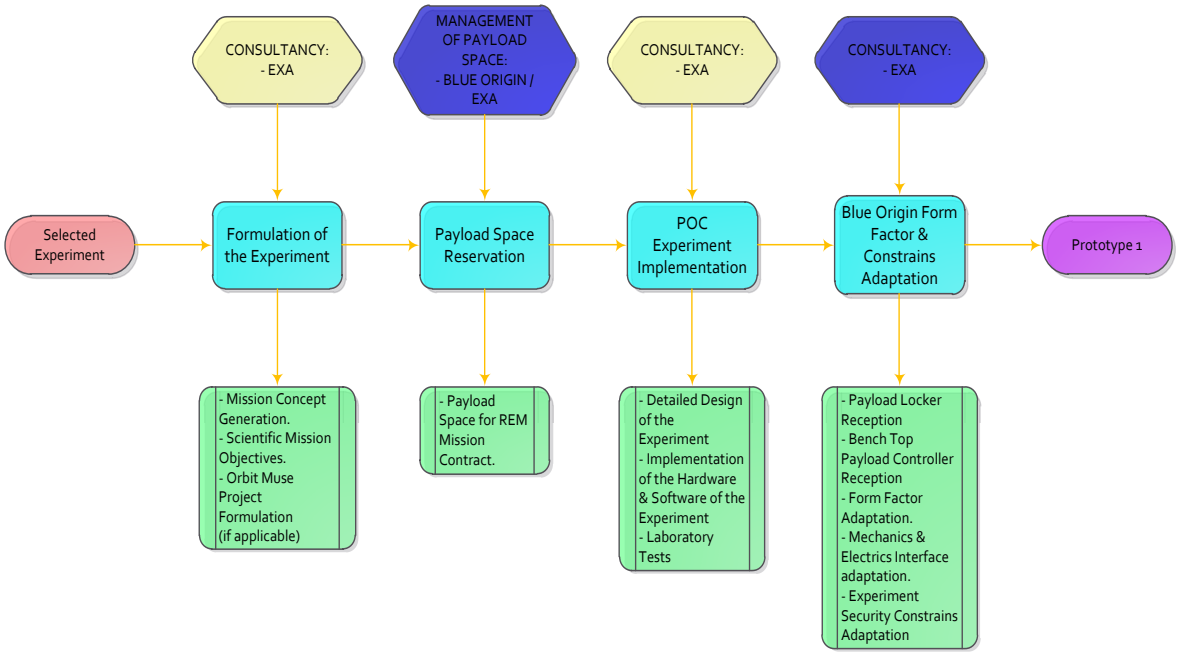



*Fig. 5. Mission Plan Stage 1*

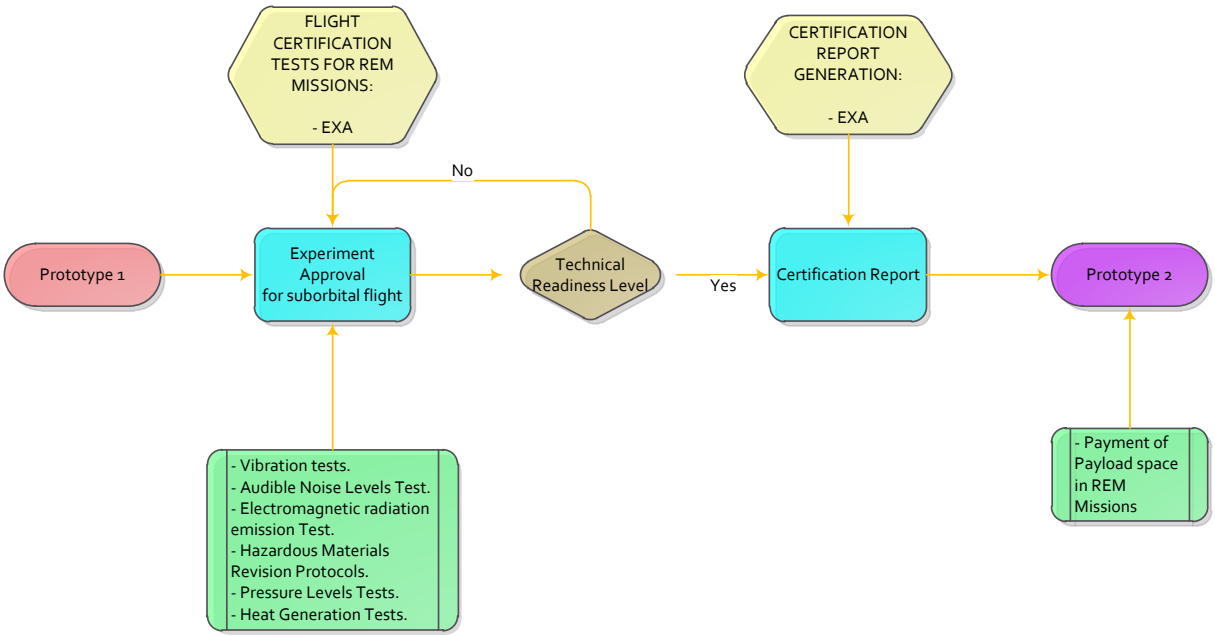



*Fig. 6. Mission Plan Stage 2*

