
AC 2012-3187: SERVICE LEARNING: ASSISTIVE TECHNOLOGY UNDERGRADUATE DESIGN PROJECTS

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Service Learning: Assistive Technology Undergraduate Design Projects

Abstract

It is essential that our next generation of engineers be educated about the needs of all individuals with and without disabilities. This may be accomplished via service learning opportunities that provide student engineers the opportunity to learn about and participate in universal design related projects. In this paper we describe a National Science Foundation sponsored project to link assistive technology needs with senior capstone design projects. The College of Engineering and Applied Science has partnered with the Wyoming INstitute for Disabilities (WIND) to publicize this program throughout the state. Assistive technology project needs requests are submitted to WIND staff. Projects are then reviewed by a team of senior design instructors to determine required senior design team size and composition to complete the projects. Student teams then choose a project and work with those who have requested the project to develop a useable assistive technology device. This program meets many needs including providing custom, assistive technology devices, meaningful capstone senior design projects and meet several ABET student outcomes. This paper provides detailed information on program implementation, challenges and successes. Several recently completed projects will be highlighted as case studies.

Overview

Every engineering program has some form of a senior, capstone design project course. The purpose of these courses is for student engineers to apply what they have learned in previous coursework toward the design of a project within specified constraints. Students are motivated by working on meaningful projects. On the other hand, those with specialized assistive technology (AT) needs often require a custom, one of a kind device. The National Science Foundation (NSF) hosts a research program to link these two groups of individuals.

In this paper the NSF sponsored service learning project to link assistive technology needs with senior capstone design projects at the University of Wyoming is described. A brief review of service learning and its characteristics as described by Eyler and Giles is provided followed by a description of the program developed to link senior capstone design projects with the needs of the assistive technology community. A review of recently completed projects is then provided. The paper concludes with a discussion of benefits to all participants: the AT community, senior design students and engineering programs.

Background

Service learning as defined by the National Service-Learning Clearing House “is a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities.”¹ While service learning programs may be quite diverse and employ students from a wide variety of age groups, there are certain common characteristics as described by Eyler and Giles. Only a brief overview of their work is provided here. The reader is highly encouraged to see.^{2,3} Service learning experiences:^{2,3}

- Have a positive effect on student personal development.^{2,3}
- Involve cooperative experiences and promote leadership, teamwork, citizenship, and communication skills in participating students.^{2,3}

- Address complex problems in complex settings. They offer participants the opportunity to develop mature problem-solving skills.^{2,3}
- Are likely to be personally meaningful to participants and enhance their social, emotional and cognitive learning and development.^{2,3}

Methods

Last year the University of Wyoming, College of Engineering and Applied Science was funded for a second five year increment of a National Science Foundation's Research to Aid Persons with Disabilities grant. This is a joint effort between the College and the Wyoming Institute for Disabilities (WIND). WIND is a member of the national network of University Centers for Excellence in Developmental Disabilities (UCEDD) whose mission is "to assist individuals with developmental disabilities, their families, professionals, and University of Wyoming students through education, training, community services, and early intervention."⁴

When the program was first developed, the organizational structure shown in Figure 1 was implemented. We have described this program structure elsewhere. The interested reader is referred to reference 5.⁵ Briefly, when a project request is received, program participants in WIND and the College of Engineering and Applied Science (CEAS) meet to determine suggested AT technology approaches that might be employed in completing the project. Also, engineering faculty mentors determine the engineering expertise, team composition and size required to successfully complete the project.

