Science, Technology and Systems Engineering Educational Activities with Stratospheric Balloons

Salvo Marcuccio, Matteo Gemignani, Giuseppe Cataldi
[1)]Dept. of Civil and Industrial Engineering, University of Pisa, Italy
salvo.marcuccio@unipi.it

High altitude ballooning is recognized as an inexpensive, yet very effective way of bringing small payloads to a region of the Earth atmosphere where ambient conditions are very close, for many aspects, to those of space. Reaching an altitude of 25 to 40 km during a 2 - 3 hour mission, high altitude balloons (HAB) experience a range of different environmental parameters, such as very low pressure (down to the mbar range) and extreme cold (- 70 °C), together with insolation and radiation conditions almost identical to those prevailing in LEO. Reaching such "near-space" region is readily feasible for student teams using simple hardware (latex balloons filled with helium) that can be procured at low cost.

The effectiveness of ballooning for STEM educational purposes in middle and high school is widely recognized [1]. At university level, ballooning can be a very powerful tool to perform valuable research [2]. However, the value of a HAB flight project goes beyond pure scientific instruction. When engaging in a HAB project, university students have the opportunity to experience, hands-on and in a fully immersive way, all the aspects of a flight project. Along with the issues involved in designing, instrumenting, building, testing, de-bugging and flying a scientific or technological experiment, the student teams are confronted with the harsh realities of working in a team, under schedule pressure, with budgeted resources. Structured project management is readily acknowledged as a necessity and is quickly and learned and willingly applied [3].

Leveraging on several years of experience with HAB missions flown for engineering research purposes, also including experiments carried out as final projects by aerospace engineering students, the Space Systems Laboratory of the University of Pisa started a student balloning programme in 2021. The programme provides funding, mentoring and logistic support to interdisciplinary teams of undergraduate and graduate students, leading to flight of a 2 kg payload in the stratosphere.

Experiment proposals are evaluated on a competitive basis after a call for proposals open to all the students. In spring 2021, the first batch of proposals was received; seleted experiments include 1)

investigation of the effects of exposure of selected micro-organisms and other biological material to stratospheric UV radiation as a Mars surface analogue; 2) recording of the solar spectrum as a function of altitude; 3) measurement of cosmic rays flux and neutron flux as a function of altitude. The experiments have been proposed and designed by mixed teams of students from different disciplines, ranging from biology and neurosciences, to physics, to mechanical and aeronautical engineering. The interdisciplinary nature of the teams is one of the most valuable aspects of the programme, allowing the participants to experience early in their student life the joys and sorrows of having to establish effective communication and decision-making mechanisms to collaborate among specialists of different disciplines.

This paper summarizes the features and the results of the programme's first edition. The main lessons learned and the educational outcome are presented and discussed.

References

1. Cheng, S. , Gerhard, D. , Gendron, F. and Ziffle, V., "Incorporation of High-Altitude Balloon Experiment in High School Science Classrooms", Creative Education, 10, 262-272, 2019

2. Larson, S., Armstrong, J., Hiscock, W., "The First Frontier: High Altitude Ballooning as a Platform for Student Research Experiences in Science and Engineering", Am. J. Phys. 77, 489, 2009

3. Golkar, A., "Experiential Systems Engineering Education Concept Using Stratospheric Balloon Missions", IEEE Systems J., Vol. 14, No. 2, 2020