Lessons Learned from Hands-On Nanosat Activities in PEGASUS Universities

Paolo Tortora[1)], Javier Cubas-Cano[2)], Martin Bugaj[3)], Matteo Ceriotti[4)]

[1)] Alma Mater Studiorum - Università di Bologna – Italy

[2)] Universidad Politecnica de Madrid – Spain

[3)] University of Zilina – Slovakia

[4)] University of Glasgow – UK

Abstract:

Since about 30 years, several Universities belonging to the PEGASUS (Cranfield University, Politecnico di Milano, Politecnico di Torino, Sapienza Università di Roma, TU Berlin, TU Delft, Università di Bologna, University of Glasgow, Universidad Politecnica de Madrid, Università di Napoli "Federico II", University of Stuttgart, University of Zilina, to name a few) have been (or are still currently) involved in hands-on nano-/micro-satellite programmes. Whether these projects led to an actual spacecraft launch or not, it is undeniable that the practical design and assembly experience can enrich the curricula of the involved students in an unbeatable way.

Almost all hands-on nano-/micro-satellite programs in the early phases considered a full end-to-end mission design and implementation – S/C bus, payload(s), Mission Control, Ground Segment – with substantial component and subsystem developments (the build-versus-buy decision matrix was typically imbalanced toward the former). However, since the introduction of the CubeSat standard in 1999, and the broad availability of standardized nano- and micro-sat components and subsystems, three main trends emerged: (a) new H/W developments were minimized and the team efforts were devoted to clever designs, assembly and testing; (b) complete CubeSat bus solutions were selected and used by those teams focusing on new P/L developments; (c) 1U CubeSats gradually left room to 3U (and even 6U) CubeSats which allowed to host more challenging experiments and provided more electrical power thanks to the larger (and potentially deployable) solar panels.

The European Space Agency and the ESA Academy (formerly ESA's Education Office) participated actively in this process. Their All ESA Academy's initiatives aimed to improve students' skills and competences for the space sector, boosting their motivation to be engaged in the space domain, and to offer a direct experience on a real space project that will help them bridge the gap between university studies and their future professional life. ESA had established in 2000 the Student Space Exploration and Technology Initiative (SSETI), which main objective consisted in creating a network of students, educational institutions and organizations on the Internet, which together would own the capability and the means to design, build and launch a micro-satellite. Since the beginning of the SSETI initiative, students from around 20 different universities throughout all Europe engaged in the development of the very first SSETI microsatellite, named as the 'European Student Earth Orbiter (ESEO). After the launch of SSETI Express in 2005, ESEO became the second ESA student satellite, and it was meant to be the technical precursor of the SSETI European Student Moon Orbiter (ESMO). Several student teams were dedicated to the development of the different subsystems and payload complements, and the launch was at that time planned in 2008, with Soyuz or Ariane 5. The SSETI-ESEO team tried a few times to pass the Preliminary Design Review (PDR), but unsuccessfully. **The very first lesson learned is that a self-organized (but non-coordinated) set of university student teams**

cannot meet the objectives of a real space project, because schedule control and team interaction are of outmost importance.

The ESA Education Office then decided to continue offering the ESEO experience to university students, but decided to rely on the coordination of an industrial Prime Contractor and System Integrator for the satellite platform. After a short experience with Carlo Gavazzi Space (currently OHB Italia), because of financial issues the Education Office decided to change approach, readdressing the project towards a smaller baseline, in order to maintain a high educational impact, but with more affordable time, technical and cost-related boundaries. Following a competitive tender, a new System Prime was selected. ALMASpace, a spin-off company of the University of Bologna later absorbed by SITAEL, was awarded the contract to redefine the ESEO baseline, and to coordinate and supervise the ESEO students teams from the technical point of view. With SITAEL, under the coordination of ESA, the satellite reached its final configuration and mission profile. In its final configuration, ESEO had a clear educational objective: for the participating university students to acquire *hands-on experience of a real space project*, in order to prepare a well-qualified technical workforce for the European space sector. Following trend (b) illustrated above, students were offered the opportunity to develop the payload (scientific instruments or technology demonstration experiments), key satellite subsystems and the ground segment (ground stations and Mission Control) to the mission, while the satellite platform was under responsibility of the industrial contractor. Since its beginning, and throughout all its phases, the ESEO programme involved more than 600 students from ESA Member States, including students from PEGASUS members (i) University of Bologna (IT), (ii) TU Delft (NL) and (iii) Cranfield University (UK).

The ESEO engineering activities performed by the university teams have been complemented by a series of additional learning opportunities during the execution of the project. Lectures dedicated to the students participating in the ESEO project were organised by the University of Bologna, the ESEO university network coordinator. In particular, 3 editions of lecture courses and internships took place between September 2013 and September 2014. Each edition included a two weeks course (one week with lectures related to space disciplines, and the second week concentrating on ESEO related subjects) followed by a third one in the form of an internship at ALMASpace premises. University credits (ECTS) were recognised to all participants. Later, training Sessions at the ESA Academy's Training and Learning Centre at ESEC, Belgium have been organised, aiming at offering a more complete preparation in satellite telecommunications and operations, especially oriented to those teams who will be involved in the spacecraft operations. At the conclusion of the spacecraft testing campaign, an additional workshop for the ESEO university teams was organised at ESTEC by the ESA Education Office in late 2018. Space engineers and satellite test experts from space industry and ESA shared with the students all the processes and the technical issues that had to be solved during the satellite test campaign, in order to give students the opportunity to reinforce their know-how and understanding of satellite engineering as a whole. **The second lesson learned is that a time-consuming nano-/micro-sat student project needs to be recognized as part of the students' study plan in terms of university credits, otherwise the commitment and the engagement (once the initial enthusiasm is over) will never be high enough to allow reaching the challenging goals of a real space project.**

The paper will describe in details the hands-on nanosat activities and projects run by PEGASUS universities and will put them in the context of the ESA-led satellite educational projects, presenting pros and cons of the different local implementation approaches.