Vertical Integration of Students and Mentoring Activities Pave the Way for Phase-II of UMES-NASA Experiential Learning Project

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Abstract
UMES-AIR (Undergraduate Multidisciplinary Earth Science-Airborne Imaging Research) project was partially funded by NASA Goddard Space Flight Center (GSFC) in the fall of 1999. The project has provided a platform for involving a group of more than twenty undergraduate students in mathematics science engineering and technology (MSET) curricula at the University of Maryland Eastern Shore (UMES) in an out of classroom active learning and exploratory research experience in the field of remote sensing and its applications. UMES, an 1890 Land Grant historically black university, has a large minority population and all efforts are made to involve minority students to participate in the project activities. The scientific objective of the project includes aerial imaging in the visible and infrared regions of the electromagnetic spectrum, land survey study of shoreline erosion, research in agricultural land use patterns, environmental studies and atmospheric data analysis. The first phase (Phase-I) of the project has been successfully completed in August 2001 when the goal of collecting remote images from a tethered blimp from a height of 2500ft. was achieved by the UMES student team working in close collaboration with NASA GSFC Wallops Flight Facility (WFF), technicians, engineers, and administrative personnel. As the first group of students who led the Phase-I efforts progressed through college and graduated or moved to junior/senior levels with more demanding academic loads, the need for vertical integration of project participants became clear. Subsequent to the Phase-I efforts that were adequately funded students in the MSET major at UMES have been encouraged to take part in the project by the participating faculty members out of their own interest without any financial incentives. Although the numbers of student participation have gone down, significant achievements have been made with regard to achieving the Phase-II goals during the years 2002 and 2003.

1. Introduction

Vertical integration of students from freshman to senior level along with graduate students goes a long way to assure continuation of projects such as the UMESAIR project. The project involves design, development and utilization of an instrumented tethered blimp for aerial imaging and analysis. Figure 1

shows a schematic of the UMESAIR project and various components. To avoid cluttering the winch and the tether lines for raising and lowering the blimp have not been shown.

