BiSKY Team, an aerospace-focused interdisciplinary student project

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Abstract— **BiSKY Team is an aerospace-focused student group from the University of the Basque Country (UPV/EHU, Bilbao, Spain) where it is a recognized teaching project. It was born in 2018 and its main activities deal with the development of the technologies involved in the design, manufacture and launch of suborbital rockets. This team is currently the only Spanish university team involved in the research and construction of hybrid engine rockets. The primary objective of the team is to enable young science and engineering students to acquire expertise in the aerospace field, and several transversal skills as well, by designing and constructing space vehicles. Further purposes include promoting science and engineering among high school students and children and to also reduce the existing disparity between male and female involvement in science, technology, engineering and mathematics (STEM). Besides, the project will make interesting contributions to space science by providing researchers with the means to test their experiments in zero gravity and high-altitude vacuum.**

BiSKY Team is divided into several specialized groups: i) Aerodynamics and Recovery, ii) Propulsion, iii) Avionics, iv) Flight Control and Simulation, v) Business and Management and vi) Structure. This interdisciplinary project makes the collaboration among all groups crucial. In this regard, the team stands for respectful cooperation between all its students. BiSKY Team is an example of a multidisciplinary student project that implements innovative technologies allowing not only its members, but also members of other student research groups and training centres, to enter the competitive sector of aerospace engineering and space science research. Even if this is a university student-developed and managed project, vocational training schools' involvement is also considered. Close contacts with research and technological institutions as well as industrial companies are pursued looking for technical advice and financial support.

Within the operations of the team, several phases are being undertaken in order to acquire the expertise necessary to design, manufacture and launch a hybrid engine rocket that reaches an altitude of 100 kilometres, also acknowledged as the Karman Line. The phases include the development of two engine test stands, a flight simulator and the complete avionics for the rockets and test stands. The expertise gained through the implementation of the mentioned technology is being applied in the hybrid engine rockets of the so-called Cosmox family, whose primary mission is to reach space and allow the research experiments to be carried out. The design of the Cosmox and future families of rockets is iterative, giving continuity to the project by allowing next generations students to get involved.

Keywords—aerospace; hybrid; rocket; student; team; inclusive; women in science; technology

I. INTRODUCTION AND STATE OF THE ART

50 years ago, mankind first stood foot on the moon during NASA's world-famous Apollo Program. Neil Armstrong´s historic words as he stepped down from Lunar Module onto the lunar surface where sent down to earth, to Spain´s *Maspalomas* telecommunications station, thus making this country part of an extraordinary endeavour. Today, almost no one in Spain is aware of this fact, and the space topic as a whole is regarded as a dull subject, even as a delusive one, by the general public.

This disregard for space is in part due to the absence of professionals with hands on experience in the field at academia. Despite having participated on the development of the Ariane family of launchers, built and operated its own satellites, and contributed to many international scientific and robotic missions, space technology is an uncommon topic in Spanish universities [1].

Students from the University of the Basque Country founded an engineering student group focused on the development of its own suborbital space launcher. Despite de activity being technology based, the end goal of the project is to encourage space enthusiasm amongst both existing university students and future generations, stimulating the pursue of STEM careers in benefit of all our society.

Half a century ago, at the time when the Saturn V was being developed, it seemed impossible for a group of students to undertake what only governments could barely accomplish, with seemingly unlimited resources when compared to those of the current student project. However, advances in rocket propulsion technology have resulted on the emergence of hybrid chemical propulsion, where a mixture of solid propellant and liquid oxidizer are used to power the rocket engine. This technology allows for the development of high thrust rocket

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engines with a much greater security margin than their liquid and solid counterparts, as the propellants are inherently safer to store, transport and operate with. Moreover, these engines are simpler to design and fabricate with conventional manufacturing resources, in such a manner that even students can accomplish it in collaboration with specialized companies.

There has been no other entity in Spain thus far that has developed real hardware for hybrid rocket engines, making BiSKY Team a national first on the application of hybrid propulsion for rockets. Traditionally, only the National Institute for Aerospace Technologies has directly worked with rocket propulsion, in the form of solid fuel engines for military applications, but nothing close to the real engines being developed at BiSKY Team [2].

