New Training Methods of the UAH Space Hardware Club

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The Space Hardware Club at the University of Alabama in Huntsville introduced a new training/introductory project for potential members called the One Month Project. This project is a simple high altitude balloon payload, to be designed, constructed, and flown by a four-person team: three potential members and an older club member who serves as a mentor and teacher. This new project provides several benefits both to the individual and to the club as a whole. As an individual, the One Month Project connects students to a mentor in the club and helps students develop a system level design perspective. The project also helps to make classroom material more relevant. This project benefits the club as a whole by teaching basic engineering skills and by weeding out uncommitted participants. The initial phases of design team formation are also expedited through the use of the One Month Project. This paper presents an analysis of the project benefits to the student and organization.

Nomenclature

EEPROM = Electrically Erasable Programmable Read-Only Memory
UAH = University of Alabama in Huntsville
SHC = Space Hardware Club
MOSFET = Metal–Oxide–Semiconductor Field-Effect Transistor
MAE = Mechanical and Aerospace Engineering
CAD = Computer Aided Design
AIAA = American Institute of Aeronautics and Astronautics

I. Introduction

THE Space Hardware Club (SHC) at the University of Alabama in Huntsville (UAH) is a student organization that designs, builds, and flies hardware related to space-based missions. Examples include submitting designs for the International CanSat Competition* and the Mars Rover Competition†, flying scientific payloads on high altitude weather balloons, and building cubesats. All of these projects require committed members with detailed technical knowledge of various mechanical, electrical, communications, and software subsystems. To ensure the continued success and excellence of these projects, new members must be added to the club. The SHC created a new project, the One Month Project, in order to simultaneously train and screen potential new members. The One Month Project is a balloon payload weighing less than half a pound that is required to measure altitude, cut itself off the flight line at an altitude of 1000 feet, descend at a rate of less than 15ft/s, and blink light emitting diodes to indicate the flight state. Teams consist of three new members placed with one older member who serves as a mentor to the team. This training project was incredibly successful on both the individual and club levels, and will likely be continued in the future.

Figure 1. A donut box provides the mechanical structure for a One Month Project.

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* http://www.cansatcompetition.com/Main.html
†http://www.rocketbattle.org/Spring_Competition.html

II. Technical Designs

Several unique designs were flown as One Month Projects. The most variation was seen in the mechanical design. Several teams used Styrofoam boxes to mount and protect their electronics, but other designs included using an empty soda bottle and even a donut box (Fig. 1). All of the teams used parachutes as descent control devices. A wide range of electrical components were used (Figs. 2 and 3), including MOSFETs, voltage regulators, pressure sensors, LEDs, thermocouples, and hotwires. One team used a razor blade connected to a servo motor to cut off the flight line, whereas the other teams used a hotwire to melt through a monofilament. The teams used either a XMEGA 128A1 or XMEGA A3BU microcontroller to coordinate all the payload operations. The hotwires were connected directly to the batteries (9 volt or AA's in series) and MOSFETs were used as switches to turn the hotwires on and off, because the 3.3 volt output of the board was not great enough to melt through the monofilament. The pressure and temperature sensors were analog devices, and the XMEGAs' onboard analog-to-digital converters were used to read the pressure and temperature data. These data were saved to an onboard EEPROM nonvolatile memory. Atmel Studio was used to program the microcontrollers. The flight software architectures were very different among teams. Some teams used specific functions for flight states, whereas other teams created a function to determine altitude and changed flight states in the main code. From a technical perspective, the One Month Project generated a wide variety of designs to meet standardized requirements.

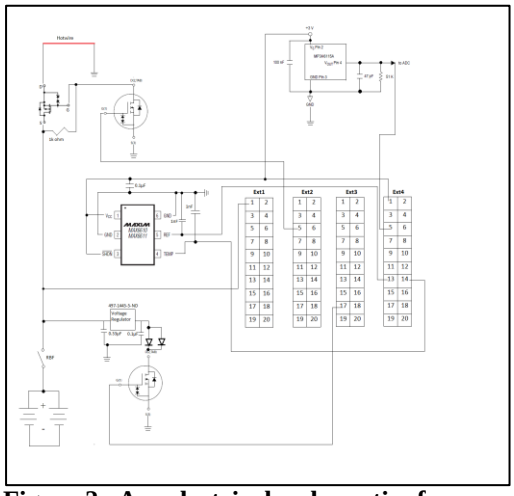

Figure 2. An electrical schematic from an One Month Project.

