

Competition, Research and Extension: The three approaches to the Popularization of Small Satellites in the Alto Paraopeba region in Brazil.

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Abstract

There are several approaches to the diffusion of the space technologies, three of them are in this work: competition, research, and extension. Thus, the objective of this work is to focus on presenting the results of the Brazilian nanosatellite team called NoizOrbita, and also to qualify quantitatively the impact of using these approaches in popularizing the topic of small satellites for space educational purposes. The team was founded on September 29, 2020, by three people: an alumni of Telecommunications Engineering at Federal University of São João del-Rei (UFSJ), Alto Paraopeba Campus (CAP), currently pursuing his Ph.D. in CubeSat Antennas at UFSC; a student currently in the 6th period of the Telecommunications Engineering undergraduate course (class of 2019); and a professor in the Department of Telecommunications and Mechatronics Engineering (DETEM). This initiative is intended to be a gateway to the space/satellite technologies in the institution and is based on three main pillars: Competitions, Research, and Extension in Nanosatellites. The team aims to obtain and develop small satellite technologies involving CAP undergraduate and graduate students, which enables them to learn the concepts of Space Engineering with the methodology of "learning by doing", covering the entire lifecycle of a spacecraft, even in a less complex way, through Systems Engineering approach. It also encourages the students to carry out scientific studies, prepare and publish papers, participate in conferences, and through extension, spread all the knowledge acquired in the various layers of society in the Alto Paraopeba region. Team members are all undergraduate and graduate students. Considering that one of the main characteristics of the team is its multidisciplinary nature, it leads to the advantage that students from all courses offered at CAP can join the group. This is reflected a lot by the concept of satellite engineering, since professionals from various areas of knowledge are sought for working with satellites and small satellites. Thus, in this work the main numbers related to the team were gathered, collected and presented in order to assess the impact and/or reach of the activities in its first year of existence. Data were extracted from databases, histories, and records on the various knowledge and information dissemination platforms. Regarding the research approach, the team obtained a significant number of scientific productions; regarding extension, presentations with satellite subjects were performed; and a great achievement with the competition aspect was obtained, which shows the effectiveness of these three approaches.

Keywords

Alto Paraopeba, NoizOrbita, Small satellites, Space education.

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Acronyms/Abbreviations

AEB	Brazilian Space Agency
CAP	Alto Paraopeba Campus
DETEM	Department of Telecommunications and Mechatronics Engineering
INPE	National Institute for Space Research
MCTI	Ministry of Science, Technology, and Innovation
OBSAT	Brazilian Satellite Olympics
SNCT	National Science and Technology Week
STEM	Science, Technology, Engineering and Mathematics
UFSJ	Federal University of São João del-Rei

1. Introduction

The Federal University of São João del-Rei (UFSJ) was founded on April 21, 1987 [1] with the name of Higher Education Foundation of São João del-Rei (FUNREI), being recognized in 2002 as a university. Currently, UFSJ has 6 campi: Alto Paraopeba Campus (CAP), Dona Lindu, Dom Bosco, Santo Antônio, Sete Lagoas, and Tancredo Neves Campus, covering a total of 5 cities. The Alto Paraopeba Campus, in particular, is located at the division of the cities of Ouro Branco and Congonhas in the region called Alto Paraopeba. The campus, whose main view is illustrated in Figure 1, was implemented in 2008, seeking to fulfill an important government policy of education [2]. It was conceived to be an engineering center [3], and among other objectives, it stands out to provide economic growth with quality of life in the Alto Paraopeba region, which for many, was another important step towards promoting sustainable development in the region.



Figure 1. Main view of the Alto Paraopeba Campus [3].

The group/team called NoizOrbita, whose logo is illustrated in Figure 2, was founded in 2020, and to the best of our knowledge, it can be considered the first initiative in the field of space engineering at UFSJ.

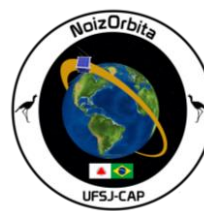


Figure 2. Logo of the UFSJ competition, research and extension team in nanosatellites.

