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SPACE EDUCATION THROUGH THE INTERNATIONAL CANSAT COMPETITION - A PLATFORM FOR HIGHER ACHIEVEMENT IN STEM FIELDS

John B. Alcorn
The University of Alabama in Huntsville, United States, john.alcorn@uah.edu

Abstract

The International CanSat Competition is an engineering challenge for undergraduate students held annually in the United States. The objective of the competition is to promote space education through encouraging students to undertake the development of a mock-satellite: a CanSat. Hence, the target group is undergraduate students in STEM fields. The objectives of a CanSat include being able to survive a rocket launch and descend from a certain altitude without being damaged. The CanSat must also transmit telemetry to a ground control station as it descends and safely carry an egg to the ground. The CanSats are designed, built, and tested by the undergraduate student teams over an entire academic year with the guidance of a designated mentor. The 2012 competition will take place in early June. The CanSat competition is highly competitive and is well known for its end-to-end project life cycle and multinational participation. The project has educational benefits with respect to several STEM fields. Students gain experience in mechanical design, software design, electronics, instrumentation, manufacturing, and project management. As a whole, the project has many similarities to the development and life cycle of a satellite. The educational benefits of the project may be assessed using post-competition student responses or a critical assessment of students' technical skills and engineering knowledge. Furthermore, the comparison of individual students' responses from one competition to the next will determine how they have improved and what lessons have been learned from past failures. The goal of this paper will be to give an overview of the educational objectives of the competition, specifically the relationships between CanSat development and satellite development, and how the project is beneficial to undergraduate students in STEM fields. Also, an analysis of post-competition student responses will be given from the perspective of several different individuals, and how the students' responses have changed from the 2011 competition to the 2012 competition.

I. INTRODUCTION

Overview

The International CanSat Competition is an engineering challenge for undergraduate students held annually in the United States. Its objectives are for a team of college level students to conceptualize, design, build, test, and fly a mock satellite (a payload that operates like a satellite but does not orbit). Objectives of the hardware include surviving a rocket launch, transmitting live telemetry to a ground station, ejecting from the rocket, deploying descent control, and surviving impact with the ground. The competition rules change from year to year.

The past two years the CanSats have been required to be comprised of two independent systems, known as a Carrier and a Lander. The two systems separate from each other mid descent, and each deploys its own descent control. The Lander is required to carry an egg safely to the ground, while the Carrier transmits telemetry to a ground control station.

Requirements

An extensive list of requirements for the hardware, the team, and operations are laid down in a mission guidelines manual. The intention of each requirement is toward either safety, failure prevention, or a general objective. For example, the competition guidelines strictly forbid the use of any pyrotechnic devices, or flammable material. This includes lithium polymer batteries, which can explode under high heat or pressure, or if an excessive amount of current is being drawn. Other requirements are geared toward the team's ability to locate the CanSat during recovery. For example, it is required that each system of the CanSat contain an audible buzzer, to make it easier to locate the hardware during recovery.

Subsystems

The competition requirements entail that there should be multiple subsystems within the CanSat. Listed, these are mechanical, electrical, descent control, software, communications, ground station, and management.

Team organization

Each team is headed by a project manager, whose responsibility is to oversee the development of the CanSat. A chief engineer oversees the integration of each subsystem with the other subsystems, and defines the integration procedure, pre-launch testing procedure, and launch checklist. All of the pre-launch procedures are laid down in a mission's operations manual, which is unique to each team.

The purpose of the mechanical subsystem lead is to design the structure that contains all of the other subsystems of the CanSat. Some of the tasks are to create a 3D CAD model of all parts, ensure manufacturability of the design, and test egg protection material.

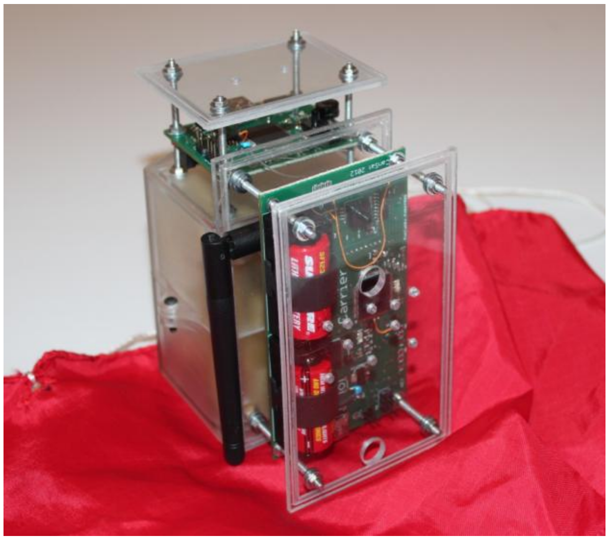

Figure 1: A completed CanSat lying on top of its parachute. The transparent plexiglass frame allowed debugging without removing the circuit boards.