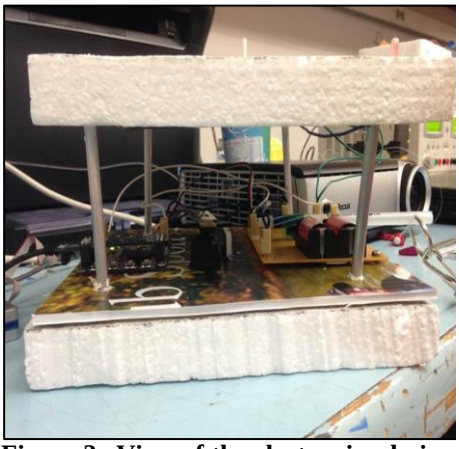

Figure 3. View of the electronics design in a One Month Project.

III. Benefits of the One Month Project

The One Month Project had an extremely positive impact on those individuals that participated. One benefit is the connection with a mentor in the club. Right away, new members have someone that knows them on a more personal level (Fig. 4). They have someone they can go to and ask questions related to technical problems, general club functions and processes, or classes. The mentor plays an integral role in retaining the new members. One issue many new members struggle with is the time commitment the club requires. Approximately ten hours a week are requested of members, and this can seem daunting in the face of classes and homework. In this case, the mentor can help the new members with time management and with scheduling time to work on projects. The mentor also has a chance to share their personal passions with the new members. For example, if the mentor has a passion for rocketry, it might inspire a new member to take up an interest in building rockets. This could also convince the new member to join a specific team that the mentor is on in order to continue learning from the mentor and building that relationship. The mentor also serves as role model for the new member. If the mentor holds an officer position or team leadership role in the club, the new member might eventually pursue one of the roles. Evan Tingley relates his experience as a mentor,

Figure 4. Project student and mentor collaborate on making a parachute.

"Being a mentor made me a better club member by serving as an introduction to team leadership, including but not limited to where to direct people when they have questions, answering questions, and the bureaucracy of the club and how to encourage a team to work. I am applying these lessons to lead a CanSat team."

By connecting new members with a mentor early on, the One Month Project immediately integrates new members into the club as well as clearly defining a resource to go to with questions.

The One Month Project also serves to introduce new members to develop a system level design perspective. Most new members join the SHC with no idea how to integrate various systems together into a final design, or even how subsystems interact and influence each other. Several lessons from the One Month Project include how selecting electrical components impacts how the code is written, and how the mechanical design needs to accommodate the electrical design. For example, if the payload includes a radio, the mechanical design needs to be RF transparent. The mechanical design also needs to protect the electronics from shocks, thermal extremes, and humidity. This integration perspective shows up in many other situations. Many engineering students are required to take a 3-D CAD class. In the class at UAH, a multi-part project is a requirement. Many of the students who had been through the One Month Project designed each part from an overall assembly perspective, whereas other students built each part individually and then tried to get them to fit together. Developing this perspective early is a necessary skill for joining a competition design team after the One Month Project. For example, many new members join a CanSat team after the One Month Project. They oftentimes focus on one subsystem, but they still need to understand how that subsystem will interact with the other subsystems. The One Month Project helps to instill a system level design perspective in new members, which is necessary for most engineering projects.

Early on in an engineering education, it is easy to get discouraged. Most classes are theoretical, with very little hands-on work or practical application. The One Month Project provides this hands-on application of engineering, and motivates members to do well in class. Many of the skills from the project are directly transferable to classes. For example, after writing the microcontroller code for the One Month Project, writing scripts in MATLAB is easier because the student has learned the basics of coding. They understand how code needs to flow, and how logical operators work. According to Adam Bower, a new club member,

"The one month project benefitted me as a student by introducing skills that I would need later in my studies that I may not have gotten by classes alone."

