

Asociación Aeroespacial Cosmos: educational impact and returns of a three-year-old student aerospace association

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Abstract

Cosmos Aerospace Association is a leading engineering students' group, located in the Universidad Rey Juan Carlos (URJC) in Madrid, Spain. Providing a one-of-a-kind opportunity to all varieties of students for both personal and engineering growth, it is one of the few active aerospace student associations in Spain. Within this work, we introduce the achievements, influence and lessons learned from our association in these years. We focus on its educational impact in the environment of the university: not only from the perspective of aerospace-related degrees but also in the promotion of STEM careers on students of all ages.

Conceived by undergraduate aerospace students and supported by professors and university staff, Cosmos was born to provide a creative and learning environment in the promotion of our passion for space and science in general. Bringing together students with similar mindsets, it has become a symbiotic platform in which all university actors share their efforts and join forces to enhance the university experience both from a curricular and extracurricular perspective.

The association is divided into three main areas: Administration and Legal, Construction, and Education. Each of these areas branch with Projects and smaller teams both transversal and vertically. Under the Construction branch, both aeromodelling, satellite and rocketry projects are found and developed. An autonomous VTOL vehicle and a solid combustion rocket are being designed with internal and external funding. Special mention goes to the design and construction of CosmoSat-1, our very first CubeSat mission, which is now starting to take off. The Education area involves the organization of cultural and educational activities, from coding seminars, hackathons to film forums or Women in STEM days, all of them transversal to the aerospace industry. In this regard, our most ambitious project to date has been SpaceCon URJC: a space-themed conference by and for university students, bringing together professionals from aerospace companies, space agencies, and research groups in a month-long virtual conference. Over a series of presentations and interviews, students can get a glimpse of a variety of possible careers in everything from satellite manufacturing, orbital mechanics, space debris, and everything in between. With an initial run in 2020, SpaceCon has been repeated in 2021 with great success.

In short, COSMOS, while promoting a passionate interest for Space, has become a common meeting point for students and professors outside the fixed and fitted courses, where creativity can boom and grow.

Keywords

Aeromodelling, Rocketry, Sci-Comm, Spacecraft-ing, SpaceCon, Student association

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Acronyms/Abbreviations

<i>GISAT</i>	<i>Grupo de Investigación Consolidado en Sistemas Aeroespaciales y Transporte</i>
<i>STEM</i>	<i>Science, Technology, Engineering and Mathematics</i>
<i>URJC</i>	<i>Universidad Rey Juan Carlos</i>

1. Introduction

Cosmos Aerospace Association is an initiative by and for students. Focused on space and aeronautical activities, it is an opportunity for undergraduate students launching their careers to collaborate, learn, and get closer to the Aerospace Academia and Industry with educational, cultural, and engineering activities. While the association was born only four years ago, diffusion and growth have been remarkable, with important contributions to the University community and social life. It has also increased contact between the University and the Industry, enhancing and promoting synergies to the advantage of all interested stakeholders. This paper develops the trajectory made from the inception of the association to its current state, exploring its structure, main activities and projects, as well as its educational and professional impact for all the involved agents.

This work is structured as follows: Section II explores the background and rationale behind the association and its origins, together with its structure and the symbiotic environment it provides. Section III develops the main projects, activities and work, and a brief overview of day-to-day functioning of the association. Section IV focuses on the educational impact of Cosmos, from a student and professor's perspective. Section V summarizes the experiences, results and lessons learned, analysing both its successes and failures. Finally, future plans and ideas and projects are introduced.

2. Background

Cosmos Aerospace Association, or Cosmos for short, was created to build and expand on the inertia of the recently created degrees on Aerospace Engineering of the Universidad Rey Juan Carlos. With the kick-off of three newly designed aerospace degrees, motivated students, researchers and young professors congregated within the same institution, with funds enough and passion projects to be developed. This led to individual and collective projects in the first years: talks which both introduced new technologies in the Aerospace Industry and presented the workaday life of an

engineer, seminars featuring women in STEM, and participation in European Engineering competitions and projects [1].

These first attempts showed the need for a better organization and more student involvement, highlighting a hunger in the University for engineering associations—the existing associations were focused on social or political movements. More technical activities were limited to classrooms and laboratories.

In this scenario Cosmos was born among a small group of students (with the support of their professors), looking to work together on common interests and explore past the limits that any fixed academic curriculum has. A wide variety of possibilities were established since the beginning, from model rocketry and international competitions to educational activities and study groups. Significantly, an emphasis was made on promoting the participation of women and other marginalized groups in STEM fields. The social impact was also important, bringing together a group of people excited about space exploration, flying, and learning, from all over the University.