More specifically, the team was founded in September 29, 2020, by three people: a former student who graduated in Telecommunications Engineering at CAP in 2018 and until then a Master's student in Space Engineering and Technologies at the National Institute for Space Research (INPE); a student currently in the 6th period of the Telecommunications Engineering course (class of 2019); and an effective professor in the Department of Telecommunications and Mechatronics Engineering (DETEM). This initiative can be a gateway to the space/satellite theme at the institution and is based on three main pillars: Competition, Research, and Extension in Nanosatellites, as illustrated in Figure 3.

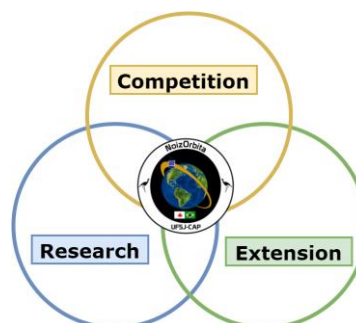


Figure 3. The three approaches proposed to the popularization of small satellites.

The team aims to develop technologies related to small models of satellites in order to train the members of the team, which enables them to learn concepts of Space Engineering, covering the entire space lifecycle, even in a less complex way, through techniques of Systems Engineering project management. Some of the objectives of the team are to carry out scientific studies, prepare papers, improve and develop new technologies, and through extension, disseminate all the knowledge acquired and developed by the team in the various layers of society in the Alto Paraopeba region. The team is formed by students from the different engineering courses available at CAP. This fact emphasizes the multidisciplinary tendency of the NoizOrbita team, and can be compared to a “real world” satellite engineering group, in which professionals from various areas of knowledge

are required for the design, development, assembly, integration, testing and operation of satellites and small satellites. Table 1 shows all the undergraduate courses offered by UFSJ at CAP.

Table 1. Undergraduate courses offered at CAP[1].

Campus	Undergrad. courses
Alto Paraopeba (CAP)	Civil Engineering
	Bioprocess Engineering
	Telecommunications Engineering
	Mechatronics Engineering
	Chemical Engineering

Regarding the organization of the team, each member is allocated in their division of choice and later, they are interconnected based on objectives, that can either be focused on the competitions, or in extension activities, which allows everyone to participate in the three main aspects of the team, each with its own specialty in an interdisciplinary and collaborative environment. In Table 2 it is possible to visualize the hierarchy of the internal divisions of the team.

Table 2. Hierarchical team divisions.

Divisions	Team Council	
	Team Leader	
	Management	Systems Engineering
	Content creation and social media	Embedded Electronics
	Human Resources	Mechanics and Structure Payload

The popularization of satellites through the three aspects of competition, research, and extension has already been extensively explored. It can be cited as a successful example of popularization of satellites in Brazil and Latin America the competition called CubeDesign⁴, which is a small satellite development competition [4]. The competitive aspect, however, is not exclusive when we talk about the popularization of satellites, since projects and ideas can be born through various approaches, being able to migrate or generate works in other approaches, as is the case of [5]. In this example, after participating in the CubeDesign competition in 2019, they carried out a study and published a scientific paper at the Workshop on Space Engineering and Technologies⁵ (WETE) in 2019, contributing to the dissemination of the research developed. Another example to be mentioned is the case of the team of students from the Cempre Benedito

Ferreira Lopes middle school in Mogi das Cruzes - SP, who also participated in the competition in the same year and won the 3rd place in the Mockup category [6]. These students were awarded a lecture on "Introduction to Space Technologies" and also a CubeSat educational workshop. Figure 4 shows the CubeSat workshop in Mogi das Cruzes city on March 12, 2020, which was carried out by the CubeDesign organizing members.



Figure 4. CubeSats workshop held as a CubeDesign award [7].

The influence between the three approaches (competition, research and extension) to popularize small satellites in Brazil is evident, as a work that can begin as a small project, then it can evolve into research, and later it can become other extension activities, as mini-courses, lectures, and workshops, which reinforces the inseparability of these three approaches. The gap between the general society and space technology is notorious, at least in Brazil, however, it is shown in this work that through the presented approaches, it is possible to bring the general public closer to the technology and research in the space area [8] and also to the STEM areas (Science, Technology, Engineering, and Mathematics) [9]. The NoizOrbita team is also part of the Space Engineering Research Group, which is currently formed by two more teams: Rocket technology (NoizDecola) and amateur radio communications (PY4CAP), but they aren't discussed in this paper. Figure 5 shows the group logo.