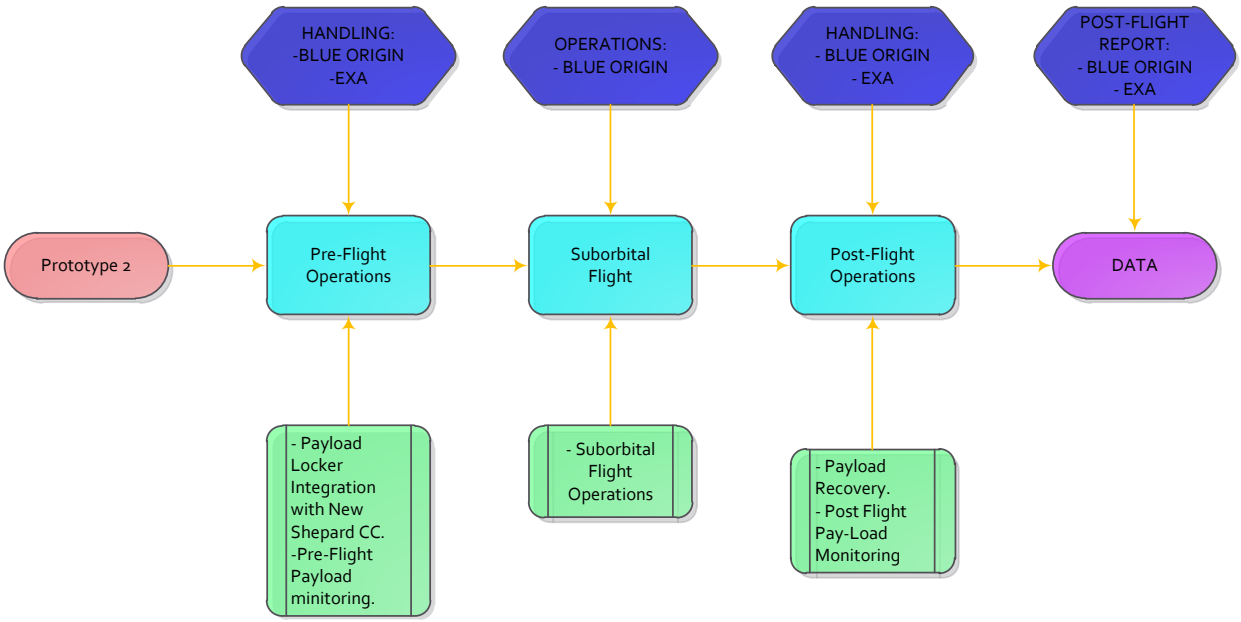



*Fig. 7. Mission Plan Stage 3*

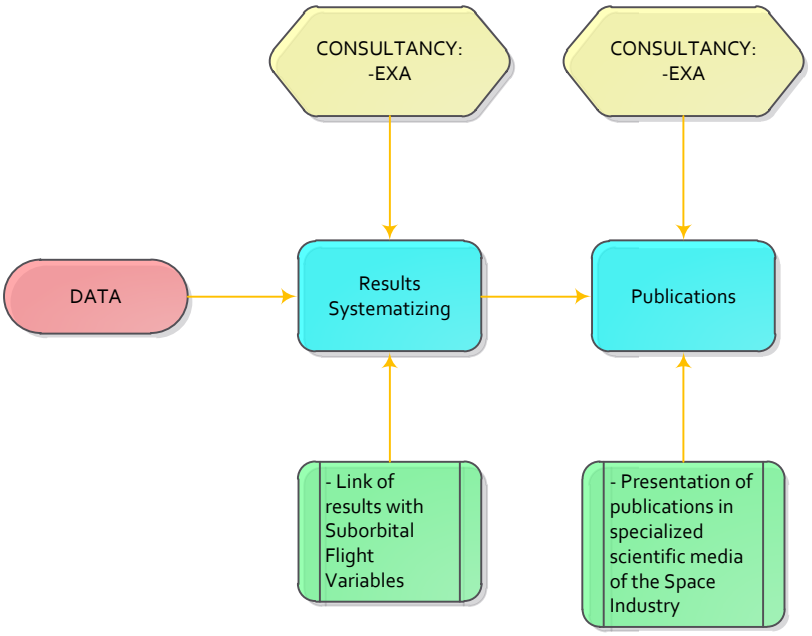



