2012 High School Teachers Small Satellite Workshop

Mookesh Dhanasar, William Edmonson
Electrical and Computer Engineering Department
North Carolina Agricultural and Technical State University
Greensboro, North Carolina 27411
Email: mdhanasa@ncat.edu

Solomon Bililign
Physics Department
North Carolina Agricultural and Technical State University
Greensboro, North Carolina 27411
Email: bililignsol@gmail.com

***Abstract*—The 2012 Small Satellite Summer Workshop was designed to introduce small satellites to classrooms in and around Greensboro, North Carolina. It was an NSF funded two day workshop for high school teachers, and was held on the campus of North Carolina Agricultural and Technical State University. This workshop consisted of two sessions that was held sequentially. The theoretical session introduced attendees to atmospheric modelling concepts, various air and space platforms, and different types sensors used to measure atmospheric and planetary properties. The hands-on sessions also consisted of two parts, with the first part focusing on developing an algebraic atmospheric model in MS Excel. A second part focused on the assemble, configuration, and testing of a can-satellite. Configuration of the sensors for the can-satellite was conducted using the Arduino development environment and the C programming language was used. A total of seventeen high school and one middle school teachers, representing ten different institutions attended the workshop. It was estimated that these teachers would directly be in the classroom with a total of 2,785 students during the academic year August 2012 to May 2013.**

I. Introduction

The two day 2012 Small Satellite summer workshop was designed to introduce small satellite concepts to high school teachers. It attracted 17 teachers from nine different high schools and one middle school representing the geographical area presented in Figure 1. These 18 teachers indicated that they would probably on average have 155 students each during the next academic year, directly impacting a total of 2785 students. The workshop was held in conjunction with the Earth atmospheric and science workshop at North Carolina Agricultural and Technical State University (NCAT). It was designed and executed in a manner to provide a smooth transition from the ongoing Earth atmospheric and science workshop. This workshop was held over a two day period and was designed with theoretical and hands-on sessions, held sequentially. The theoretical session introduced its attendees to atmospheric modelling, various air and space platforms and sensors used to measure atmospheric and planetary properties. The hands-on sessions focused on the development of a computational atmospheric model, as well as, the assembly, configuration and testing of a can-sat system. It is hoped that by providing the teachers with an option to merge theory with a hands-on activity that can execute easily in the classroom, students would become motivated to pursue studies in the STEM related disciplines.

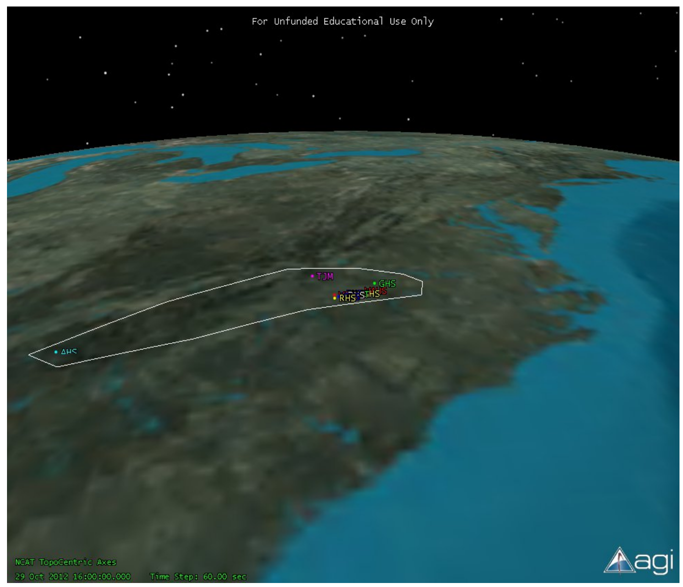

Fig. 1. Geographical region influenced by workshop.

II. Workshop Outline

The outline of the 2012 small satellite workshop was as follows;

- Attendees were introduced to an algebraic concept used to develop an Earth atmospheric model in Microsoft Excel.
- They were then introduced to various air and space platforms that can be used to collect atmospheric data.
- Next they were introduced to the underlying scientific principles used to design sensors.
- Finally, the attendees assembled, configured using the Arduino development suite and tested a can-satellite.

