The Student Aerospace Challenge: a European multidisciplinary contest and tertiary educational programme

Natacha Callens[1], *Marie-Christine Bernelin*[2], *Philippe Coué*[2], *Marine Regnier*[3], *Mathieu Beylard*[4]

Abstract

Inspired by the first successful tests of a private manned spaceplane in 2004, the Student Aerospace Challenge was created in 2006 by the European Astronaut Club and its partners - Dassault Aviation, the European Space Agency, the International Astronautical Federation, Safran and Thales at the time - to allow European university students to explore some aspects of manned suborbital vehicles. Until 2020, the Challenge focused on a local reusable vehicle reaching Mach 3.5 and an altitude of 100 km. Since the 15th edition, to better respond to the evolution of the sector, a second vehicle is proposed: a hypersonic vehicle dedicated to point-to-point transportation taking, for example, less than two hours to travel from Barcelona to Tokyo.

Each year, the Steering Committee defines several work packages corresponding to a large variety of study domains realistically related to this type of innovative vehicles like aerodynamic and flight control, structure, reusable propulsion, airworthiness, promotion, market analysis, legal frame & medicine. The introduction of a second vehicle having a quite different mission led the Committee to introduce dedicated topics. In addition, for the current edition, a new work package was proposed to cover potential applications of suborbital flights other than carrying passengers.

In function of their background and interest, European University students have the opportunity to work, during several months, on a topic related to one of the work packages and to explore new solutions. Proposed projects should be technically realistic, economically viable and environmentally friendly. Reports and posters issued by student teams are evaluated by the Steering Committee some weeks before the “Suborbital Day”, a dedicated event organised like a mini-symposium, usually on-site where students present orally their projects and meet representatives of the different partners. The best-quoted projects are rewarded with prizes, among them, the ESA Grand Prize offering the winner team the unique opportunity to present their project in an appropriate European space-related event.

To date, 216 teams and 998 University students coming from all over Europe already took part in the Student Aerospace Challenge, a motivating and ambitious multidisciplinary educational programme. Their participation allowed them to complement their knowledge, learn new skills and enlarge their network in the space sector.

Keywords

Challenge, Education, Manned spaceplane, Project-based learning Suborbital

[1] Corresponding author: European Space Agency, Belgium, natacha.callens@esa.int
[2] Dassault Aviation, France
[3] ArianeGroup, France
[4] National Air and Space Museum of France, France

Acronyms/Abbreviations

ACE *Astronaute Club Européen (European Astronaut Club in English)*
CV *Curriculum Vitae*
EADS *European Aeronautic Defence and Space*
ELGRA *European Low Gravity Research Association*
ESA *European Space Agency*
IAC *International Astronautical Congress*
IAF *International Astronautical Federation*
ISS *International Space Station*
MAE *Musée de l'Air et de l'Espace of Paris – Le Bourget*
RISpace *Reinventing Space Conference*
VSH *Véhicule Suborbital Habité (Manned Suborbital Vehicle in English)*
WP *Work Packages*

1. Introduction

The Student Aerospace Challenge [1] was created following a meeting between the promoters of a manned suborbital vehicle project and tertiary education students from some French “Grandes Écoles” at a Job Fair in June 2006. The professionals wanted to find some "young talents" for their “Véhicule Suborbital Habité” (VSH) project, and the students were looking for concrete innovative and motivating projects they could contribute to.

Schools and Universities were more and more pushing their students to invest themselves in intra or extra-curricular projects to complete their academic studies and in parallel aerospace industry wanted to hire young professionals with hands-on experience, teamwork, and project management skills in order to accelerate their professional insertion. It was thought that an ambitious federating multidisciplinary education programme would be the best way to provide a framework of cooperation and innovation.

The Challenge initially brought together Dassault Aviation, Safran and Thales, three French aerospace companies, with the support of the International Astronautical Federation (IAF) and the European Space Agency (ESA). The European Astronaut Club (French acronym ACE), which was the official promoter of the VSH, was asked to pilot this student competition. The creators of the Challenge were very confident about the future success of this initiative because of a buoyant suborbital context where projects were multiplying (especially in the United States). Indeed, SpaceShipOne, built by the famous aerospace designer Burt Rutan of Mojave-based Scaled Composites, had carried out the first private human suborbital flights in history and won the XPrize in 2004 by reaching the edge of space (at an altitude above 100 km). This amazing success was a key milestone in space access story and for private space explorers’ future journeys. It showed that a small, motivated team was able to design and to build a manned space vehicle without governmental support. It marked the beginning of New Space.