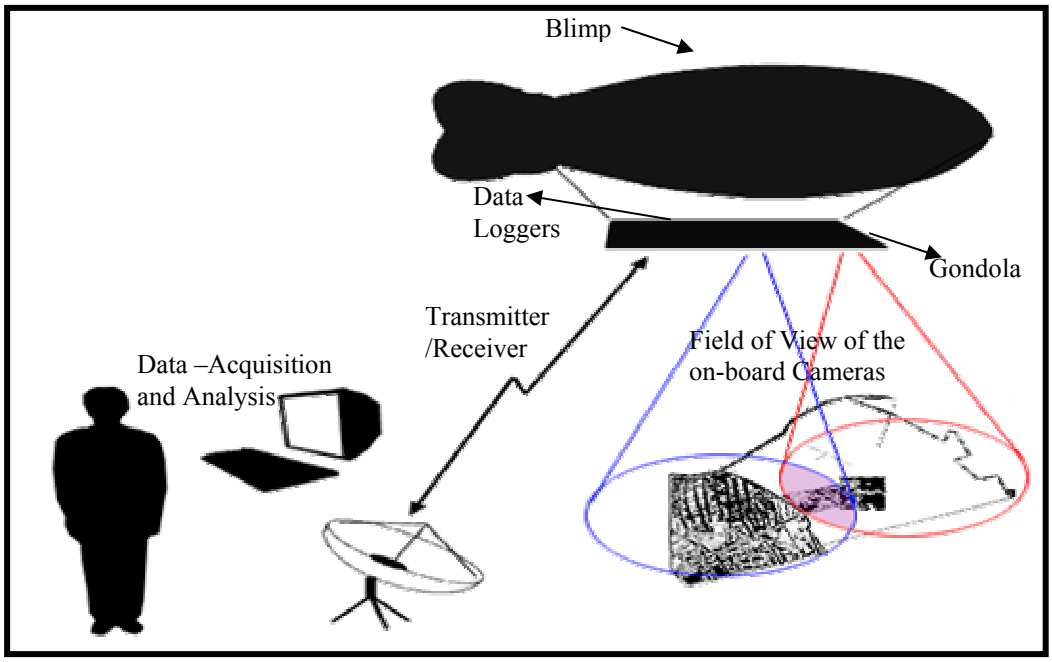


Figure 1 : Schematic Of The UMESAIR Project

During the early part of the first phase, efforts were directed towards payload design, system integration, and management efforts for collecting remote images from a tethered blimp from a height of up to 500 ft. using a manual winch. Significant strides were made with the project during the year 2001. The Phase-I goal of collecting images from a helium filled tethered blimp from a height of 2500 ft. was successfully achieved by students working in close collaboration with the NASA-GSFC's Wallops Flight Facility (WFF) engineers, technical, and administrative personnel using a custom designed automated winch in the summer of 2001. Efforts were also directed toward acquiring appropriate hardware and software for digitizing the collected images and performing image analysis.

The successes of the UMES student teamwork and collaboration with NASA engineers and staff have been reported before [1-3]. Two blimp launches have been conducted successfully by UMES student teams in Phase II, first on November 1, 2002 in the UMES Campus and the second on November 21, 2003 at NASA Wallops Flight Facility. The project goals have been successfully accomplished. Vertical integration of students and smooth transition of responsibility and knowledge of launch procedure to the new student participants were successfully accomplished. NASA engineers, staff and technicians as well as UMES faculty members who have assisted with both Phase-I and Phase –II of the UMESAIR project also contributed significantly towards maintaining the continuity of the project, by mentoring the students and setting appropriate goals.

2. UMESAIR PHASE-II Goals

The Phase-II goals for the UMESAIR project can be summarized as follows:

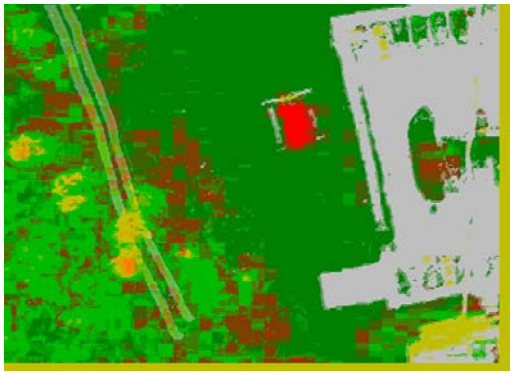
(i) Appropriate documentation in the Phase-I stage to pass information to new student teams in Phase-II.

(ii) Continued group meetings at convenient times throughout the academic year and at more regular intervals prior to blimp launch dates with a view to inform the student participants with regard to prior achievements and launch procedure.
(iii) Utilization of the blimp as an atmospheric data logging unit along with aerial imaging capability developed in Phase-I.
(iv) Demonstrate that blimp launches can be broadcast live over the internet for all interested audience/spectators.
(v) Design, build, and suspend a new structurally improved gondola with aerial imaging and atmospheric data-logging capability to the blimp and demonstrate that it provides comparatively steadier images with respect to the Phase-I gondola.
(vi) Integration of image analysis efforts using MATLAB Image Processing Toolbox with the Introduction to MATLAB course offered by the primary author for Engineering and Mathematics & Computer Science students.
(vii) Continue to provide opportunities to students to attend and give presentations at conferences.

3. Accomplishment of Phase-II goals (2002-2003)

Blimp launch on November 1, 2002

Goals (iii) and (iv) above were demonstrated during the launch at UMES campus on November 1, 2002. The overriding intent of the initial stage of the Phase-II efforts was to have a smooth transfer of knowledge and experience from the group of students that led the Phase-I efforts to a new group of primarily freshman and sophomore students in the MSET majors at UMES. It was decided to conduct the blimp launch on campus in early part of November of the fall semester of year 2002 to a height of 500 ft. The same set-up as the one described in reference [2] for the blimp launch at NASA Wallops Flight Facility in the summer of 2001 when the proposed Phase-I mission objectives were successfully demonstrated was used. During this launch besides aerial imaging the utilization of the blimp-gondola system as an atmospheric data logging unit was demonstrated successfully. Lightweight data-loggers were identified [4] and incorporated in the UMESAIR blimp gondola to acquire atmospheric data pertaining to temperature, pressure, humidity and light intensity as the blimp was raised and lowered. The data was subsequently downloaded to a computer and plotted using appropriate software.