A. Earth Atmospheric Model

The Earth atmospheric model was developed using a NASA model that can be found at reference [1]. This algebraic model calculates temperature and pressure as a function of altitude. These properties are then used to determine the density at that particular altitude. The following are the set of algebraic equations that are used in the algebraic model;

- For an altitude(h) that is $<$ 11000 metres(m)

$$T = 15.04 - 0.00649h \quad (1)$$

$$p = 101.29 * \left[\frac{T + 273.1}{288.08}\right]^{5.256} \quad (2)$$

- For an altitude where 11000m $<$ h $<$ 25000m

$$T = -56.46 \quad (3)$$

$$p = 22.65 * e^{(1.73 - 0.000157h)} \quad (4)$$

- For an altitude where h $>$ 25000m

$$T = -131.21 + 0.00299h \quad (5)$$

$$p = 2.488 * \left[\frac{T + 273.1}{216.6}\right]^{-11.388} \quad (6)$$

- Density for all of the above altitudes is obtained from the equation of state

$$\rho = \frac{p}{[0.2869 * (T + 273.1)]} \quad (7)$$

These equations were then used to create an Excel worksheet that modelled the Earth atmospheric properties. Figure 2 presents Earth's atmospheric temperature, pressure and density as a function of altitude. Microsoft Excel was chosen because it can be considered a visual programming environment and because of its availability.

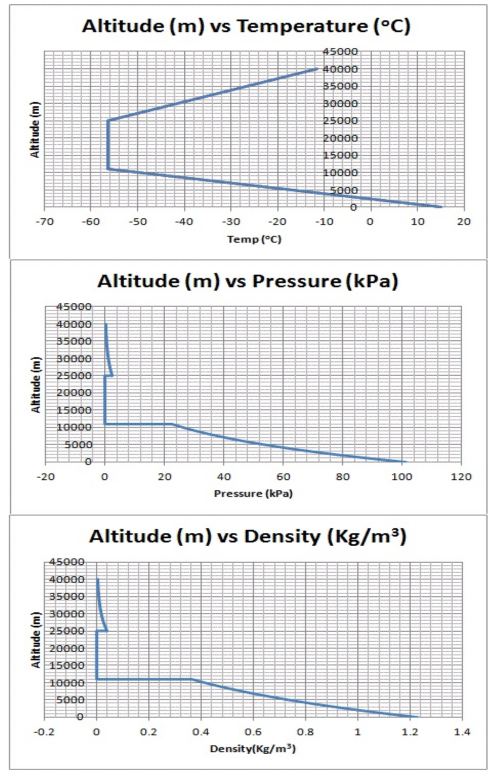

Fig. 2. Earth Atmospheric Model developed using MS Excel.

B. Platforms

There are many air and space platforms that are used to collect atmospheric and planetary data. In this section of the workshop attendees were introduced to these platforms. Air platforms were subdivided into two categories;

- Aerostats: Lighter than air vehicles, and
- Aerodynes/Airplanes: Heavier than air vehicles.

In both cases a brief history, engineering principle associated with the design and operations, and advances in each fields was presented and discussed. Figures 3 and 4 provide examples in both categories.

Space platforms introduced to the attendees were;

- Space Shuttle,
- The International Space Station,
- The Apollo Spacecrafts,
- Space Probes, and
- Satellites.

As with the air platforms, a brief history, engineering description, function and scientific contribution for each space platforms was presented. The objective of this exercise was to impart to those attending some idea of the engineering challenges associated with the design and operation of any space platform.

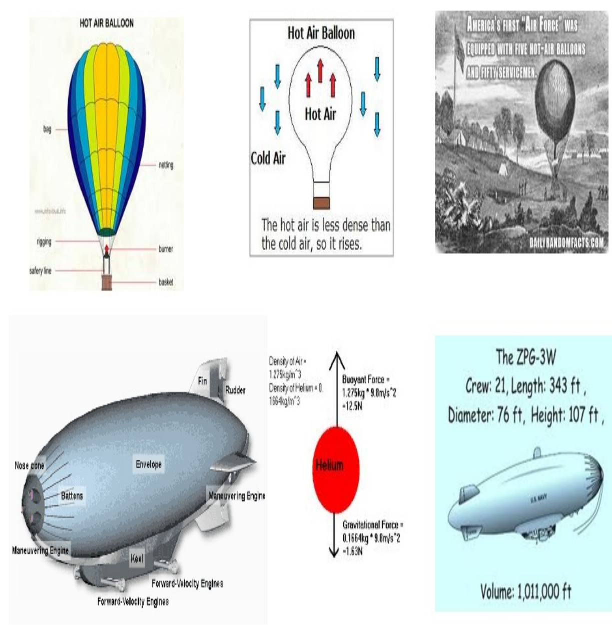

Fig. 3. Lighter than air vehicles[2]

