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## **AC 2012-4168: NASA ADCAR PROJECT IMPACTS ENGINEERING TECHNOLOGY PROGRAMS AT CALU**

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Jeff Sumey is an Associate Professor in the Department of Applied Engineering and Technology at California University of Pennsylvania. In addition to teaching and developing curricula in CalU's CET, EET, RET, and CS programs, he has been active in recent years with grant projects sponsored by ONR and NASA involving data gathering technologies.

**NASA ADCAR Project Impacts Engineering Technology Programs at CalU**  
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**ABSTRACT:** The *Aerial Data Collector and Reporter*, “ADCAR”, is the result of an applied research project at California University of Pennsylvania (CalU) in conjunction with researchers within NASA to create an inexpensive aerial data gathering system utilizing kites and commercially available components. In a collaborative effort, faculty and undergraduate student research assistants from Computer Engineering Technology and Geographic Information Systems disciplines at California University of Pennsylvania have developed a prototype ADCAR unit. The prototype has been successfully flown under tow in the Chincoteague Bay near NASA’s Wallops Flight Facility in Virginia. Applied research projects such as this clearly demonstrate the significance of engineering technology’s role as the bridge between technology and engineering and the tremendous value of hands-on experience provided by engineering technology programs. This paper describes the ADCAR project and its impact on Engineering Technology programs at California University of Pennsylvania.

**INTRODUCTION:** In an effort to reduce costs and deployment considerations of aerial data gathering interests, NASA has funded a research project through East Stroudsburg University, a Pennsylvania State System of Higher Education sister school, to develop a low-cost, lightweight system that could be deployed via a kite while under tow. Using “delta” kites and moderate airspeed in the 5-15 mph range, it was predicted that a 5 pound payload could be supported. This payload was to include a radiometric microspectrometer and necessary computing components to capture, record, and transmit real-time spectrometry and GPS data. Although one previous related work<sup>1</sup> was identified, that work was not known to use a radiometric spectrometer and self-contained complete embedded system. Applications of this technology are wide-ranging and include marine and terrestrial ecobiology, polar icecap studies, agricultural crop enhancement, and environmental impacts of weather disasters and man-made effects such as deforestation, mining, and drilling operations.

**TECHNICAL DESCRIPTION:** The prototype system described in this paper was designed around the USB4000 microspectrometer by Ocean Optics which in the visible/NIR configuration responds to a wavelength range of 350-1100 nm. For the computing solution, the “Overo Fire” Computer-on-module (COM) by Gumstix Inc. was used. The COM is a six gram Linux-based PC with WiFi roughly the size of a stick of gum. When coupled with their “Gallop” module, power conditioning, GPS and accelerometer functions are added. Completing the prototype is a USB hub, a lithium-ion battery and power regulation module. Benefits of LiIon batteries include high power-to-weight capacity, relative temperature insensitivity, high charge rate and durability. The block diagram in Figure 1 shows the configuration of these components. As depicted, the microspectrometer is downward-facing to record terrestrial light energy; however, a second zenith-facing spectrometer could readily be accommodated to measure ambient / solar light energy. The console block was used for early development but was later dropped in favor of using the more convenient wireless link for both development and operational activities. It is worth noting that the prototype unit including the case and mount weighed a mere 1.75 pounds. When combined with the kite appropriate for this payload weight, an all-up-weight of approximately 2.5 pounds or 50% of the target weight was achieved.

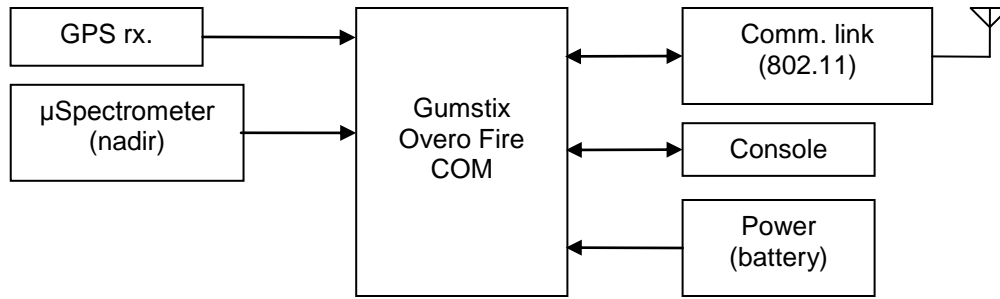


Figure 1: ADCAR Block Diagram

Operationally, the spectrometer can be viewed as a 3648x1 “slice” of spectral intensity data wherein each pixel produces a 16-bit count of its assigned wavelength of light seen within the set integration time. The assigned wavelength of each pixel is given by the formula:

$$\lambda_p = C_0 + C_1p + C_2p^2 + C_3p^3$$

where:

- $\lambda_p$  = wavelength of pixel p
- $C_0$  = wavelength of pixel 0
- $C_1$  = 1<sup>st</sup>-order coefficient (nm/pixel)
- $C_2$  = 2<sup>nd</sup>-order coefficient (nm/pixel<sup>2</sup>)
- $C_3$  = 3<sup>rd</sup>-order coefficient (nm/pixel<sup>3</sup>)

The  $C_i(i=0, 1, 2, 3)$  calibration coefficients are unique to and stored within the spectrometer. For the spectrometer used in this prototype, the actual visible range was 342 to 1033 nm. Initial testing of the spectrometer readily indicated different signatures of various scenes such as sky, grass, pavement, etc.

On the software side of the project, a library to communicate with the USB4000 microspectrometer was first developed. The software library provides functions to acquire configuration and spectrometry data as well as to manipulate operational parameters of the spectrometer as shown in Table 1. This library is built upon the popular “libusb” component of modern Linux distributions<sup>1</sup> and has proven to work remarkably well.

Function name	Description
USB4000_open	open connection to spectrometer and initialize it
USB4000_close	close connection to spectrometer
USB4000_set_integration_time	set integration time for acquiring spectral energy
USB4000_query_info	provides access to spectrometer configuration variables
USB4000_read_pcb_temp	reads raw ADC value representing PCB temperature
USB4000_read_status	reads variable spectrometer operating parameters
USB4000_read_spectra	the most important function, performs a spectra acquisition and returns results
USB4000_get_calibration_data	reads & returns spectrometer’s 4 wavelength calibration coefficients
USB4000_temp	reads PCB temperature in degrees C

Table 1: Spectrometer module functions

For main system control, the overall ADCAR software periodically reads data from the spectrometer and GPS, combines that with battery voltage status and a timestamp, then stores all data to a data logging file. The period of data samples can be changed to suit resolution and/or time duration requirements. Following a mission, the data can be wirelessly transferred to a PC for subsequent data analysis and archival functions. To monitor conditions during a mission, the prototype also broadcasts status data packets which can be received and displayed by a remote monitoring console. To demonstrate this functionality, a remote monitor client using LabVIEW was developed; the result of which is shown in Figure 2.