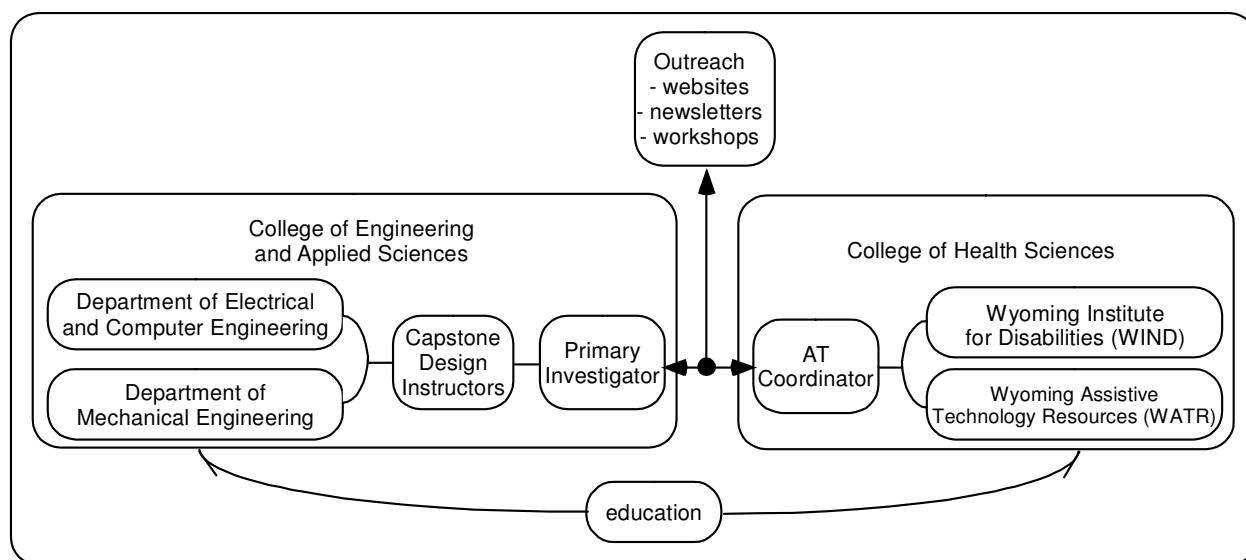


Figure 1. Program structure with education and outreach aspects.

Aside from completing assistive technology projects, an important component of the program is education. The education component is conducted in both directions. Assistive technology specialists conduct an awareness seminar for senior design students within mechanical, electrical and computer engineering. In a similar manner senior design instructors conduct "Life is a Switch" workshop to AT professionals throughout the state. This workshop is described in greater detail later in the paper.

For the second increment of the program we established the following objectives to enhance and extend the existing program:

- “Provide UW engineering students multi-disciplinary, meaningful, community service design projects.
- Provide persons with disabilities assistive devices to empower them to achieve maximum individual growth, development and independence to afford them the opportunity to participate in all aspects of life as they choose.
- Provide engineering students education and awareness on the special needs and challenges of persons with disabilities.
- Provide engineering students exposure to the biomedical field of engineering.”⁶

Since launching the second increment of the program in Fall 2010 four projects have been successfully completed which involved eight student engineers. Also, two “Life is a Switch” seminars have been conducted at two locations in the state to approximately 40 AT professionals. In the next section a brief review of several projects recently completed is provided to illustrate the depth and scope of possible projects.

Results

In this section we report on recently completed projects. For each project we provide the design team composition and a brief project description. Extended descriptions of these projects will appear in an upcoming edition of the National Science Foundation’s Engineering Senior Design Projects to Aid Persons with Disabilities.

Project: Sunrise Alarm Clock for the Hearing Impaired

Student engineers: James Follum, Electrical engineer and Jennifer Catchpole, Computer Engineer

Project description: A prototype alarm clock was developed for individuals with hearing impairment. Reference Figure 2 (left). Three separate alarm systems were included in the device. Each of these systems was doubled, allowing for use by two individuals simultaneously. The visual alarm was designed to mimic the sunrise rather than utilizing harsh, flashing lights. This sunrise can be created using any lamp with an incandescent bulb. Each user selects the duration of the sunrise as well as the option for the light to flash when the designated alarm time is reached. By using these visual cues to wake the user, the device is more pleasant.⁷

Along with the visual stimulus, a physical alarm in the form of a vibrating wristband is included with the device. Reference Figure 2 (right). The wristband produces vibrations strong enough to be effective yet not so intense as to create discomfort.⁷