Small satellite represents an emerging class of space platforms. It provides to the user an inexpensive, technology driven space asset that can be designed and built to target a specific function. The development time frame for small satellites is relatively shorter than the development time frame when compared to traditional satellites. This represents an opportunity to capitalize of emerging space technologies. One way of thinking about these space platforms it that they are

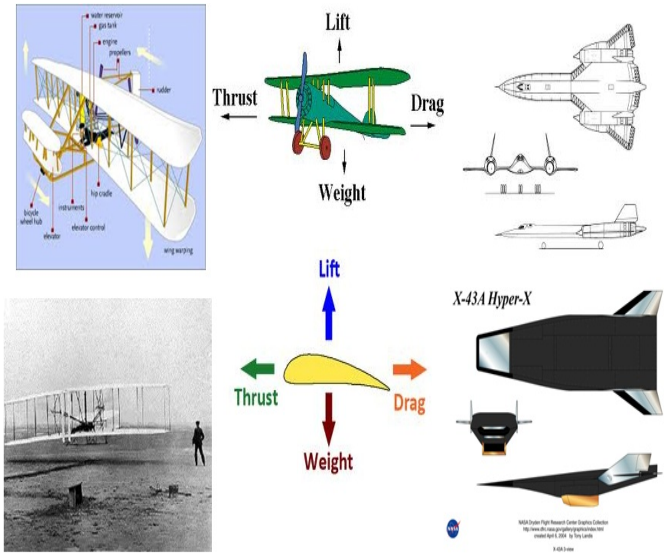

Fig. 4. Heavier than air vehicles[2]

smaller versions of larger satellites, but cost less to develop, uses advance technologies, and can be designed, developed and deployed in a shorter time frame. Figures 5 and 6 presents small satellites. Small satellites can be effectively used to demonstrate scientific STEM concepts in the classrooms.

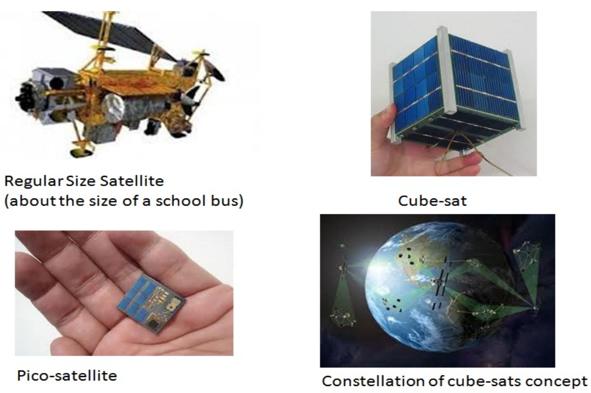

Fig. 5. Different sizes of satellites. [2]

C. Sensors

Every object in the universe emits some form of Electromagnetic Radiation. This section of the workshop introduced attendees to the underlying principles associated in the choice and design of sensors. It included a session of how knowledge of the electromagnetic spectrum, Figure 7, influence the design of different sensors. The example used was the measurement of the carbon dioxide concentration in the atmosphere by the WNI Satellite, Figure 8.

D. Can-Satellite Workshop

The cumulative activity at the end of the small satellite workshop was the assembly, configuration and testing of a can-satellite. A can-sat was chosen simply because of its availability, cost, and the fact that the can-sat bus contain most of the same subsystems that you would find on a satellite. For this activity, “turn key” can-satellite kits were obtained from Pratt Hobbies. The objective was that each teacher attending the workshop would have a working model to take back to their classes. Figure 9 presents the block diagram of the can-satellite sub-systems. The individual subsystem components are presented in Figure 10. Figure 11 presented the assembled can-satellite. Configuration was accomplished with the use of the Arduino development software, using the C language.