CLASS DISTRIBUTION FOR SELECTED IMAGE

No:	*Class*	*Samples*	*Percent*
1	concrete	61211	11.3
2	red shed	2231	0.4
3	grass	108603	20.0
4	orange leaves	766	0.1
5	yellow leaves	274877	50.7
6	green leaves	57617	10.6
7	treeline	37050	6.8
Total		**542355**	**100.0**

Figure 2 : Image Analysis Using Multispec.

Selected frames of the digitized images from the November 1, 2002 flight have been analyzed by the students using Multispec image analysis software developed at Purdue University [5]. The software is available for free of cost for downloading from the internet. Figure 2 shows an image acquired during the November 1, 2002 launch from a height of 500 ft. and its' analysis using Multispec for land use patterns. The fall colors of November are clearly visible in the image.

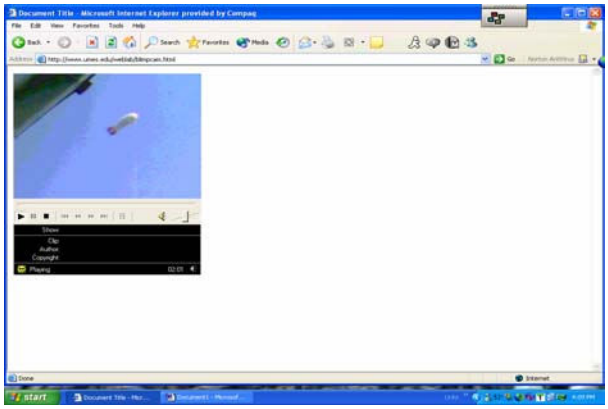


Figure 3: Blimp Launch As Seen Over The Internet

Goal (iv) was also demonstrated during this launch. With the support of Information Technology staff on UMES campus, the UMESAIR team was successful in transmitting the blimp launch over the internet using a web cam. Figure 3 is a screenshot from a networked computer in the student dorm that was set to the appropriate URL using a web browser to witness the blimp launch. This capability has a variety of possibilities in the future with regard to outreach activities related to the project.

A web cam was attached to a laptop computer with a wireless network card and carried to the outdoor launch site to acquire and transmit the image data. A wireless ACCESS POINT with a 100 ft ethernet cable was located in a nearby laboratory in close proximity to the launch site within the transmission range of the wireless transmitter to provide a seamless connection to the wired network. Appropriate settings were achieved to transmit the streaming video pertaining to the live blimp launch using one of the web servers on campus.

Interested readers can acquire more information on the wireless ACCESS POINT and wireless PC Network Card from the website of the vendor [6].

Blimp launch on November 21, 2003

Goal (v) was demonstrated during the launch at NASA WFF on November 21, 2003.

The gondola that was developed and instrumented for the Phase-I efforts worked adequately. However, the shape of the gondola did not allow for it to be suspended from the blimp in a manner that would restrict the movement of the gondola due to small disturbances caused by wind and other perturbations. The students involved in the Phase-I stage brainstormed and came up with a new gondola design that would absorb small perturbations and disturbances while suspended from the blimp resulting in a steadier image. (See Figures 4 – 6).

Figure 4: Phase-I Gondola

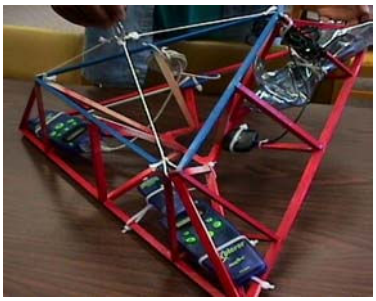


Figure 5: Phase II Gondola

Figure 6: Suspension of Phase-II Gondola

Initially it was planned to move all the cameras, transmitters, circuitry, power supply and other relevant components from the old to the new gondola. During the development stage it was decided it was best to keep the old gondola as it is and develop the new gondola from scratch. The original gondola had both a color and black and white camera. It was decided to go with just one color micro-video camera and transmitter with a transmission distance of 1000 ft in the new one. This was considered adequate to demonstrate the objective.

As in the Phase-I efforts to sustain a blimp launch for a 2 hour duration it was decided to carry adequate power on the new gondola for the camera(5 Volt) and transmitter(12 Volt) . The data loggers identified came with their own power supply.