During summer 2006, a first edition of the Student Aerospace Challenge was launched. The Challenge evolved from the second edition with the participation of the Musée de l'Air et de l'Espace of Paris – Le Bourget (MAE) which started hosting the annual Suborbital Day. In the third year, the VSH project of the initial partners having evolved, EADS (now Airbus) also joined the Challenge. For the current 2021-2022 edition, the partners are the ACE, ArianeGroup, Dassault Aviation, ESA and MAE.

Not only had the partners evolved over the years but also the participating students. Initially the Challenge was dedicated to French students only but from 2014-2015 edition, some teams from other European Universities started applying and nowadays students are applying from all over Europe. It is worth to be noted that the Europeanization of the Challenge was an initial goal of its founders.

After 15 years, the Challenge is still existing thanks to the strong commitment of the partners and the interest of the students. It is a very successful tertiary education activity thanks to the continuous adaptation and improvement of the competition according to the expectations of the partners and students, but also the evolution of the aerospace sector.

2. Suborbital vehicles

Initially, the partners’ objective was to imagine solutions directly applicable to the VSH, a manned airborne suborbital vehicle studied by Dassault Aviation to transport six people at the edge of space. From 2012-2013 edition, three other vehicles were proposed to the students: SpacePlane (ArianeGroup), SpaceShipTwo (The SpaceShip Company/Virgin Galactic) and Lynx (XCor). New Shepard (Blue Origin) was added for the 2016-2017 edition allowing the teams to expand their projects which could be airborne or not and taking-off horizontally or vertically. Nevertheless, students were always given the opportunity to design their own vehicle shape and configuration.

For the 2018-2019 and 2019-2020 editions, only one reference vehicle was proposed to have all teams working on the same basis. The

shape was chosen independent from existing professional projects (see Figure 1) and its main characteristics were the following ones:

- Length: 18 m,
- Wing span: 13 m,
- Empty weight: 10 t,
- Propellant mass: 10 to 15 t,
- Max altitude: 110 km,
- Max Mach: 3.5,
- Weightlessness duration: about 5 min,
- Max acceleration: 4 G,
- Total mission time: about 90 min from take-off to landing.

Figure 1. Student Aerospace Challenge's reference vehicle ©ACE

However, for the 2020-2021 edition, because of the evolution of the sector, partners found it important to offer students to work on another use of the suborbital flight: a vehicle able to transport passengers or freight on intercontinental distances at very high speed. This vehicle:

- Is dedicated to regular passengers' transportation (10, 50 or 100 people),
- On a distance greater than 10,000 km (Barcelona to Tokyo, for example) in 2 h max,
- Is equipped with liquid hydrogen and oxygen rocket engines.

The stakes being very different from technical and business points of view, it seemed urgent to the partners to approach in parallel vehicles for local suborbital flights (tourism and sciences) and those for intercontinental suborbital flights.

3. Work Packages

In order to provide students with a clear working basis and to offer a large variety of topics to attract students with different backgrounds, the partners decided, from the first edition, to adopt a work principle based on annual work packages (WP). Each WP describes shortly the context and proposes some topics of investigation. The number of annual WPs, domains and topics of investigation have evolved over the years taking into account the interest of the partners and the evolution of the aerospace sector. In average, nine different WPs are proposed every year out of which six are chosen by the student teams. Only two WPs have been proposed throughout all editions of the Challenge: Propulsion and Legal aspects. Propulsion is also the most studied WP with 59 student projects and Legal aspects the only WP studied by a team every edition. Other non-technical WPs like Promotion/Communication and Market Analysis are proposed since several editions but do not attract yet many non-STEM students.