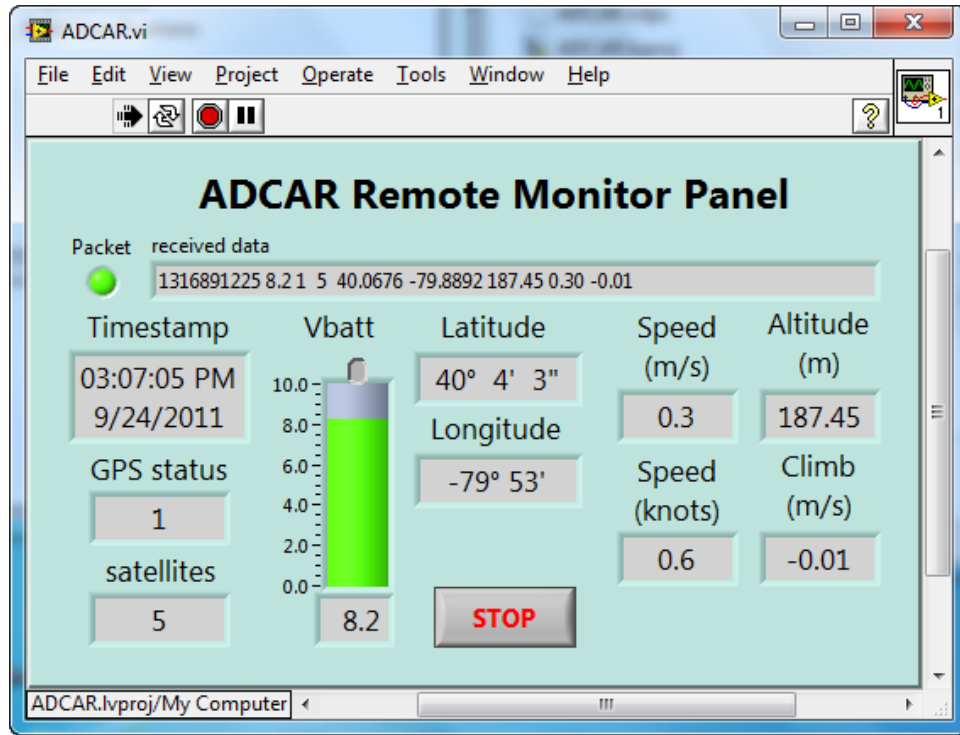


Figure 2: ADCAR Remote Monitor Panel

When deployed, ADCAR is suspended under the tether line to a delta kite using a picavet and two-point mount. Picavets are popular with kite aerial photography and serve to keep the suspended payload level and to prevent rotation about the surface normal vector. The deployment testing of this project included delta kites with 7-, 9-, and 11-foot spans. Best results were obtained with the 9-foot kite and boat speeds of 6-8 mph.

**DISCUSSION:** At CalU, this year-long project was the first of its kind in the Engineering Technology program areas, i.e. to involve applied-research on a grant project using undergraduate students. This project directly engaged one student from each of our Engineering Technology and Geographic Information Systems programs at CalU.

A number of interesting challenges surfaced when applying undergraduate students to such a project. The ideal student candidate would be a junior who has completed a number of 300-level courses but will still be actively enrolled for another year so as to stay with the project. Typically these students have full schedules and are primarily concerned with successfully completing

required courses as soon as possible. Acclimating new student assistants each semester, although does directly expose more students to research projects, can delay timely progress due to the principle investigator / project manager engaging in additional and sometimes repetitive training, briefings, and project management. However, the benefits are certainly noteworthy. A student who participates in such a project holds a number of advantages over his/her peers. This student will have more experience in independent research, development, testing, documentation, and application of program skills on a project separate from standard projects normally experienced by all program majors.

Following a job interview of an undergraduate research assistant on this project, it was revealed that some 75% of the interview was concerned with experiences gained from working on this project. Prospective employers are currently highly interested in what makes a candidate stand out from the peer group. Research projects also provide opportunity to experience the “big picture” of project development. In this project for example, multi-disciplinary tasks involving a variety of skills such as component specification, selection and procurement; mechanical fabrication; embedded software design, implementation and testing; documentation; and flight requirements provided a rich arena from which to gain experience. Indirect benefits also exist. Current students in the ET programs, now aware of applied-research grant project opportunities within their program area, are more motivated to stay in their ET program of choice because they see real-world application of the program content. They are also encouraged to better prepare for and approach senior project or other capstone experience. Finally, the presence of such a project in the department has also proven useful as a recruiting tool in that prospective students and their parents are impressed to see funded research-related activities present in a traditionally non-research program.

**SUMMARY:** Although advantages of integrating applied research into an undergraduate engineering technology program may not be directly quantifiable, these programs can clearly benefit from such activity. At CalU, the Computer Engineering Technology and Electrical Engineering Technology student enrollment has increased over the past five years from a combined total of about 90 majors to the current total of 150. There are a variety of explanations for this; however, it is the author’s conviction that one reason is the infusion of applied research grant projects into the programs over the same time period. In the modern age of high-paced advancements in technology, applied research is abundantly available and provides another means for traditionally teaching schools to contribute not just to individual student goals but to the technological advancement of society.

#### REFERENCES:

1. Balsley, Ben B., Jensen, Michael L., and Frehlich, Rod G. "The Use of State-of-the-Art Kites for Profiling the Lower Atmosphere." Boundary-Layer Meteorology 87.1 (1998): 1-25. DOI: 10.1023/A:1000812511429

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