The final stimulus provided by the device is an audio alarm. Since certain frequency ranges are often easier for the hearing impaired to notice depending on the specific configuration of their hearing disability, two choices in pitch have been included in this prototype. With the audio alarm system operating in conjunction with the other alarm systems, this prototype is able to wake its users.⁷

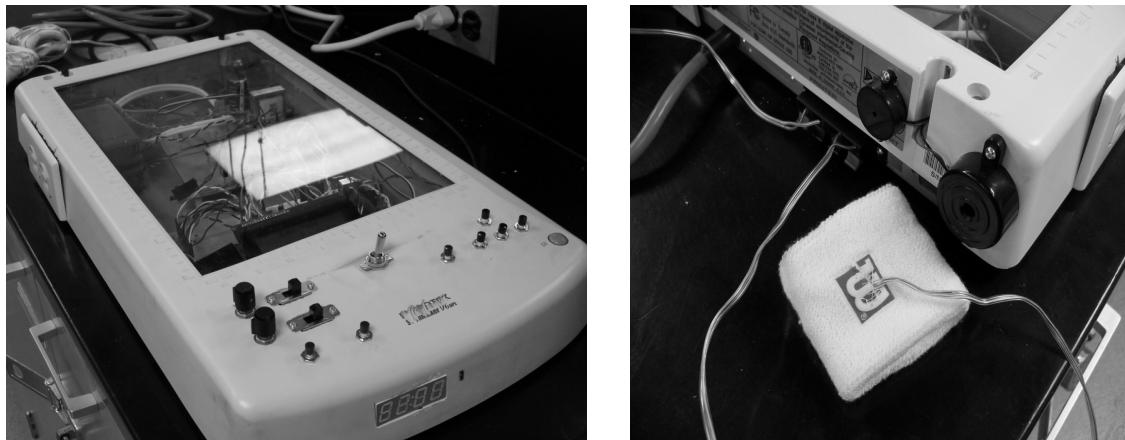


Figure 2. (left) the Sunrise Alarm Clock prototype and (right) audio and physical alarms.⁷

Project: Two Way Communicator

Student engineers: James Branscomb, Electrical Engineer and Scott Rigg, Electrical Engineer
Project description: A two way system was developed to enhance communication between two hearing, or speech, impaired individuals. The device is contained within two wirelessly connected keyboard equipped units for use between two individuals seated from 0 to at least 20 feet from each other. A user can type their desired communication on one of the attached keyboards. The device will then output the communication stream as both text and speech for the other user to read as well as hear.⁸ A block diagram of the device is provided in Figure 3 (top) while a picture of the completed prototype is provided in Figure 3 (bottom).

Device capabilities include:⁸

- Accepts input from two users
- Provide textual and/or audio output with the ability to vary output characteristics (i.e. voice, pitch, volume, etc.)
- Stores 2GB of conversations data
- Wireless transmission between two devices
- Liquid crystal display (LCD) output

Project: Color Detector

Student engineers: Anthony Michaelis, Electrical Engineer

Project description: The purpose of designing and implementing this device was to enable colorblind individuals to determine the color of ordinary objects they encounter. From power up, the device is designed to actively detect and determine the colors of objects, while continually reporting the results to the user through a Liquid Crystal Display (LCD) screen.⁹

An Arduino Duemilanove microcontroller is responsible for controlling all device operations. This microcontroller was chosen due to its ability to communicate with and control the ADJD-S371-Q999, Red Green Blue (RGB) sensor. The two devices communicate via a Two Wire Interface (TWI). When power is applied, four light emitting diodes (LEDs) illuminate the object surface. The resulting light reflection from the object surface contains the information