For the current 2021-2022 edition, students could choose between the following 13 WPs:

- WP1 - Applications,
- WP2 - Promotion / Communication,
- WP3 - Legal frame,
- WP4 - Medicine,
- WP5 - Reusable propulsion / Maintenance,
- WP6 - Suborbital flight history,
- WP7 - Market analysis,
- WP8 - Structure suited to suborbital flight,
- WP9 - Aerodynamic and Flight Control,
- WP10 - Airworthiness,
- WP11 - Mission profile and Concept,
- WP12 - Infrastructures for fuel supply,
- WP13 - Commercial operations.

WPs 1 and 9 address topics related to vehicles performing local suborbital flights. WPs 11, 12 and 13 are proposed for the second time, because topics are linked to ultra-long range vehicles. For other WPs, students must select the vehicle family they want to work on. Partners are looking for economically viable and environmentally friendly solutions as these criteria are becoming more and more important in aerospace projects whether they are commercial endeavours or agency programmes. Nevertheless, proposed solutions shall remain technically realistic. The most iconic results obtained during the first twelve editions are presented in paper [2].

4. Organisation of the Challenge

4.1. Application Process

4.1.1. Eligibility criteria

All students enrolled in a European university located in one of the ESA Member or Cooperating States [3] can participate in the Challenge and, since 2014-2015 edition, teams should be composed of 2 to 5 students. For some specific WPs where multidisciplinary knowledge is needed (Medicine for example), students from two different institutions are authorized to create a single team.

4.1.2. *Application Form*

Teams wishing to participate in the Challenge should get an oral authorization by an official of their institution, fill in an application form, choose a WP and provide a motivation letter.

4.1.3. *Application Validation*

Following a selection process by the Challenge's partners, selected teams have to get their participation officially endorsed by a representative of their institution.

4.2. *Project preparation*

Each team receives an access code to a download platform where previous reports are stored. Students have around 6 months to work on their project. Two progress reports should be submitted by the teams and are reviewed by aerospace experts before the delivery of the final report, abstract and poster.

4.3. *Suborbital Day*

Each edition of the Challenge is concluded by a one-day event called the Suborbital Day, which takes place at MAE. It is organised like a mini-symposium with sessions per WP chaired by partners' representatives. Each team delivers a 10-minute oral presentation of its project followed by a short discussion. Moreover, a European astronaut is invited to join this educational event and offer an inspirational lecture. It is a unique opportunity for the students to network with aerospace experts from partner institutions and industry as illustrated on Figure 2.

Figure 2. Students and aerospace experts networking during the Suborbital Day 2018 ©DAE

4.4. *Awards*

As the Challenge is a contest, the partners rank final reports and posters. "ESA Grand Prize" offers the best-ranked team the unique opportunity to present its project in an appropriate European space-related event such as the International Astronautical Congress (IAC) as illustrated on Figure 3, the Reinventing Space Conference (RISpace) or the European Low Gravity Research Association (ELGRA) Symposium. The two following ranked student projects are granted with "ArianeGroup Prize" and "Dassault Aviation Prize". The team having produced the best poster is awarded through the "Communication Prize" sponsored by ACE. Finally, as oral presentations are evaluated during the Suborbital Day, the team whose performance is the most appreciated receives the "Suborbital Day Special Prize" offered by MAE.

Figure 3. IDEST-DAST team presenting their Challenge project at the IAC 2018 ©ESA

4.5. *Closing Ceremony*

In addition to the Suborbital Day, every two years, during Paris Air Show at Le Bourget (France), partners organise a special closing ceremony for the awarded teams in the ESA's pavilion. This is another unique opportunity for the students to meet with ESA astronauts and to benefit from a VIP visit of the exhibition. It allows them to learn more about the aerospace domain and to exchange with the main actors.

5. Result

5.1. *Participants Overview*

Since 2006, 15 editions of the Challenge have been organised and 216 teams have participated to the entire contest totalling 998 students. On average, 14 teams representing 66 students participate to each edition. 27 students have participated to two editions and one student participated to three, working on different WPs and winning a prize each time!

The number of females has been fluctuating over the years, as shown on Figure 4, with an average representation of 20.4%.