In the last decade, the number of aerospace student led projects across Europe has become remarkable, many focusing on satellite technology, but most being centred on the development of rockets. The current common goal for all projects is to develop the technology to reach the frontier between Earth´s atmosphere and outer space, also known as the Karman line. Being able to do so not only provides international pride and recognition, but the possibility of offering local scientists and researchers an easy, cheap and reasonably reliable access to suborbital space flight of small payloads.

This paper introduces BiSKY Team's progress both in the technological and educational field since it was born in September 2018, emphasising the facts that made this university project thrive. The rest of the work is structured as follows. In Section II, the project's main objectives and scope are described as the project's raison d'être. Technical planning is detailed in Section III and IV. In Section V, the benefits for students involved in the project are presented, followed by Section IV, in which transversal competences developed are more detailed. Finally, Section V concludes this paper and focuses on BiSKY Team's future work, also referred as "team" from now on.

II. Objectives and scope

BiSKY Team pursues two different types of objectives: ones dealing with competences and skills acquisition and others related to the development of suborbital launchers. Both are strongly connected as the second ones are the main tool to fulfil the first objectives.

A. General objectives

Important efforts have been undertaken all over Europe since the last decade to foster young vocations for the STEM studies. One of the most attractive aspects of science and technology is the development of impressive products (equipment, vehicles, software,…) proving the extraordinary connection of science and technology with our present technological lives and the incoming future. As a consequence, BiSKY Team tries to be an additional contribution in this promotion work around our area of influence, even at elementary schools.

The early involvement of a high percentage of female engineering students in the team is a promising response, due to the low involvement of women in STEM careers at the university in which BiSKY Team is based. Since its creation, BiSKY Team has been trying to fill the existing gap in male and female involvement in the aerospace sector by creating a non-hostile working environment and doing outreach.

As a secondary objective, BiSKY Team tries to foster the pubic appreciation for the technologies related to space science and engineering, especially in the Basque Country and in Spain.

Spain has recently seen the creation of some NewSpace start-ups such as PLD Space or Zero2Infinity, but a lack of industrial tradition, and as a consequence, infrastructure, has sometimes acted as a roadblock for the rapid development of said companies. To compensate the lack of tradition, BiSKY Team is involved in projects where universities and companies collaborate to create an adequate environment for a further development of technology and the corresponding industries. Some examples are listed below:

- Cooperation with research groups by enabling micro-g experimentation, making it easier, faster and cheaper for the local research community to carry out their experiments. Basque university groups have already shown interest for this kind of cooperation.
- Apprenticeship and collaboration with companies related to the aerospace sector. The support and feedback of highly experienced personnel collaborating with the team and its members gives the opportunity for participants to acquire business experience as well as technical advice.
- Apprenticeship and collaboration with other educational institutes as professional training, with the aim of allowing university students to better understand manufacturing processes, as well as enhance the motivation of students of this kind of schools.

B. Specific objectives

The specific objectives are the ones dealing with the design, manufacture and launch of suborbital vehicles. These objectives include many different sub-objectives: from getting the required financial support to obtaining a working space at university, from specific software development to detailed thermomechanical and aerodynamic simulations, from parts fabrication (with a lot of collaboration form vocational schools) to their final assembly, from an adequate collaboration following rules and standards to a quasi-professional management of the project.

In the next section the scope of this paper will focus on the description of the ongoing activities related to these specific objectives.

III. Recent and ongoing activities

In order to design a rocket capable of reaching space, the corresponding project must consist of several phases divided

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into two different work areas that enable the application and the verification of the technologies involved.

First, the development of commercial launchers based on solid fuel engines with the aim of developing and testing the avionics and flight simulator completely developed by BiSKY Team. The phases are named after the rocket developed: Alpha, Bravo and Charlie. Alpha is the first rocket launched by BiSKY Team, in September 2018, which fulfils the following objectives: i) Dissemination of the project and recognition by different associations and companies, thus gaining credibility to be able to obtain the necessary financing, ii) Creation and testing of a first flight simulator, iii) Development of own technology required for the launch, flight and data collection. Bravo was able to measure altitude, pressure, gravity, angular velocity and obtain GPS data. As a result, the avionics could make in-flight decisions like deploying the parachute, save the data in an SD and send them via a telemetry link. Finally, Charlie will be a demonstrator of the technologies implemented in Cosmox, being able to entirely test the recovery system and electronics.