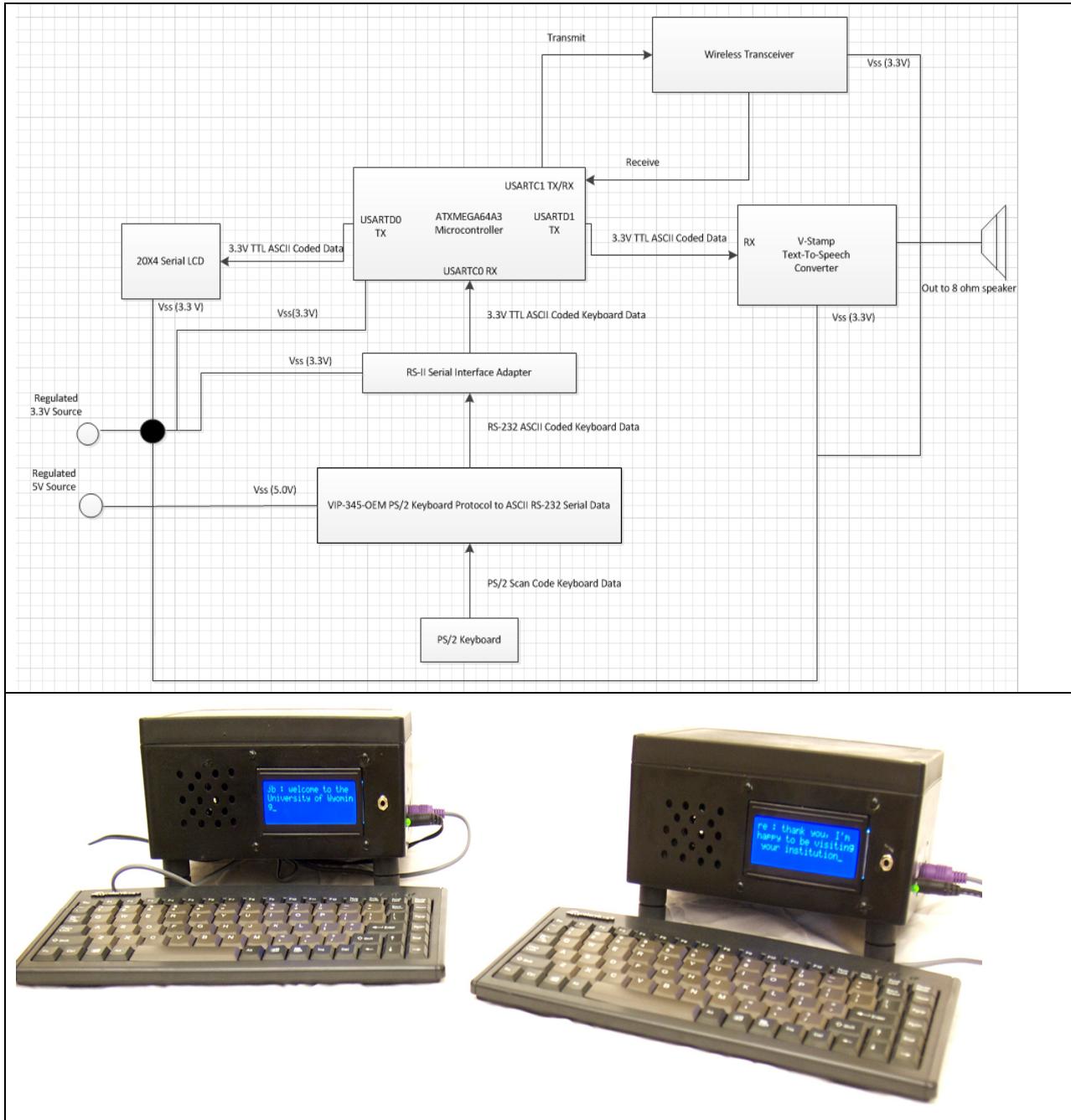


Figure 3 (top) block diagram of the two way communication system and (bottom) completed prototype (photo courtesy of J. Barrett, 2012).⁸

used to determine the color of the object. Using integrated light to digital converters, the RGB sensor measures the reflected light through three optical filters corresponding to red, green, and blue light. These measurements are used to determine RGB components, one for each of the three colors of light and then are supplied to a color determination function. Once the color has

been determined, the device will display the result using a standard 16x2, general input/output, LCD device. The device continues to provide measurements and results until power is turned off.⁹