To the founding members it was clear that a structured and diverse association was necessary. Although the aims were ambitious and vague at the start, as is to be expected, over time three main areas were identified, as presented in the introduction: Legal, Construction and Education. The vision for the association was clear: by the students, for the students. The aim is to learn, grow as better professionals and partake in activities that promote technical aspects and to grow as people.

This three-area division was thought not as a vertical and self-contained but as a way of concentrate the efforts of all the members in focalized activities. An emphasis has been placed on being by the students, for the students, with timelines adapted to the course loads and schedules of the university and working to give access to a wide variety of experiences and opportunities. In addition, as will be seen in the following sections, many of the activities have an audience beyond Cosmos members--making an impact on the university, as well as secondary schools and different levels of education.

The internal structure of the association is divided into two main layers: the board of directors and the organic teams. A horizontal structure is promoted across and along the two, as these two layers only serve to functionally divide internally the different activities and



workload to be completed. The decision-making process is always handled by all the members.

The board of directors is composed by elected members and takes care of the correct development of the association as well as handling current and future issues and projects. It oversees legal, financial, management, and bureaucracy, and guides the association. Finally, one of its crucial activities is the filtering of the proposed projects and to prepare their resource allocation that will be approved by the assembly of members. The board, together with extra helping members that support their activities, is what is defined as Legal Area.

As for the activities, the second layer is composed of all of Cosmos' members, divided into two main clearly defined areas: Education and Construction. Within this, there are workgroups focused on individual projects or activities. Each team is headed by one or two leads (usually, project manager and technical officer), who coordinate with other teams and serve as a guiding voice for all the activities carried out within the team. This stratification is highly inspired by the working organization in the aerospace industry, and it is expected to evolve under the system engineering philosophy.

The Education Area has the widest variety of activities, and these tend to be more short-term, general and with a smaller group behind each. The aim of the group is to promote general scientific interest among members, with special focus on the aerospace world, while also divulging and introducing non-STEM people into the very same topics. Related to this team, a Research Group was founded within Education to have a first-hand experience of an academic career at an amateur level, in close collaboration with the Aerospace Research Group of the URJC, GISAT.

The Construction Area is where the passion projects are made possible. They are mainly developed in stages over time, iteratively. Construction is divided into two main teams, working separately in the development of aeronautical and satellite vehicles, projects to be described further below.

The four-year lifetime of Cosmos has brought to life (and laid to rest) many projects across many fields of knowledge and interests, to greater or smaller success, but always enriching and experience full. While these projects have traditionally been born and held within both Education and Construction, in many cases their multidisciplinary nature have bridged all the association's functional and structural

barriers, promoting teamwork and collaboration among associates.

These two areas are, since their formation, intertwined. The industrial, academic and research contacts made by the educational team throughout the talks and activities are then feedbacked towards construction. Not only to promote new ideas, strategies, and ways of organization but also to stablish funding, resources, and engineering bounds within them. As a result, passion projects with original ideas from students are shared with industrial agents and researchers, creating a perfect breeding ground for innovation.

3. Cosmos' principal projects

3.1. Education Team: main projects overview

For the Education team, one of the first and most successful activities has been the organization of a series of lectures from young professionals in the field of Aerospace Engineering over the span of several years. These talks, started by professors and members of the GISAT, were professionalized and structured, passing for disperse sessions mostly guided and filtered by company interests to topic-oriented conferences and seminars with technical, professional, and human perspectives. Over time, Cosmos, together with the professors and researchers of the university, has hosted lectures on cutting-edge space applications: origami structures, small satellites, space weather, modern technologies for propulsion, and much more.

Also, a series of Crash Courses have been recursively held and offered by members, with the aim of helping students from our faculty who struggled with tools useful for their studies, such as LaTeX, Matlab, Catia, Julia, and Python. Although they started being presential, they were easily passed to online lectures with the pandemic, being now imparted mostly in hybrid format to allow as many students as possible to attend. To impart these courses, an extra effort was made to include experts in these tools as part of the lectures, being an example the Aeropython association [2] or Catia experts from the aerospace industry.

A very popular activity was the organization of visits to companies and sites of interest: ESAC, Airbus, Thales Alenia Space, and others.

Another focused of the Education team has been on visits to secondary schools, mentoring programs, and participation in university orientation fairs have allowed Cosmos to impact the lives of future engineers, especially providing visibility of women in STEM fields.

Also, along this line, several panels have been organized for International Women's Day, discussing topics that impact STEM fields and women working in aerospace.

One of the more ambitious projects is the organization of study groups for the more difficult subjects within the aerospace curriculum. In Cosmos' groups, veteran students helped younger members as amateur professors with the most requested curriculum subjects. This was a space dedicated to problem-solving and helping those who need a little more help to grasp the difficult concepts. This created an environment where the students worked together to better understand the subjects and helped each other to learn. It also helped students isolated during the Covid pandemic to get to know others.