Second, the design and manufacturing of hybrid technology engines. Therefore, two test stand engines are being developed, denominated M1 and M2. M1 is a proof of concept that is not meant to fly but to obtain data and acquire know-how. As this is the first engine designed by the Team, its components are simplified. Gaseous oxidiser is used, leaving the vaporisation apprenticeship for the M2 engine. Heavy, high-temperature materials constitute the chambers and the nozzle so as to ensure the data acquisition for which this engine is constructed. With the obtained information, the team's own simulator will be tested and used to design the second hybrid engine, M2. M2 is a more representative engine which can easily be integrated into Cosmox. It is a powerful engine based on lighter materials, liquid oxidiser, optimised nozzle, a more advanced feeding system with a swirl injector and an in-house designed tank. After M2 testing, Cosmox will be built and launched, propelled by a self-designed engine.

IV. Cosmox Rocket

The final goal of the first three years of BiSKY Team activity must end with a self-designed hybrid engine rocket and including innovative solutions in its avionics, its recovery procedure and possible applications. In Figure 1 a simplified representation of the technical planning for the final design of this rocket is shown.

M1 and M2 testing stands will be crucial to optimise the different systems to be integrated in the Cosmox engine: the N_2O pressurized low-weight storage and the corresponding filling station, the oxidant injection system and the combustion chamber, the solid fuel composition and the high-temperature nozzle. From a detailed analysis of all the data gathered using previous solid engine rockets, the avionics, the flight simulator, the recovery system and the possible pay-loads incorporation will also be optimised.

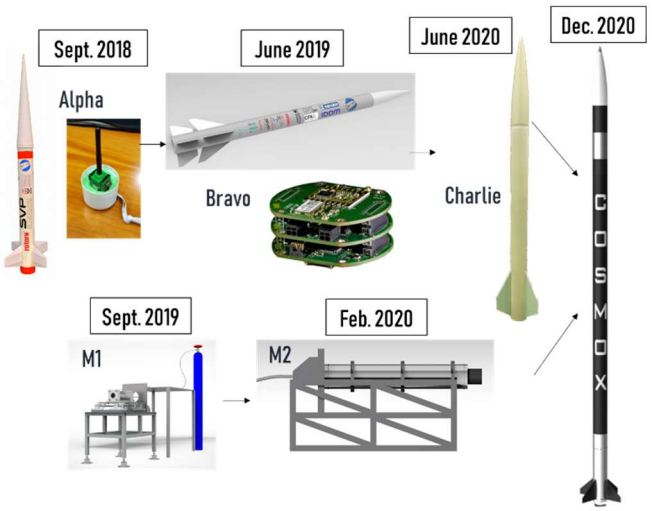

Fig. 1. Schematic of BiSKY Team's technical planning to Cosmox rocket.

After the first Cosmox rocket is launched, named Cosmox I, one Cosmox rocket will be designed and launched every year, each one improving the technology and design of the previous rocket's components. The project's final goal is to design a Cosmox rocket that will reach the Karman line, commonly referred as the boundary between the atmosphere and space.

V. Benefits

The aforementioned interdisciplinarity of the project is a key aspect of the educational benefits that the students involved in BiSKY Team gain. It allows the sharing of knowledge among the students of different university degrees in the framework of the design of a rocket. This framework also provides the members of the team with a practical focus and application of their knowledge, be it their own expertise or the knowledge gained from interactions with other members who are knowledgeable in other areas. This practical approach to the learning experience complements perfectly the sometimes too theoretical education received at university.

Apart from the shared knowledge and the practical applications, there is also an inherent benefit to being involved in a project like BiSKY Team in the form of the self-education that is necessary. Although most of the concepts required for the design and operation of a space vehicle are too specific to be developed in full detail in class, the basis upon which to build the necessary skills is fully covered. This presents the students with the perfect opportunity (or obligation) to acquire the knowledge by themselves and then prove their understanding with the application of their newly gained know-how on a rocket, a skillset that is really valuable if the student is to enter the professional market.