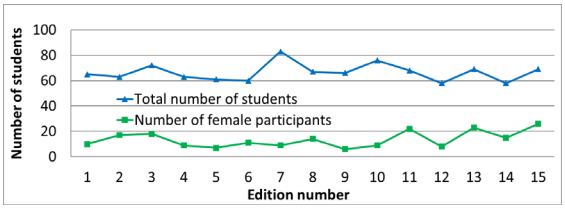

Figure 4. Comparison of the total number of students versus the number of female participants per edition of the Challenge

As illustrated on Figure 5, during the eight first editions of the Challenge, only French teams participated but from the 9th edition in 2014-

2015, the contest became slowly European with teams applying from other countries.

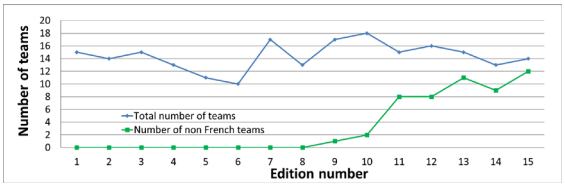

Figure 5. Comparison of the total number of teams versus the number of non-French teams per edition of the Challenge

The number of countries has been growing over the years to reach a record of 8 different countries for the 12th edition in 2016-2017. Table 1 shows the represented countries and the respective number of teams and institutions.

Table 1. Countries represented in the Challenge, corresponding number of teams and institutions

Country	Number of teams	Number of different institutions
Bulgaria	3	1
France	165	41
Germany	4	2
Greece	2	2
Italy	9	2
Poland	5	2
Portugal	3	3
Romania	5	2
Spain	5	2
Sweden	1	1
Switzerland	1	1
The Netherlands	2	1
United Kingdom	11	6

5.2. Feedback

The partners recently conducted a survey among former participants to assess the impact of the Challenge on their studies and careers. 92 of them answered the anonymous online questionnaire, so around 9% of the total number of participants (many e-mail addresses were no longer valid). As illustrated on Figures 6 and 7, even if most of them participated recently in the Challenge, they represent participants from the first to the latest edition of the Challenge who worked on a large variety of WPs. At the time of their participation, 37% of them were Bachelor students and 67% Master students.

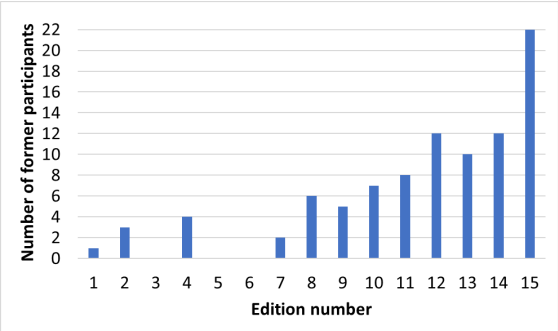

Figure 6. Distribution of the former participants who answered the survey over the different editions of the Challenge

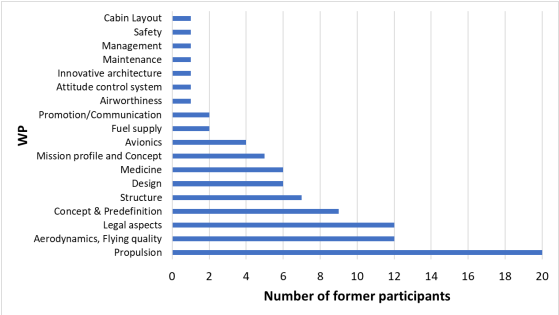

Figure 7. Distribution of the former participants who answered the survey over the WPs

As shown on Figure 8, most of them in an engineering field but some in legal, business, design, medicine, and science fields.

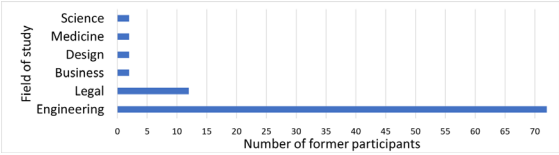

Figure 8. Fields of study of the former participants who answered the survey

71% of these former participants are still in touch with other participants and 26% made contacts during the Challenge who served them later in their studies and/or career. 75% promoted the opportunity after their participation and 87% added their participation to their C.V. The participation to the Challenge was part of the studies of 46% of these former participants. Table 2 shows how their participation in the Challenge influenced decisions regarding their studies and/or career.