The final design packaging system for this device is a flashlight-like casing. This packaging system was chosen to provide the user with a familiar look and feel, while aiding the use of the device. The only actions required for the operation of this device are turning the power on and pointing and holding the device towards the desired object, for which color is to be detected. Once powered, the device will initialize all components and enter into a fully automated sequence. It optimizes the Red, Green, and Blue (RGB) sensor and detects, determines and the color. When the color of an object has been determined, the device will use an LCD screen to display the color, along with the RGB component.⁹

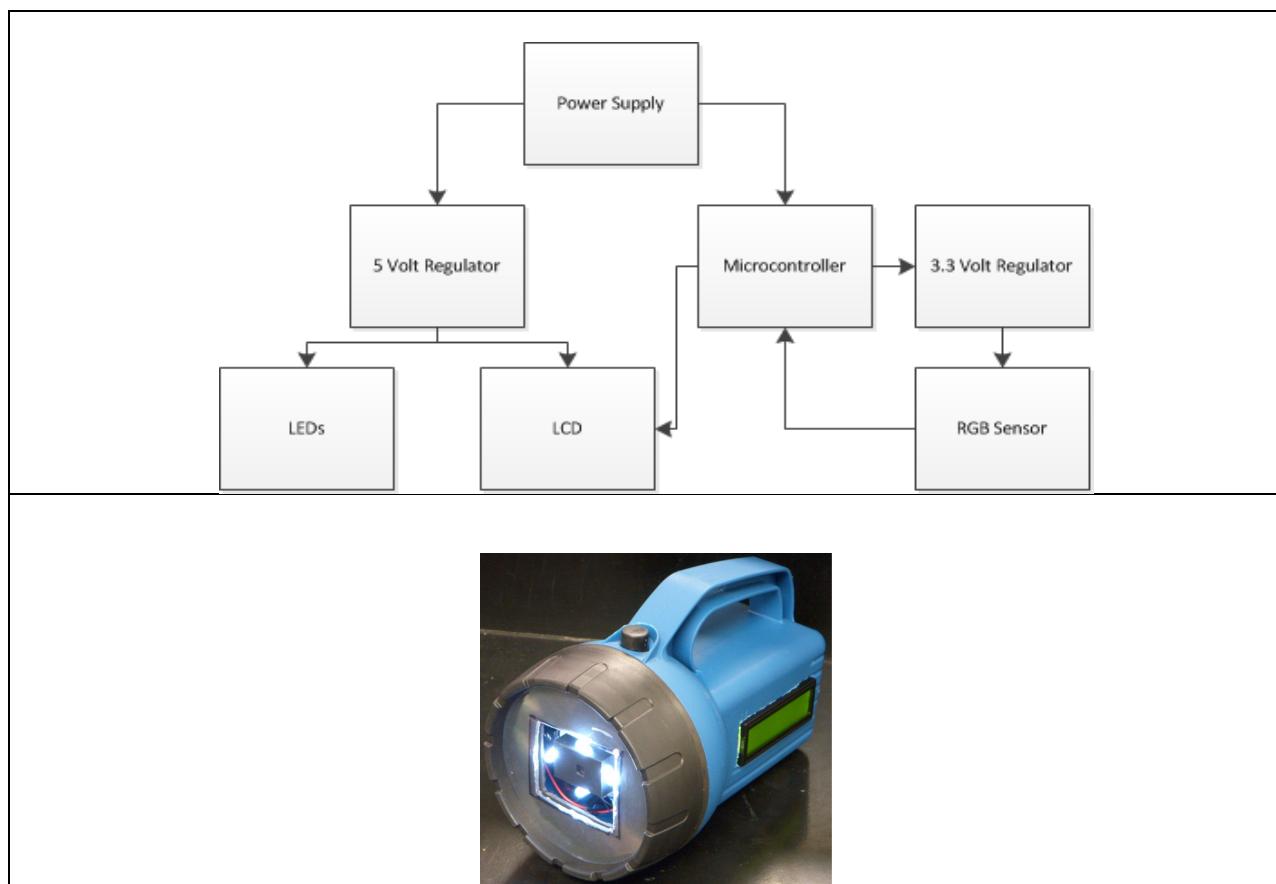


Figure 4 (top) block diagram of color detector and (bottom) prototype.⁹

Project: Assistive Fishing

Student engineers: Kristianna Bilan, Nicholas Borrego and Thomas Gebes; Mechanical Engineers

Project description: Student engineers worked closely with Mr. Peter Pauwels of Accessible Fishing¹⁰ to develop an assistive casting and take up system for use on a dock or within a raft. Mr. Pauwels provides accessible fishing opportunities for those in wheelchairs. The system is joystick controlled but can be adapted for use with other AT interfaces such as sip and puff inputs. The primary specification of this design was to have the ability to have a variable casting

distance ranging from 30 feet to 80 feet and the ability to set the hook. A design was made that incorporated a linear spring and linear actuator. In this design, the linear actuator stretches the linear spring effectively storing energy in the spring. Once the energy has been stored, a solenoid releases the stored energy and rotates the fishing rod about a fixed point. Another solenoid is used to release the fishing line and lure. This system is controlled by a five input joystick interfaced to a microcontroller that allows the user to control every aspect to maximize fishing enjoyment.¹¹ Technical details of the project are provided in.^{10,12} A picture of the completed prototype is provided in Figure 5.



Figure 5. Assistive fishing device.¹⁰

Project: Life is a Switch

Student engineers: Steven Barrett and Jeffrey Anderson, Electrical Engineers