Some of the student members worked with the faculty and NASA technicians to develop the power supply arrangement for the new gondola. The schematic of the circuit developed is shown in Figure 7.

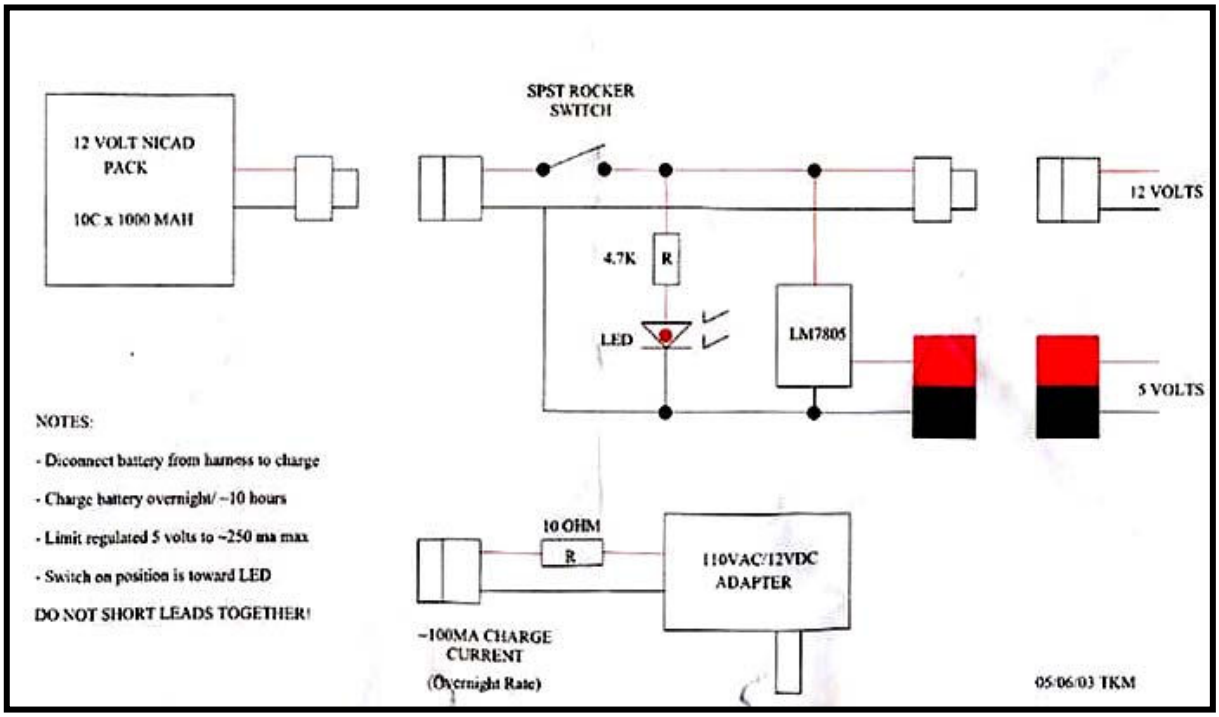


Figure 7: UMES AIR Phase II Power System : Battery/Charger/Switch Harness/Regulator

Lightweight data-loggers that were used during November 1, 2002 launch were utilized with the new gondola as well to acquire atmospheric data pertaining to temperature, pressure, humidity and light intensity as the blimp was raised and lowered. The data was subsequently downloaded to a computer and plotted using appropriate software. While all the other loggers had performed satisfactorily for the launch on November 1, 2002 , the pressure sensor yielded erroneous results. Proper precautions were taken for mounting the pressure data-logger during the November 21, 2003 launch with the new gondola. The result of the pressure sensor reading during the launch, calibrated to blimp height is shown in Figure 8.