Skill devlopment is an objetive of the Introduction to Machining class offered through the MAE department. Students understand why parts are made a certain way, because the machining tools have limitations on what they can cut. Students are also encouraged to do well because they want to learn how to machine parts for other club projects. Overall, the One Month Project encourages students to excel in classes, because it provides an application of the skills learned in those classes.

Using the One Month Project has several club wide benefits. Design teams need members with a basic skill set, and the One Month Project teaches new members these skills. New members learn how to solder safely and correctly, and how to write code in C for microcontrollers. Furthermore, these skills are taught in a hands-on manner, similar to how they will be applied. This speeds up initial design team formation, because all the members have a basic level of competency. Adam Bower again relates his experience,

"The one month project benefitted me as a space hardware club member by putting me on the same playing field as members that had been in the club for years. It allowed me to dive into a challenging competition called CanSat that is normally a senior design project, but I was competing as a freshmen."

The One Month Project introduces new members to design presentation in the form of a post flight report. The ability to present a design articulately and concisely is a critical skill for an engineer. The two main design

completion the club participates in, CanSat and Mars Rover, include design reviews. Thus, the One Month Project gives members a small piece of everything they will experience on a competition team.

Design team formation is expedited through the One Month Project because new members have a chance to find the areas they want to focus on. If new members know their focus areas, work can begin sooner, and teams can be balanced in terms of making sure every subsystem has someone working on it. Working on the One Month Project teams also allows members to evaluate other members as potential teammates. Different work and communication styles come to light, which can be used to prevent team conflict later on. Additionally, leaders naturally emerge from working on the One Month Project. Thus, new members have a chance to evaluate potential team leads and see who they would work best with. The One Month Project speeds up the initial phases of team formation by highlighting everyone's strengths, weaknesses, and personality traits before work on the design begins. Just as important, the One Month Project serves to weed out noncommitted members before design teams form. This is important for forming stable teams, and is necessary because many of these design teams have fixed delivery dates. If team members do not deliver their portions of the project, the entire team is put in a bad position. The One Month Project is a great tool for the SHC to use in putting together committed, efficient, and knowledgeable design teams.

IV. Mission Results

From a technical perspective, the One Month Project was a great success. All but one team delivered their project to the flight line on time, and the balloon launch (Fig. 5) was useful for teaching new members the methods of high altitude ballooning, which is an essential component of the club's activities. Four of the payloads were seen to cut off the flight line, and two were recovered successfully. Ten new members of One Month Project teams are now on CanSat teams, and two others are designing and building a scientific payload for a BalloonSat flight.

Figure 5. The night launch of the One Month Projects on a high-altitude balloon.

V. Conclusion

The One Month Project is definitely a successful training tool, and should be continued in the future. It provides a way to immediately integrate new members into the club while teaching them the basic skills needed to be contributing members of design teams. The project has many benefits for the individual, from networking to forming a design perspective to motivation in classes. From a club level perspective, the One Month Project allows for quicker design team formation, and helps avoid the pitfalls of non-compatible team compositions and noncommitted members. Dr. Francis Wesslling, the Space Hardware Club advisor, nicely summarizes the benefits,

> *"The One Month project has brought together the new members and the established members in an expeditious manner. The new members have been able to get to know the others more quickly and allowed them to pick up many of the skills necessary to design and build a functioning payload. This has turned out to be an efficient way to develop the talents of both the new and the older members. The new members learn technical skills and the others learn to teach and can sharpen their own skills."*

It is hoped that many of the senior club members will serve as future mentors, and that members who participated in the One Month Project this year will also serve as mentors. Areas of improvement include streamling the design process by giving defined dates for components to be complete, as well as creating a formal teaching structure. One issue that was seen with the One Month Project was that mentors were lacking knowledge of certain subsystems (particularly coding). To remedy this, mentors should undergo two-three training meetings where these basic skills are refreshed. This training could be extended into building a sample One Month Project in August before the potential members are placed onto One Month Project teams. As the One Month Project is improved into the future, it is expected that the retention rate of trained and motivated members will be increased.

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