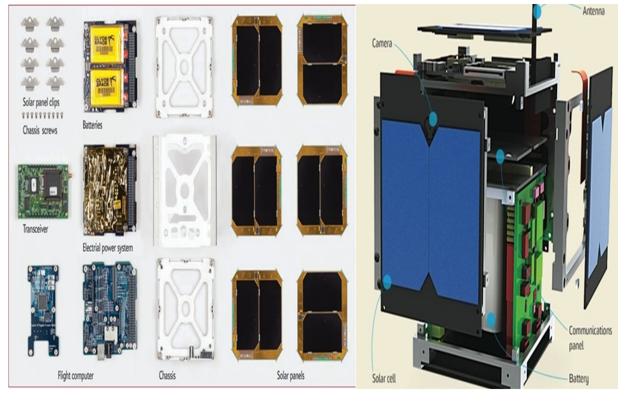

Fig. 6. Cube-sat components(left), assembled (right)[2]

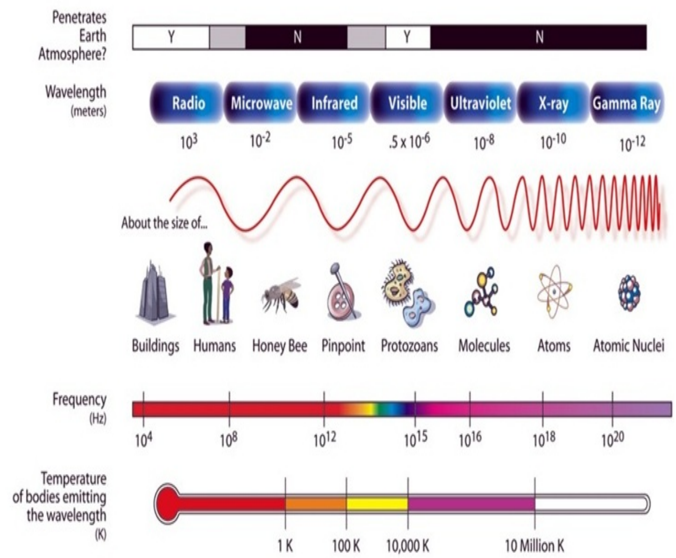

Fig. 7. Electromagnetic Spectrum[2]

III. Attendees Evaluation and Responses

In order to assess the workshop impact on the attendees a simple evaluation form was designed. The driving concept for the design of the evaluation form was the maximum participation from the attendees. It consisted of five questions that were weight numerically from 1-5, with the 1 carrying the greatest weight. The following were the questions used on the evaluation form;

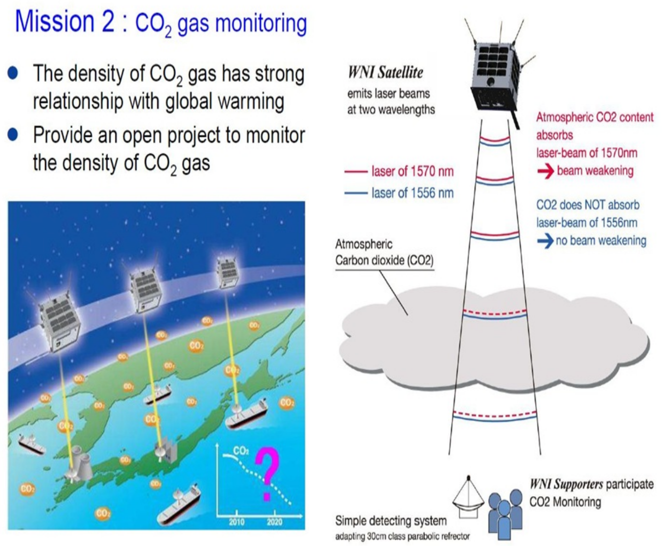

Fig. 8. Use of the Visible-Ultraviolet region of the EM spectrum in CO_2 sensors [2]