*Fig. 8. Mission Plan Stage 4*


*Fig. 9. LATCOSMOS-C: Latinamericans in Space*

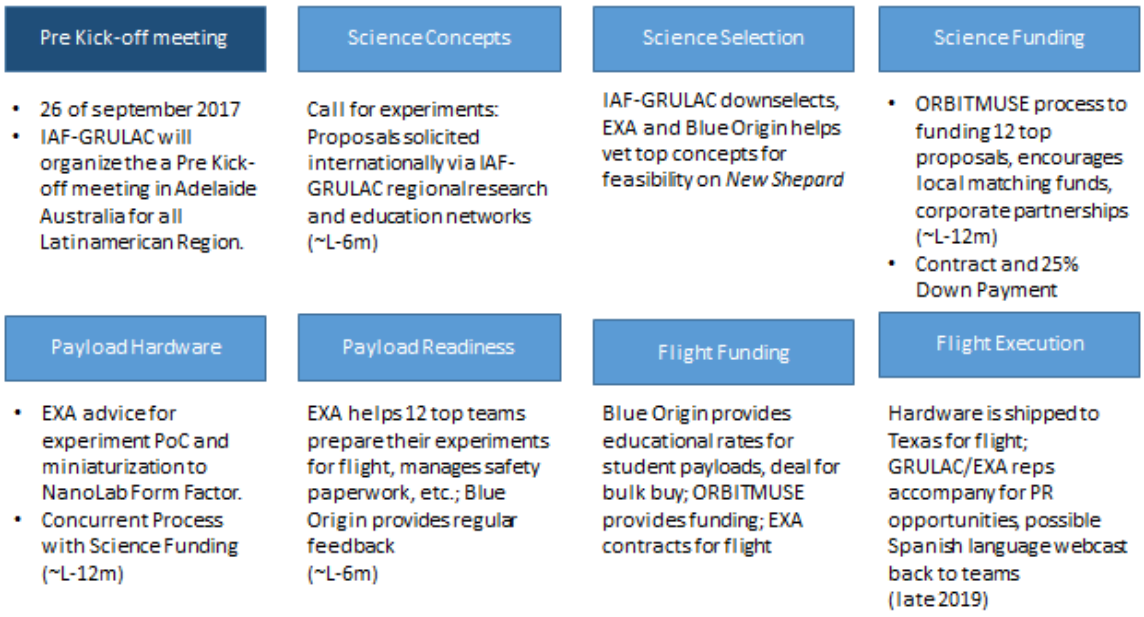



*Fig. 10. Programatic*