The Education group also has a strong focus on culture and society. Film club activities for aerospace movies in the university were popular, even among non-STEM students, before sanitary measures made them impossible. The podcast, debate forum, YouTube channel, and magazine have been explored to potentially reach both associate and non-associate interested students, also developing non-technical skills of those team members usually more focused on engineering. Such formats have accommodated everything from philosophical discussions to monthly reviews of relevant aerospace ephemerides.

Among all these, the most significant educational project to date is the SpaceCon congress. Already held twice, since 2020, the SpaceCon project aims to offer students a closer insight into the space industry and space-focused academia, bringing in cutting-edge research lecturers and industry stakeholders, space agencies, as well as amateur and professional associations, in a congress-like format, with dedicated sessions for top areas within the aerospace sector. The success of this initiative has constructed invaluable bridges between the URJC and the professional space communities, resulting in fruitful collaborations between the two, while promoting management, organizational, and other soft skills among the hosting Cosmos members.

3.2. Aeromodelling Team: main projects overview

The aeromodelling branch of Construction has focused for the past years on a series of flying wings, named after "HC-1". This project allowed students to put into practice theoretical background by conceptualizing, designing and making the entire vehicle from scratch.

In addition, the current flagship program in the aeromodelling team is D.I.A.N.A. This program is composed of four projects: Fixed Wing 0, Fixed Wing 1, GNC and VTOL0. The goal of Fixed Wing 0 is to manufacture open-source model aeroplanes by applying and experimenting with project management different methodologies, such as Agile. Fixed Wing 1 is a modular 3D printing model aeroplane in which the aerodynamic configuration and performance of the vehicle is interchangeable. The objective of the project members is to become proficient pilots and trainers, leveraging the model aeroplane capability to adapt to the pilot's skills, together with developing a conceptual tester for clients, who can customize the model aeroplane behaviour. The GNC project aims to develop the autonomous flight and stability algorithms and software for both an UAS multirotor and UAS fixed wing, to be embedded in future team vehicles independently of their aerodynamic configuration. Finally, the VTOL0 is an unmanned aerial, electrical vertical take-off landing system, whose application is to analyse natural disasters and to search for lost people autonomously.

In addition, the team has also launched dedicated flying simulator courses, taught by Cosmos PPL(A)-accredited associates. They have been a great opportunity for him to share his experiences and allowed students to get a first-hand experience of pilot training.

Yet another fun but still remarkable activity of 2021 was a large-scale handmade kite-flying competition, organized in collaboration with the local government to involve secondary-school (including special education students) as well as university students. After the success of the competition, it will be celebrated again in 2022, with the aim of flying more than 50 handmade kites. While the technical load of this project is smaller when compared to previous ones, the aim of it is to promote social interest into the aerospace practice, together with strengthening local bindings and social community activities.

3.3. Satellite Team: main projects overview

An important part of Cosmos development has been the development of several NewSpace-related projects, getting students hands-on real engineering technological challenges which will face sooner or later. In particular, the Satellite team was created back in 2019, where several Cosmos members developed the Attitude Determination and Control Subsystem of



FOSSASAT-2 mission, from the open-source FOSSA Systems association.

The second main project of the Satellite team is COSMOSAT-1, a CubeSat that is being developed together with the British company B2Space with their “Fly your CubeSat” program. It consists of the design, construction and subsequent launch of the CubeSat during one academic semester. The COSMOSAT’s systems will initially be tested during a stratospheric balloon flight as a first iteration this 2022, reaching conditions very close to space, as preparation for its main objective and mission: a microwave In-Orbit Demonstration for energy collection and transport. This project has been well received by the academic staff, as well as the directorial team at the university, and this is complemented by high participation and organization of those Cosmos members which are involved in the project. Students from different degrees are getting involved in this project and supplying much multidisciplinary expertise. The CubeSat is also eye-catching to collaborations in the industry and at the university.

The project is very exciting, working directly on something that will fly in space. Additionally, the wide range of skills needed to design all the subsystems in a CubeSat are an excellent place to apply things learnt in the classroom and gain practical experience. The collaboration with B2Space has allowed the members to develop skills in project management, approaching it as a serious engineering project following the steps currently seen in the industry.

4. Educational interest and perspective

Independently of the success of the different activities accomplished throughout these years, their educational and social impact cannot be neglected. Cosmos offers a platform where students can apply theoretical knowledge acquired in class in real engineering projects, introducing members to the daily life of their future careers. In addition, given the wide variety of activities and their nature, other non-technical skills are promoted on the daily basis of the association, such as project management, teamwork, oral expression, interests for other cultures, social interaction and engagement... In these two past years, the latter have become increasingly important, at times in which the sanitary situation has made bonding nearly impossible among new university students. In this context, Cosmos has provided a social support network in which

members are able to get to know each other, something vital within the academic process.