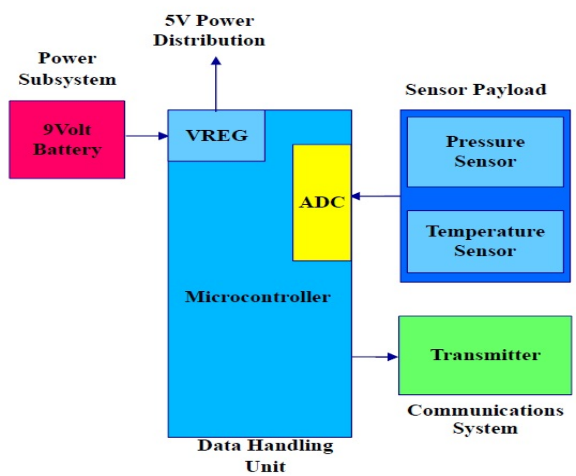

Fig. 9. Block diagram of the can-sat subsystems [3]

- Question 1: How would you rate the content organization for this section of the workshop?
- Question 2: How would you rate the content of the workshop?
- Question 3: How applicable is this content to what you teach?
- Question 4: How likely are you to attend future workshops or recommend this workshop to your colleagues?
- Question 5: How likely are you to use content from this workshop in your classes?

The responses from this part of the evaluation is presented in Figure 12. In Figure 12, each participant is assigned a number and their response to the evaluation questions plotted. The two main objectives associated with this plot are to;

- Identify the individual participant's response to the questions, and

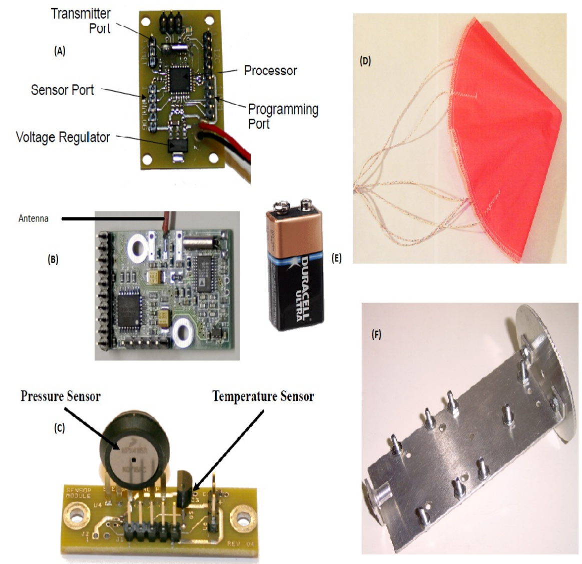

Fig. 10. Can-sat components (A)Processing Unit,(B) Communication Subsystem,(C) Atmospheric Sensor Payload,(D)Attitude Control Subsystem,(E)Power Supply,(F) Structure[2]

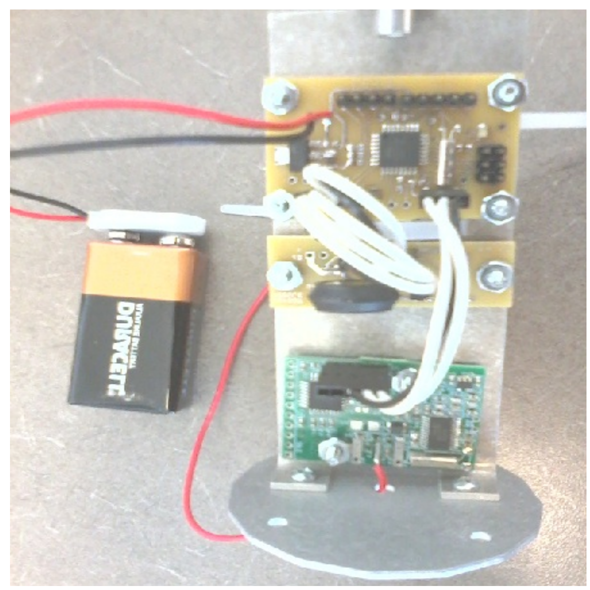

Fig. 11. Assembled Model

- Observe the overall trend to the questions by the group.

Closer examination of the data, indicated that 78 percent of those attending the workshop rated the organization of the workshop with a grade B or better and were likely to use content from the workshop in their classes. Also from the data, 89 percent of those attending rated the workshop content with a grade B or better, and indicated that they would attend or recommend future workshops. Only 61 percentage of those attending were able to rate question 3 with a grade B or better; indicating that the materials were somewhat related to what they teach.