Table 2. Answers from the former participants to the question: Did your participation in the Challenge influence decisions regarding further studies/career?

43 %	Yes it influenced my decisions, it confirmed/reinforced my opinion on what I want for my future studies/career
42 %	No it did not influence my decisions, I already knew what I wanted to do in the future
9 %	No it did not influence my decisions, it was not really helpful
4 %	Yes it influenced my decisions, it made me realise I want to change my plans as I
1 %	Yes it influenced my decisions, it made me realise the aerospace sector was not where I wanted to work

92% of the former participants confirmed that their participation in the Challenge allowed them to complement the skills and competences they gained during their studies and 77% already applied what they learned. Figure 9 shows that in addition to acquiring knowledge in a specific domain, former participants also developed some skills, in particular teamwork and project management but also interdisciplinarity.
62% of these former participants are now working, 33% are still studying and 5% are currently looking for a job. 65% in the aerospace domain and 58% in a field related to the WP they selected during the Challenge.

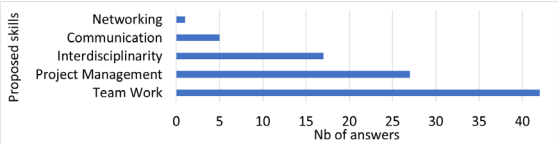

Figure 9. Answers from the former participants to the question: What was the most useful skill you developed during the Challenge?

6. Impact of Covid-19 situation

As many activities throughout the world, the Challenge was impacted by the Covid-19 pandemic. During the 2019-2020 edition, being not able to organise the Suborbital Day at the MAE in June, partners first postponed the event for several months and finally decided to organise it online as it was important to maintain an event. For the 2020-2021 edition, the same situation occurred, and the Suborbital Day was again held online. Both events were delivered using collaborative tools as illustrated on Figure 10. Connection tests were made one week prior with all participants to avoid technical issues. The virtual Suborbital Day allowed student teams to present their projects and receive their prizes but meeting with an ESA astronaut and exchanges with the partners' representatives and experts were not as easy as usual despite a nice virtual environment.

Figure 10. Some experts and students participating to the 2020 virtual Suborbital Day

In 2021, Thomas Pesquet recorded from the ISS, during his Alpha mission, a welcome video for the participants of the online Suborbital Day as illustrated on Figure 11. This was a very nice surprise!

The partners of the Challenge strongly hope to organise again the Suborbital Day at the MAE in June 2022. Even if the two online editions were successful interaction between the students and the professionals was limited whereas it is a key element of the Challenge.

Figure 11. Capture of Thomas Pesquet's Welcome video recorded from the ISS for the 2021 online Suborbital Day

7. Conclusions

The Student Aerospace Challenge is a unique European multidisciplinary contest for university students allowing them to work in teams for several months on a space-related project while getting feedback and meeting with professionals from the sector. Since 15 years, the Challenge has been successfully organised, even during the Covid-19 pandemic, allowing in one hand, students to complement their knowledge and network with aerospace actors and in the other hand, partners to meet students and identify future talents to maintain the appropriate workforce. For future editions, after the Covid-19 pandemic, partners would like to strengthen, the networking element of Challenge and to attract more non-STEM students into the Challenge to better support the evolution of the European space industry.

Acknowledgements

Thank you to all past and present Challenge's partners and experts as well as the European astronauts who took part to Suborbital Days and Closing Ceremonies: Jean-Pierre Haigneré, Patrick Baudry, Léopold Eyharts, Reinhold Ewald, Thomas Pesquet and Michel Tognini.

References

[1] Student Aerospace Challenge website: studentaerospacechallenge.eu. Last visited: 11th March 2022.

[2] Ph. Coué, M-C. Bernelin, M. Beylard, N. Callens, J-Ph. Dutheil, H. Marée, M. Valès, The Student Aerospace Challenge, a unique contest and tertiary educational programme in Europe, 70th IAC, Washington D.C. (USA), 2019.

[2] ESA website - list of ESA Member and Cooperating States: ESA - Member States & Cooperating States. Last visited:11th March 2022.