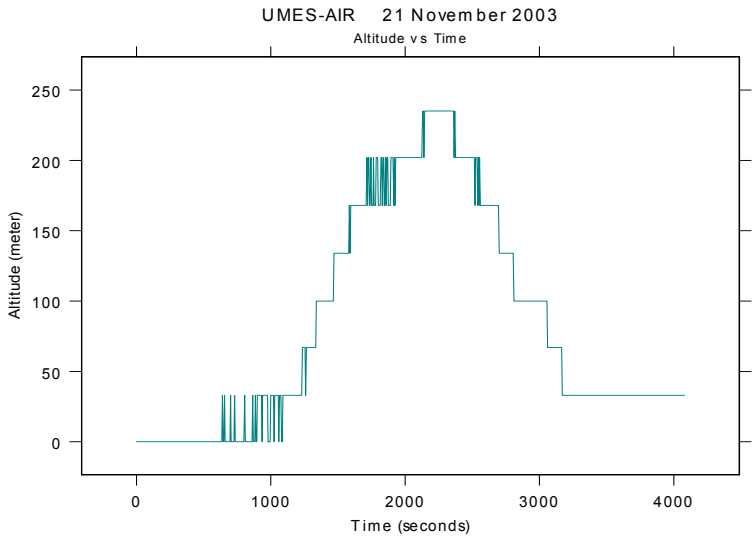


Figure: 8 – Pressure Data Logger Recording During The November 21, 2003 Blimp Launch

The result appears to be consistent with the launch activities and expected readings. The tether attached to the blimp has been marked at roughly every 30 meters or 100 ft. intervals. The launch team was instructed as has been practiced in prior launches to stop at the tether marks for couple of minutes before letting the blimp move up higher. The stair case like reading of the pressure (calibrated to height) reflects this fact both during ascent upto around 240-250 meters (800-850 ft.) and then back down. Although the tether on the winch would allow going upto 2500 ft. care was taken stay within the range of the transmission distance of the 2.4 GHz. Audio-Video transmitter on-board the new gondola.

Figures 9 and 10 are the readings of the temperature sensor and the humidity sensors reading during the launch.

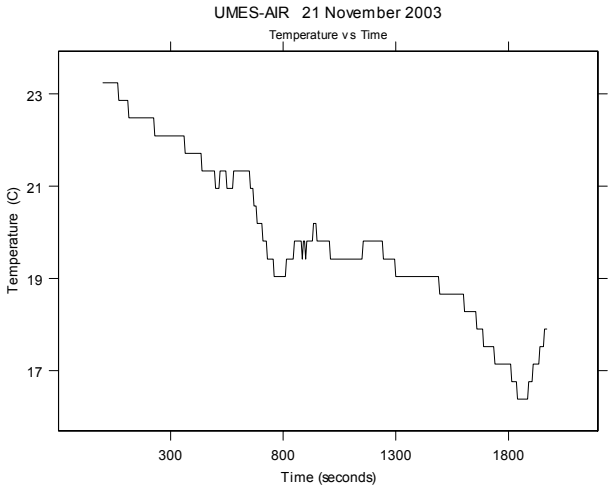


Figure 9: Temperature Vs. Time (Nov 21, 2003)

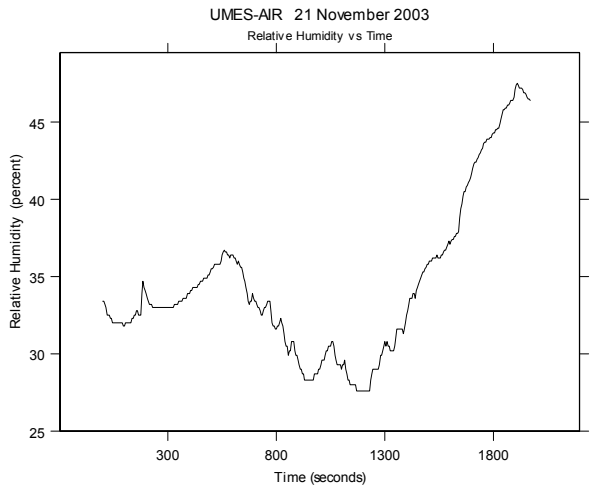


Figure 10 : Relative Humidity Vs. Time (Nov 21, 2003)

The launch was conducted late afternoon into early evening, gradual descent of the temperature with time indicates how the atmospheric temperature decreased with the fading sunlight.