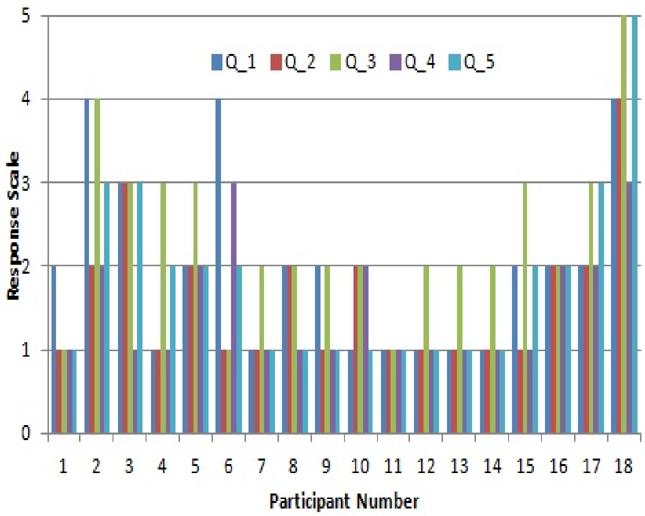

Fig. 12. Survey Evaluation Data

The following section will list the attendees comments that were left on the evaluation form. It is important to note that these comments are exactly what was written. It is hoped that the reader will be left to interpret these comments without any bias from the author;

- "Presenters know how the content can be interpreted or translated into the North Carolina Course of Study. Which common core objectives would be addressed."
- "Please provide more info relating to lesson planning and how the info can be used in our classes. The 1st two days were great but the rest of the week needed more structure."
- "I found the beginning of the programming to be very confusing. Once we figured out voltage had to be converted into pressure/temperature it made a little more sense but the program didn't work, very frustrating. Overall the instructor was very knowledge."
- "I really enjoyed the workshop and learning about the satellites and writing a computer program. I think it is informative and will allow the students a very handsome opportunity."
- "Earthquakes were awesome! Weather - not so much. Satellite workshop was good."
- "I have not had any programming experience and enjoyed the challenge. I need a receiver."
- "Overwhelming amount of information but good material. (referring to entire session)"
- "New information; useful for Astronomy class and Physical Science"
- "Working on creating teachable labs/activities that correlate with the new unpacking of standards."
- "I found the satellite workshop to be highly engaging, and even intellectually challenging. While it would be a bit cost prohibitive, I think that it demonstrates a way to engage students in the scientific process and gain hands on experience with topics and concepts that are usually abstract and students lack interest in."
- "I have enjoyed the workshop."
- "This was an outstanding workshop! I learned a great deal about satellites, how they are built, and how they are programmed. The weather information and processes of how the data is collected and used will be rich material that will enhance all aspects of STEM in the high school where I teach. It is over 90 percent African American with the rest of the population made up of the Latino community. We very much need programs like these."
- "Provide a few more feasible examples of how this information is correlated with the curriculum and how it can be practically used in the classroom with 30+ students."
- "I left feeling like my knowledge that these are satellites wasn't supplemented or added to I was thoroughly confused by the code issue."

IV. Recommendations

This was the first small satellite workshop that focused on high school teachers and therefore serves as the starting point for future workshops. It was held in conjunction with the Earth Science and Atmospheric workshop. The workshop was offered over a two day period, and the contents, though condensed, covered a very wide base. Recommendations that I would suggest for future workshops are;

- Workshop needed to have a longer duration. It can still be held in conjunction with the Earth Science and Atmospheric workshop, but instead of being held over a two half-day periods, it could be five half-day secessions.
- There need to be some way of following up with the participants when they return to their home institutions.
- There need to be sufficient materials to distribute to participants so that they can take it back to their home institutions.

V. Conclusion

Fig. 13. Participants at the end of the workshop.

The main objectives of the small satellite workshop was the introduction of small satellites to high school teachers and identify how these platform can be used to promote Science, Mathematics, Engineering and Technology (STEM) education in local high schools. It is the opinion of the authors that if the teachers are excited then this excitement is transferred to the classroom. The hands-on component was very well received, and while there was a significant learning curve in executing the programming aspects, a large percentage of the attendees showed enormous interest, and were actively discussing about how best they can implement some of these activities in their classes.

REFERENCES

[1] http://www.grc.nasa.gov/WWW/k-12/airplane/atmosmet.html
[2] Compilation of images that was found on the World Wide Web
[3] http://www.pratthobbies.com/