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# STRATOSPHERIC BALLOONS LAUNCHES FOR SYSTEM ENGINEERING EDUCATIONAL COURSE

**Abstract**

The rapid growth of complexity of modern space technical systems had increased demand for Systems Engineering (SE) skills. And in order to overcome this gap new approaches are needed in the field of SE education. This paper describes SE courses for MSc and Ph.D. students conducted on a regular basis at Skolkovo Institute of Science and Technology. The primary attention is paid to the use of stratospheric balloon launches for course projects. Motivation and major outcomes of the course taught in the fall term 2014 - 2017 are presented.

The educational process for such disciplines as SE requires attractive and practical examples. A significant increase in students involvement can be achieved by introducing real-life problems and genuine customer needs. Teamwork and interaction with field experts, practical work, and hands-on experience are essential for understanding the concepts and methods of SE. This course provides an opportunity to experience a full project in 2 months time.

The paper describes utilization of High Altitude Balloons (HABs) to facilitate teaching SE in the aerospace field. Relatively small cost, latex balloons can deliver several kgs of payload to altitudes of 25-30 km. Projects with HABs lay the groundwork for space hardware projects in minimum time. This near space environment allows to convey main principles of systems engineering and conduct some experiments.

For the course project described in this paper, our colleagues from the Space Medicine Research Institute (Moscow) agreed to play a customer role. The experiment was to study reaction of living cells to stratospheric conditions. During the term students went through all major system life cycle stages, such as stakeholder analysis, concept development, manufacturing, operations and system disposal. 30 students, split into five groups, were interacting with the customer and experts in various domains. Eventually five different concepts were presented to the customer, all of them were approved and launched. Two teams were able to provide results sufficient for the customer needs (cells survived the experiment). All teams identified the lessons learned and gave a positive feedback on the experience.

While teaching this course we successfully applied the CDIO (Create, Design, Implement, Operate) approach, which implies active learning and consideration of the system lifecycle. The HAB approach to teaching SE has evaluated at Skoltech for 4 years with success. We consider it as a well proved approach to introduce students to complex space system engineering.