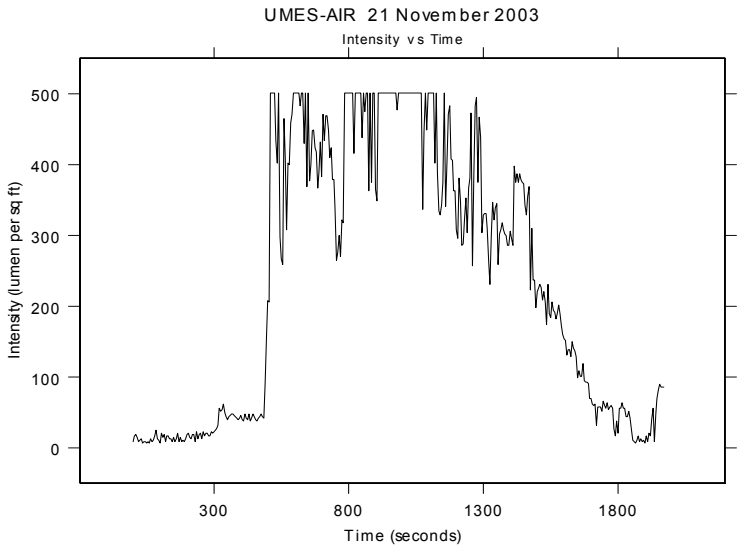


Figure 11: Light Intensity vs. Time (November 21, 2003)

The light intensity graph (Figure 11) demonstrates the clarity of the sky and the emergence of the gondola from the relative shadows on the ground to bright sunshine while the blimp was climbing. The light sensor is saturated soon after launch. When the descent began, the available light declined with the setting sun as indicated in Figure 11.

The accuracies of several of the sensors integrated with the loggers, as provided by the vendor [4] are: ±0.7°C for temperature, ± 5% for relative humidity, ± 20% for light intensity, and ±0.15 kPa for pressure.

Throughout the launch the images were transmitted to the ground station and recorded on a VCR unit for further analysis. As expected the acquired images were much steadier compared to the recordings that were done using the old gondola.

Integration of Image Analysis Effort with Introduction to MATLAB Course

The primary author offers a course titled Introduction to MATLAB (ENME 271) at UMES. The course is open to Engineering and Mathematics & Computer Science majors at UMES. The course focuses on fundamentals of linear algebra, programming and fundamentals of the basic MATLAB software. The students are required to perform project work in the course using the MATLAB –Image Processing Toolbox [7]. In an effort to integrate some classroom activities with the largely out of classroom experience of UMESAIR project, the digitized frames of the captured aerial images during the blimp launch were analyzed by the ENME 271 students using the Image Processing Toolbox of MATLAB as their course project. The students developed their own MATLAB code with appropriate guidance from the instructor (primary author) to obtain information regarding land use patterns from the images. This gave the students insight into how the Multispec and ERDAS software [8] used for image analysis efforts for the UMESAIR project worked, besides providing a third software environment for image analysis efforts related to project.