The different backgrounds of the members of BiSKY Team also present the participants with an excellent opportunity of networking outside their specific fields of study, building strong relationships with future professionals of the wide range of fields involved in the project. Apart from the networking within the team, BiSKY Team favours the expansion of the network of

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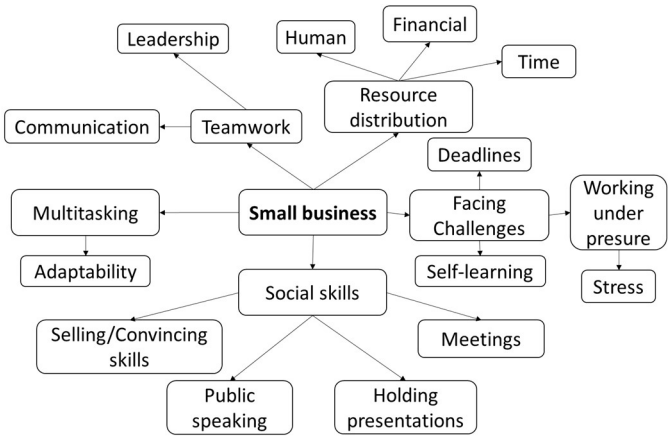

Fig. 2. Transversal competences acquired by BiSKY Team members.

its members by being a project actively involved in events related to aerospace activities such as conferences, symposiums and rocketry competitions. This also allows its participants to broaden their perspective of the space sector and NewSpace actors that will, in the future, be some of the entities that employ them.

VI. Transversal competences

With this project, team members have the opportunity to develop not only technical skills, but also transversal competences or "soft skills" as the ones shown in Figure 2. The team has the chance to experience a full business situation, gaining confidence in fields such as teamwork and leadership and becoming familiar with both self and group organisation.

The support received from companies varies from financial aid - essential in this kind of projects, where the investment in technology is significant - to technical assistance. This is a very much needed and appreciated knowledge which fills the lack of experience in fields that are rather unknown or new to the student.

The above-mentioned interaction with enterprises enables the students to have a direct relationship with possible employers, which is beneficial for both parties. On the one hand, the employer has the possibility to meet well prepared and hardworking students with an interest in the company. On the other hand, members have the opportunity of not only writing their bachelor's or master's thesis at one of this enterprises, but also getting to know possible future workplaces which is an advantage when trying to get a professional position such as an internship. In addition, members master how to hold presentations, attend to meetings, write emails and many more. This, in turn, results in an even bigger educational benefit for the student in question, as they will not only develop their skill set at BiSKY Team, but they will also be able to grasp how the professional working environment is.

At the same time, participants learn how to work under pressure and how to multitask, for they have to continue with their university studies while they are active members of the project. This shows a full commitment and hard work from the members, as it is a voluntary project. All that is achieved with both high motivation and effort.

VII. Conclusions

BiSKY Team is a university level rocketry team born in September 2018 with the aim of designing and manufacturing its own hybrid rockets. This is a novel project in Spain, where there has been no other entity developing hybrid rocket engines so far. A students-group of the University of the Basque Country gave birth to this project in order to enhance aerospace technology and science apprenticeship within engineering and science colleagues in a practical way. But not only involved students take benefits of the project, the team also gives prominence to their stakeholders such as sponsor enterprises, professional training institutes and young schoolgirls and schoolboys. The team aims to capture the interest of young school students and women, promoting the female participation in this sector. Consequently, BiSKY Team is continuously participating in events related to aerospace activities: conferences, symposiums, rocketry competitions, etc.

As for the technical procedure, the team's planning is divided into two work areas in order to construct an entirely self-designed hybrid rocket. The first focuses on the development of complete own avionics and testing of the team's flight simulator with the rockets Alpha, Bravo and Charlie. The second is the design of hybrid rocket engines, two engine test stands are being developed to ensure the required know-how to develop the team's first hybrid rocket, Cosmox.

Finally, future work will focus on the development of BiSKY Team's first hybrid rocket as well as on the improvement of its technology year by year. In that way, the team will be able to support research groups that need launchers for different experiments. At the same time, gaining a reputation may attract the attention of young students that might want to get involved in the aerospace sector. This may help strengthen the aerospace science and technology network.

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