Figure 5. Space Engineering Research Group logo.

Therefore, the main objective of this work is to show the approaches used to obtain the presented results (competition, research, and

⁴ <http://www.inpe.br/cubedesign/2021/>

⁵ <http://www.inpe.br/wete/2019/>

extension) for the popularization of small satellites in the Alto Paraopeba region.

2. Methodology

The methodology used in this work is based on the analysis of the main metrics that are directly or indirectly related to the NoizOrbita team in order to evaluate the impact or the reach of the group's activities over its first year of existence. Data was extracted from the group's databases, histories, and other records on various platforms that disseminate knowledge and information.

3. Results and Discussion

In this section, the metrics related to the three approaches (competition, research, and extension, respectively) are presented.

3.1. Results of the competitive approach

The team's first approach to the popularization of small satellites brings with it the competitive bias, in total harmony with the "learning by doing" methodology. In this case, the small satellites competitions, which the team can participate in, allow students to gain experience by covering part of the lifecycle of satellites, providing them experience in the design, development, assembly, integration, testing, and operation of these artifacts. The main numbers or results of the team related to this approach came from two competitions: the 1st OBSAT (Brazilian Satellite Olympiad MCTI - Ministry of Science, Technology, and Innovation) and CubeDesign. Table 3 shows the obtained results from these competitions.

Table 3. Participation in small satellite competitions.

Category	Description	Year
CanSat	CubeDesign, 2nd virtual edition (INPE) – Interrupted.	2021
CubeSat	1st place [10] (mission to monitor agglomerations of people in remote areas - AGLOSAT-1), 6th place (mission to monitor greenhouse gases (EEG) using a constellation of CubeSats - ÉOLOSAT-1) and 8th place (mission to monitor ionizing radiation in the lunar environment - CURIASAT-1) in the first regional phase (state of Minas Gerais) at the 1st Brazilian Satellite Olympiad MCTI (OBSAT2021), receiving as a prize 3 CubeSats kits from the Brazilian startup PION Labs.	2021

Moreover, Figure 6 shows the final results (from the first regional phase of the 1st OBSAT), where three out of four sub teams of NoizOrbita (that won the 1st, 6th, and 8th places) were

awarded one PION CubeSat kit each. Figure 7 shows the PION CubeSat kit.



Figure 6. UFSJ teams patch missions for the first phase of the Brazilian Satellite Olympiad.

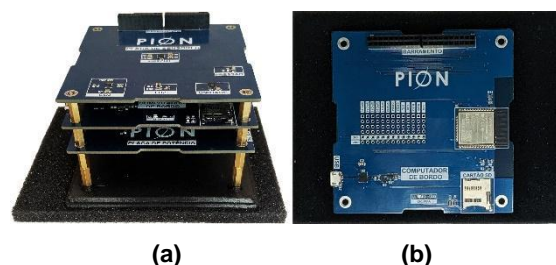


Figure 7. One of the three PION CubeSat kit awarded in the OBSAT: (a) Perspective view of the subsystems and (b) Top view.

3.2. Results of productions connected to the research approach

Regarding the approach related to research, team members have the opportunity to get started in the scientific environment in several ways: undergraduate final work, scientific research, and other academic works with space themes. Support and tutoring are offered by more experienced team members and advisors, so even any initial research can evolve into quality scientific papers at events and conferences inside and outside the university. Table 4 presents some papers and works that have been developed with the collaboration of team members.

Table 4. Main scientific productions.