The electrical subsystem lead is to select appropriate instrumentation for the CanSat through trade studies, work out a power budget for the system, and design circuit boards to house a microcontroller and other circuitry.

The descent control subsystem lead manages the parachutes and/or other descent control material. Interaction with the mechanical subsystem is critical since mass budgets and structure come into play here.

The software design lead takes charge of defining the CanSat's operational logic. Algorithms are put into code, and the CanSat is programmed and tested. Interaction with the electrical subsystem is crucial.

The ground station is required to monitor the CanSat during its flight, and to aid in recovery (since the system may land several hundred meters away from the launch site). Responsibilities include writing software that communicates with the CanSat via radio, building an antenna tower, and testing the system as a whole.

The communications subsystem requires configuring the radios and antenna and defining algorithms for data handling. This subsystem interacts with electrical, software, and ground control very closely.

The purpose of project management is to manage the schedule, budget, procurements, development, and document progress.

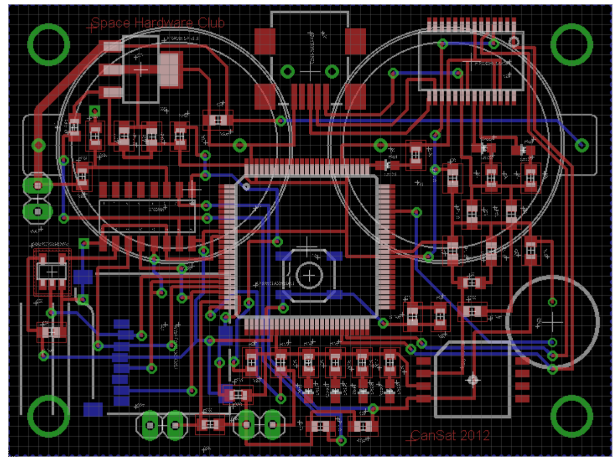

Figure 2: A CanSat circuit board, designed by a college freshman with no previous experience.

Design Reviews

Each team is required to give two design reviews and a post flight review. A Preliminary Design Review (PDR) is written by the team to lay out completed trade studies, concept design, and preliminary schedule. A Critical Design Review (CDR) is used to give details about the design of each subsystem, give the status of the budget and procurements, and how much fabrication has been completed. A Post Flight Review is presented to the judges after the competition to give details on the successes/failures of the hardware during operation and to document lessons learned. The score the team receives on the PDR, CDR, and PFR are very influential on their final score.

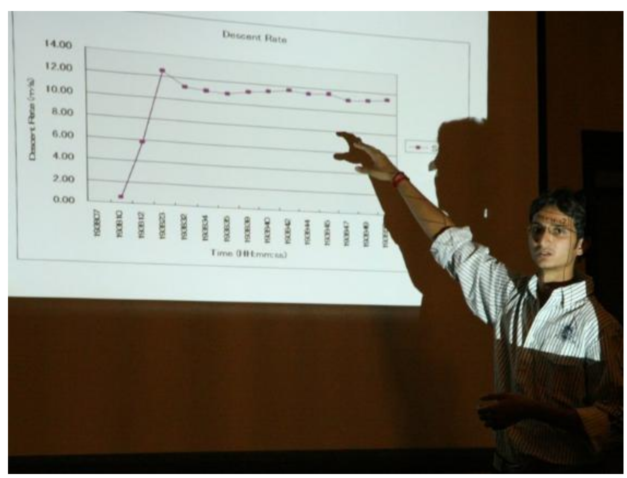

Figure 3: A student presents data during a Post Flight Review (PFR).

II. EDUCATIONAL OBJECTIVES

Similarity to Satellites/Space Hardware Development

As per the name of the competition, CanSats have similarities to the purpose and design process of a satellite, although it goes without saying that there are a lot of obstacles the environment of space presents that a device limited to the lower atmosphere doesn't need to worry about. The structural subsystem, for example, must fulfill many of the same requirements such as shielding electronics and payload from the environment and restraining embedded systems. The CanSats' communication and data handling systems consist of the same basic components as a satellite.