Figure 11: A Digitized Frame From Nov 21, 2003 Launch

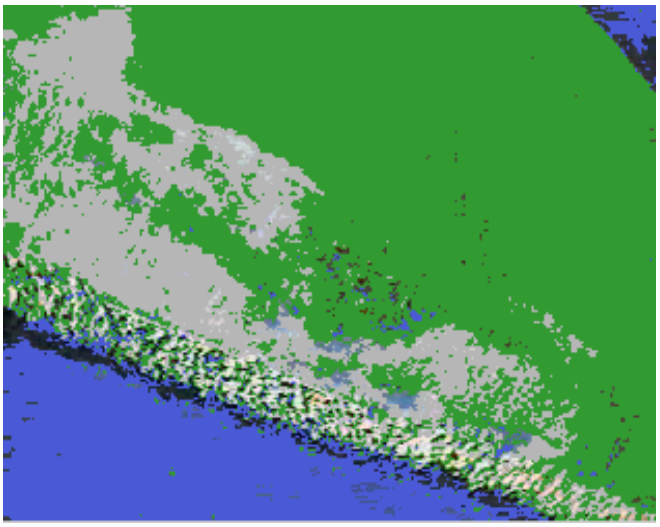


Figure 12 : Pseudo-Color Image After MATLAB Analysis

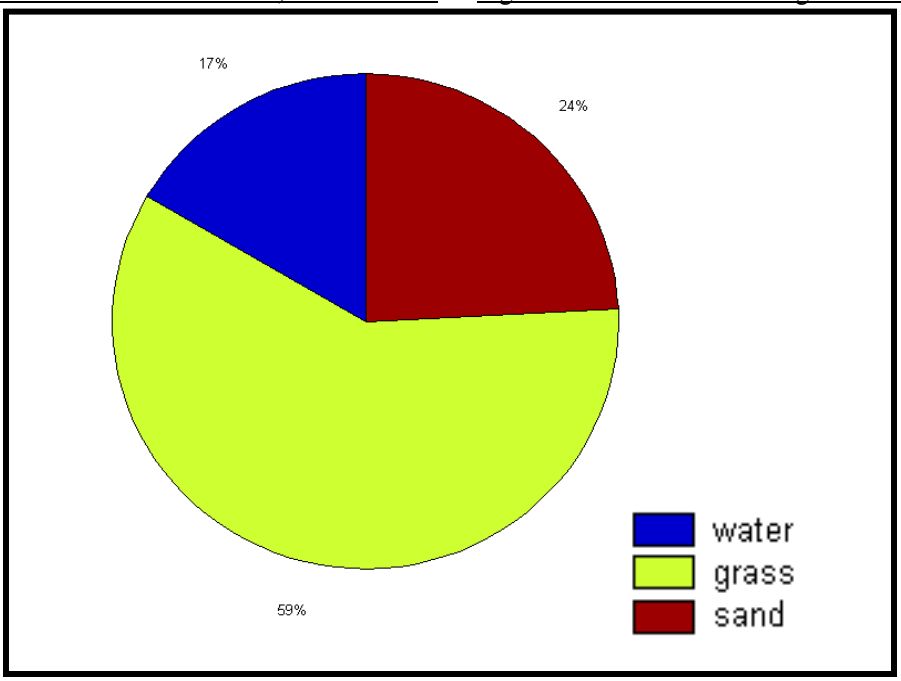


Figure 13: Land Use Pattern Results Of MATLAB Analysis Of The Image In Figure 10.

Thus Goal (vi) of Phase-II discussed above was accomplished during the Introduction to MATLAB course offered in the spring and fall semesters of 2003 academic year. Figure 11 shows a digitized frame from one of the aerial recordings of the blimp camera from the November 21, 2003 launch. The students analyzed how much of the image was occupied by grass, sand and water. During the analysis the RGB images were scanned by appropriate programming and as each pixel with a preset criterion for identification was reached a false color was assigned to the location to generate a pseudo-color image as shown in Figure 12 which clearly distinguishes the separate regions. The number of pixels of each region was counted to generate the pie-chart representing the land use pattern generated from within MATLAB as shown in Figure 13.

In conformance with the Goal (vii) of Phase II, some of the student team members and one of the UMES faculty member who is also a co-author of this paper participated and presented a paper [9] in the ASEE Mid Atlantic Regional Conference in April 2003 at Kean University. The paper and the presentation were primarily based on November 1, 2002 blimp launch.

4. Conclusion and Acknowledgment

The UMESAIR project has continued to provide enriching learning experience for the participating students from fall semester of 1999 till date. Student transitions from Phase-I to Phase-II have been successfully encountered by way of vertical integration of student teams as well as mentoring efforts by NASA collaborators, UMES faculty and experienced student team members. University System of Maryland (USM) and NASA have provided both financial and administrative support for the project. Involved faculty and NASA engineers have utilized the opportunity to provide reinforcement of classroom instruction as well as nurturing a variety of life-skills among the students that is seldom possible in the limited scope of classroom setting.

In the event of these activities, a variety of possibilities have opened up for refining and improving activities pertaining to:

(i) refinement of atmospheric data logging capability;
(ii) outreach efforts using internet broadcasting capability;
(iii) integration of project activities with classroom instruction;
(iv) scientific research related to algal bloom, land use patterns, shore line erosion, precision farming;
(v) improved mobility of launching apparatus and ground station equipment to perform launches in remote locations.

It is hoped that the students will continue to be involved in the project and future funding will be identified for continued support of the project to achieve some of the proposed capabilities.

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