From the university perspective, the appearance of the Cosmos association meant a changing point on how to interact with our students and how to define innovative and improvement strategies. As stated in the background section, the appearance of the aerospace degrees at the URJC meant not only new highly motivated students in our institution but also the beginning of the academic career of a group of young professors. Most of us, repatriated from international institutions, saw these new degrees as an opportunity of teaching in a renewed and updated way.

Finding such a clear synergy with the Cosmos Association allowed us to join forces with them and to set common goal for the improvement of their education, as well as their human quality of our students. In particular, the Aerospace research group, GISAT works together with Cosmos as a pillar on improvement to attract industrial, technical and human talent and resources to the orbit of the university.

The benefits from the Education branch are clear: they reach where professors cannot in the classroom and laboratories. Not only by organizing seminars or study groups, but also by bringing external professionals to complete the industrial point of view sometimes missing in the Academia. Additionally, these educational activities translate into an active involvement of the speakers from the talks or lecturers of the seminars with the Aerospace Area of the URJC, allowing for industrial collaborations (research projects), academic ones (fundings and technical support for the Cosmos Activities) and even the addition of new associate professors that allow for active knowledge transfers.

However, the most important result for the university, and particularly for the Aerospace Area, that Cosmos has brought is the materialization of the curricular learning in terms of real projects. It has been more than proven that although the theoretical background is and will be always needed, the learning-by-projects approach is crucial for STEM students. And although this kind of learning can be forced in the different courses of the university, exams and gradings always remove the-fun-of-it. Cosmos and its construction branch provide an opportunity to gamify the academic process. Supervised by their professors and guided (and hopefully, sometimes funded) by the industry agents involved with the university, the projects become tangible solutions where a full set of soft and hard skills is learnt: from systems

engineering to the applications of the equations and simulations from their courses.

For all the above, having a strong, organized, and proactive organization of students is a key element to the education of better engineers and, consequently, a better industry in the future.

5. Results and lessons learned

The impact of Cosmos has been far greater than was imagined when the idea was first born. The students who take on an active role in Cosmos have a structure to support their ideas and projects--as has been described above, there is a broad area of impact! Additionally, those students who are new to the university or to student groups have found it a welcoming place where they can participate in a variety of activities before they find what suits them best. Additionally, and more rarely for STEM associations, Cosmos has a large impact on the student body as a whole--especially on STEM students who are not members

Collaboration with companies and organisations has also increased visibility of the university within the industry, promoting a symbiosis that will impact the careers of students for years to come.

However, not everything has been smooth flying. A variety of challenges have been faced within the association, especially in participation, coordination, and leading roles. Currently, over 200 students have passed through Cosmos with differing levels of participation. While some members spend many hours a week on Cosmos activities, others chip in smaller chunks of time when they can spare them. This has not been considered a problem--the ultimate goal is for Cosmos to serve as a backup to the ideas and especially the needs of the students. However, there are often problems with members who commit to projects and then are unresponsive when it comes to participating, resulting in overload and tension for leading members.

The other recurring issue faced in Cosmos has been filling the more organizational roles. While the construction projects are impressive, and the educational activities rewarding and entertaining, the association could not function if not for the secretaries, treasurers, presidents, and directors. The roles carried out by these members are seen as less attractive or entertaining. It has, as a result, been harder to fill these positions, and moments of transition have led to organizational disarray.

6. Conclusions

After nearly four years of experience, the resulting association is one where the senior or graduated students can collaborate with new students, continuing work on existing projects, and maintaining a space supportive of many kinds of exploration and learning. One of the main goals inside Cosmos is to inspire and increase the interest between the students in space and STEM activities, engage them in the aerospace world and encourage them to leave a mark in science. In addition to the successful results and projects completed up to this day, the experience of the past four years has shown valuable lessons from which to learn and advance towards such ultimate goals.

As for the future of the association, it is intended to continue with current projects and keep learning from the mistakes, forging new alliances with the aerospace industry and other associations with the same interest as Cosmos. The Education team is still growing, coming up with new activities every day. In 2022, they will be participating more actively in several events focused on younger students. There are plans for conferences with even more international collaboration soon. The Aeromodelling team is currently embarked on many ambitious projects which will see it through the end of this year and into the next. Inside the Construction team, it is planned to develop a rocketry team, in which the students will be able to get in touch with rocket science.

Overall, Cosmos has grown to the point where more ambitious projects have become feasible, and this will lead to more collaborations with industry and international agents. Students pass through on short timescales, but our hope is that the association will remain a constant and will welcome many future generations of students to the URJC.

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