Mars Science Laboratory "Curiosity" has an atmospheric re-entry concept that resembles the goals of many of the past CanSats (see figure 4). For example, some of the CanSats use a deployable decelerator that has similar functions as an atmospheric re-entry blast shield. Furthermore, even though it is unheard of for a CanSat to separate into individual systems using a skycrane approach like Curiosity, the CanSats have two subsystems that separate during descent and a delicate payload to deliver to the surface.

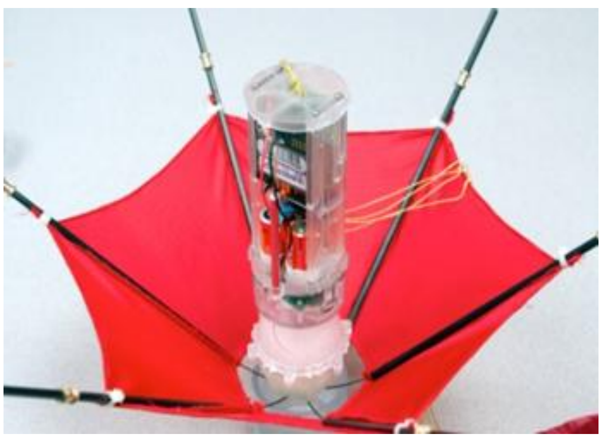

Figure 4: A CanSat with a deployable descent decelerator which resembles an atmospheric retry blast shield.

Benefit for Students in STEM Field

Most engineering curricula require courses in mechanical engineering and electrical engineering. The students involved in the development of a CanSat are benefited through this by being previously familiar with concepts and techniques prior to seeing it in a classroom. For example, ABET* accreditation requires the students to take a course in circuit analysis. A student involved in a CanSat team may already have this experience prior to entering the class.

* Accreditation Board for Engineering and Technology, Inc. A non-governmental organization for qualifying science and engineering educational programs.

IV. STUDENT FEEDBACK

Through student interviews, knowledge of how their experience participating in building a CanSat can be obtained and compared to experience gained from the classroom. The following information was taken from students from the University of Alabama in Huntsville CanSat 2011 and 2012 teams.

Technical Skills

Most students remarked that they felt one of the most valuable experiences they gained from working on the project was that they learned (or improved) one or more technical skills. The most common of these mentioned is soldering. Most students get significant experience soldering electronics throughout the course of a year. Other technical skills mentioned during student responses included machining, additive fabrication, and welding.

Software

Nearly all students felt that the software they had gained experience in would be useful in their future careers. Many of the students that participated got the chance to learn (or improve) their CAD (Computer Aided Design) skills. Also, some students learned to use FEA (Finite Element Analysis Software) and CAM (Computer Aided Machining) software in conjunction with the CAD programs used to design their hardware. Other software experience gained included programming environments, such as Visual Studio, AVR studio, and Arduino.

V. CONCLUSIONS

Engineering competitions provide undergraduate college students with a unique learning experience that enhances their education and gives them insight into their future career. The CanSat competition provides students with the opportunity to implement their coursework and learn valuable new technical skills that are not commonly gained in a classroom environment. The cradle to grave project life cycle of the CanSat competition gives students the chance to work on a project that will progress from a concept level design all the way through flight. Statistically, nearly all of the students that participated had grades that were exceptional. Universities should support and encourage student groups that take on endeavors such as student engineering design competitions.

VI. ACKNOWLEDGEMENTS

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VII. ABOUT THE AUTHOR

John Alcorn is an undergraduate student at the University of Alabama in Huntsville. He is pursuing a bachelor's degree in Aerospace Engineering. He plans to begin his graduate studies in 2014.

Alcorn spent summer 2012 interning at NASA Marshall Space Flight Center, where he worked in the Metal Joining and Processes branch on SLS (Space Launch System) flight hardware.

Alcorn is very active in a student engineering group at his university, where he has been involved in several projects. He acted as project manager during both 2011 and 2012 for UAHuntsville's International Cansat Competition team, and has been involved in multiple science payloads that have been launched on high-altitude weather balloons.

[1] International CanSat Competition. Retrieved August 2012. Site: http://www.cansatcompetition.com/Main.html.

[2] Accreditation Board for Engineering and Technology, Inc. Retrieved August 2012. Site: http://www.abet.org/accreditation/.