Category	Description	Year
Undergrad. final work	Victor Henrique Santos Soares. "Deriving requirements for the design of a CanSat Launch Vehicle (VLC) through a Systems Engineering approach". UFSJ - In progress.	2021
	Isabela Tavares Silveira. "Applications of machine learning techniques in telemetry data from the Brazilian satellite SCD-2". UFSJ - Finished.	2021

Scientific research	Project entitled "Ground-Board Communication Earth Station for Stratospheric Balloons and Small Satellites" [11]. Student: João Pedro Polito, Advisor: Antônio Cassiano Júlio Filho (INPE), Co-supervisor: Marconi de Arruda Pereira (UFSJ).	2021
Articles accepted for publication	Title: "Denialism in the Popularization Satellites Use". E-book against science denialism, PUC-MG.	2021
Articles published in congress	Title: "Deriving requirements for the design of a CanSat Launch Vehicle (VLC) through a Systems Engineering approach". In WETE 2021.	2021

3.3. Extension numbers

One of the aspects that can differentiate the NoizOrbita team from other competitive teams at UFSJ is the extension approach, as the group also aims to extrapolate the limits of the university in order to impact different layers of society. The objective is to provide to the population in general a simpler and closer look to space themes, and show them the consequences and impacts of space research on everyday life. Activities carried out by the group are presented in Table 5.

Table 5. Main numbers extension results.

Category	Description	Reach
Presentation for students	Introduction to Telecommunications Engineering	50 students
	Introduction to Mechatronics Engineering	50 students
	CAP-UFSJ New students Welcome Week	195 students
Event organization	1st Space January	285 participations
	1st Week of Space Immersion of CAP.	180 Participations
Podcasts	Noiz Em Órbita	21 reproductions
Academic weeks	Space Philosophical Coffee	54 reproductions
	Telecommunications Engineering Week at UFSJ	35 Participations
	Mechatronics Journey	20 participations
Social media	Mechatronics Engineering Week at UFSJ	18 people
	Instagram	718 followers
	Facebook	101 likes
Professional media	Youtube	693 views
	LinkedIn	159 followers

In order to support the various projects under development and, at the same time, support the effectiveness of the popularization of small satellites, the team has resorted to several possible funding sources inside and outside UFSJ, as detailed below, in order to raise financial resources for the feasibility of some of its projects.

3.4. Project financing

Regarding fundraising, the objective is to continuously reach funding opportunities inside and outside UFSJ to support the development of small satellites for competitions, including subsystems to assist in the research and development of the work. Moreover, another objective is to purchase electronic components for extension activities purposes, such as the elaboration of mini-courses on CubeSats. UFSJ had a funding opportunity (UFSJ/PROEN/009 2020) in which the team raised the amount of R\$15,505.69 (€2814,22) to be used for purchasing components.

3.5. Future works

As a future work plan, the group has already obtained several educational materials (which are listed in Table 6) to support extension activities at schools of different levels of education in the cities of the region of Alto Paraopeba. The material was provided by INPE (National Institute for Space Research). Other activities proposed for classroom teaching are also detailed in Table 6.

Table 6. Future works.

Category	Description
Nanosatellite Learning Kits	Introduction of small satellite concepts to elementary and high school students, with lectures and assembly practices, integration and testing of CanSats and CubeSats.
INPE teaching materials	Publicity material from both INPE and AEB (Brazilian Space Agency), in the form of stickers from INPE, from the Brazil-China CBERS partnership satellite, puzzles, booklets, folders, etc.
Plastic bottle rocket workshops	"Development of plastic bottle rocket" workshops for presentation at the National Science and Technology Week (SNCT).

4. Conclusions

Based on the numbers presented in this work, related to the first year of the existence of the NoizOrbita initiative, it is evident the importance of the three approaches presented to achieve

the objective of the popularization of the small satellites theme in the Alto Paraopeba region, mainly. The competitions, through the exchange of experiences between the teams, and with the union of students to overcome challenges, prove to be an efficient way to motivate and encourage team members to improve themselves technically, and also develop and improve teamwork. The research, in turn, encourages students to participate and prepare academic works and, with that, generate scientific productions for the dissemination and improvement of space technologies. Finally, the extension approach makes it possible for the space theme to find a way outside university and reach various layers of society, initially in the local region of Alto Paraopeba, but also beyond (due to the virtualization of activities amid the COVID-19 pandemic), obtaining national visibility. The presented results support the methodologies applied by the team (competition, research, and extension) for the dissemination of the small satellites theme, resulting in a significant number of people impacted by the team.

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