Project description: A workshop was developed by two student engineers entitled “Life is a Switch.”¹³ The purpose of the workshop is to teach AT professionals on how to adapt off-the-shelf battery operated toys with an external switch. These adapted toys are useful for teaching cause and effect relationships with challenged children. The workshops are also a useful method of publicizing the senior design – assistive technology program to practicing professionals in the state likely to have clients that need the program’s service. The workshop was presented at two different locations during the past calendar year to approximately 40 AT professionals.

Discussion and Conclusions

The service learning project to link the needs of the assistive technology community to senior design students have benefited all participants:

- Individuals within the AT community receive custom AT devices to enhance their daily life.
- AT professionals receive workshop training on adapting off-the-shelf toys for their work with children.
- The next generation of engineers is educated on appropriate Disability Etiquette.
- Senior design students work on meaningful projects.

In addition, there are several ABET accreditation related benefits. In “Criteria for Accrediting Engineering Programs,” Criterion 5 -- Curriculum states “Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.”¹⁴ This criterion further defines design as “the process of devising a system, component, or process to meet desired needs. It is a decision making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.”¹⁴

Furthermore, Criterion 3. Student Outcomes describe what “students are expected to know and be able to do by the time of graduation.”¹⁴ Participation in an assistive technology based senior design projects allow students exposure to a number of these student outcomes including [quoted directly from:¹⁴

- “(a) an ability to apply knowledge of mathematics, science, and engineering
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.”¹⁴

Participation in the program is not without challenge. Considerable experience was gained in the first increment of the program. Challenges are discussed in reference 15.

In closing, we highly encourage participation in this program by other universities. Feel free to contact the primary author for additional information on projects or devices discussed within the paper.

Acknowledgments

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The success of this program is due to the diligent effort of each participating student engineer.

- James Follum, Electrical Engineer and Jennifer Catchpole, Computer Engineer
- James Branscomb and Scott Rigg; Electrical Engineers
- Anthony Michaelis, Electrical Engineer
- Kristianna Bilan, Nicholas Borrego and Thomas Gebes; Mechanical Engineers

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