Use of NASA University Competitions as Augments to Curriculum

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Abstract - *Use of the National Aeronautics and Space Administration (NASA) themed competitions as part of a curriculum augmentation program can provide students with the tools to transition from academics to industry as seamlessly as possible. Currently, the use of the University Student Launch Initiative (USLI) Competition and the Moonbuggy Competition has given students the ability to work on real-world projects. This has the goal of design, procedure, and review process that adheres to NASA guidelines. Students are required to participate in the design process for two separate projects yearly. This consists of a lunar-based transportation system for two astronauts and the design, construction, testing, and launch of a high-powered rocket capable of one mile altitude with a scientific payload capable of collecting data. Students are also in the research phase of a university-built nano-satellite that is dedicated to research based on the effects and/or causes of climate change.*

Keywords: NASA competitions, curriculum augmentation, University Student Launch Initiative, moonbuggy, cubesat.

1 Introduction

Tuskegee University has a rich history dating back to 1941 in the aerospace field. From the beginnings of the Tuskegee Airfield training in 1941 to the creation of the Aerospace Science Engineering department in 1983, Tuskegee has been in the forefront of aerospace education. Tuskegee University is the first and currently the only Historically Black College and University with an Aerospace Engineering department.

As part of the accreditation process through Accreditation Board of Engineering and Technology (ABET) [1], the department is required to make quality enhancement plans and internal reviews. Part of the review included a renewed focus on aspects of design which is required in capstone design courses. Many sources of final projects have been used in the past, including Requests for Proposals (RFP) from the American Institute of Aeronautics and Astronautics. Technical elective courses and capstone designs are used to give students the ability to coalesce their learned skills into a final project or design.

The curriculum enhancement provided by the NASA competitions is two-fold. First, the students use all of their knowledge gained over the previous three or four years to develop a design based on requirements set forth by a vendor (NASA). Second, the students are exposed to the design and review process used by NASA, Department of Defense, and many corporate entities at which they will be eventually employed. The desire of the enhancement is to bridge the gap between academics and industry, allowing students to make the transition as seamless as possible.

NASA has provided an opportunity for schools to compete in design-oriented competitions. These competitions are run from the beginning of the Fall semester and culminate before the end of the Spring semester. This allows students to start their designs with a clean sheet at the beginning of the capstone design/technical elective series and finish before graduation. Students are required to follow all procedures set forth by NASA which mimics the design and review process currently in use within NASA.

The students are allowed to participate in one or both of the competitions as well as participate in the Cubesat program. The Cubesat program is not part of the standard curriculum but is available to students to work on regardless of academic progress. This paper details some of the aspects of the students' designs and progress. At present there are approximately twenty students participating in one or both of the programs sponsored by NASA. The team leaders are Christopher Coleman, a senior in Aerospace Science Engineering and Raquel Faulkner, a senior in Aerospace Science Engineering. They are supervising the proposal writing, budget analysis, marketing program, detailed trade study and literature review, and any interaction with industry as needed. Bruce Heath, an instructor in the department is also involved with the students by assisting in the web development for each program, web conferencing, and proposal writing.

Currently, there are several visits by the alumni association that provide mentorship to the students. These mentorship visits put the alumni and students in the same room and allow them to work problems associated to the project. This gives students the insight as to how people in the industry approach similar problems.

The curriculum will be further enhanced by the addition of several modules of instruction based on Systems Engineering. These modules were developed and presented at several NASA conferences by Dr. David Beale of Auburn University [2]. These modules were developed as part of a research grant provided under the Exploration Systems Mission Directorate (ESMD) at NASA Kennedy Space Center (KSC).

Funding for the USLI and Moonbuggy programs are provided by the Alabama Space Grant Consortium (ASGC), directed by Dr. John Gregory [3] as well as release time by the university up to 15 percent per project.

2 USLI Program

The University Student Launch Initiative (USLI) [4] program is designed to give students the ability to design, test, and launch a high powered rocket under the guidance of NASA, Tripoli Rocketry Association (TRA) [5], and National Association of Rocketry (NAR) [6]. These entities provide guidelines to the students in regards to design methodology, safety requirements, report preparation and presentation, and procedural aspects required in many agencies.

The USLI program was used during the 2008-2009 academic year as part of the Missile Design and Analysis course, AENG 493. This was a technical elective designed to give students the background in aerodynamics, stability, propulsion, and payload preparation of small rockets and missiles. The students designed and built a rocket of 4.0 inches in diameter, 110 inches in length, and capable of flight over 7,000 feet above ground level. Drawings of the initial and final rocket design configurations are shown in Figs.1 and 2. The rocket's predicted altitude, velocity, acceleration, and weight loss are plotted in Figs. 3-6.

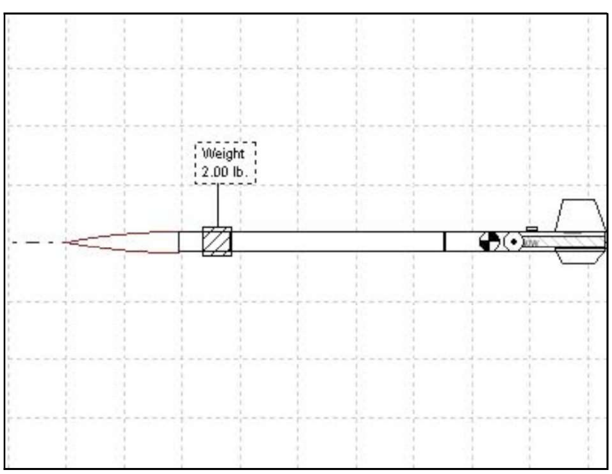

Figure 1. Overall initial configuration of 2008-09 rocket.

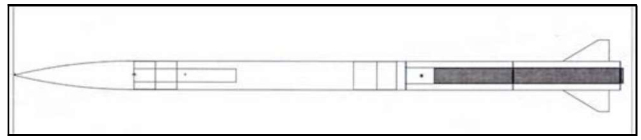

Figure 2. Final configuration of 2008-09 rocket (fin redesign).

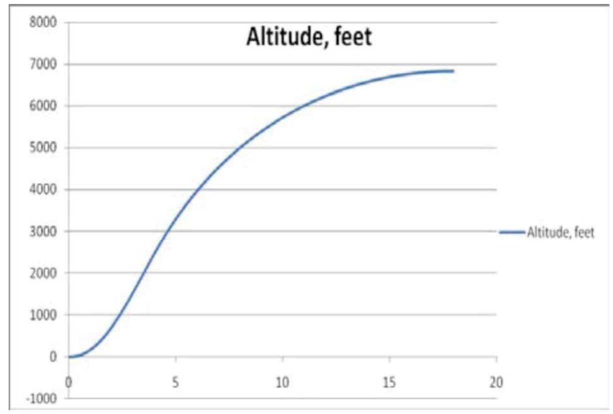

Figure 3. Predicted altitude of 2008-09 rocket versus time in seconds.

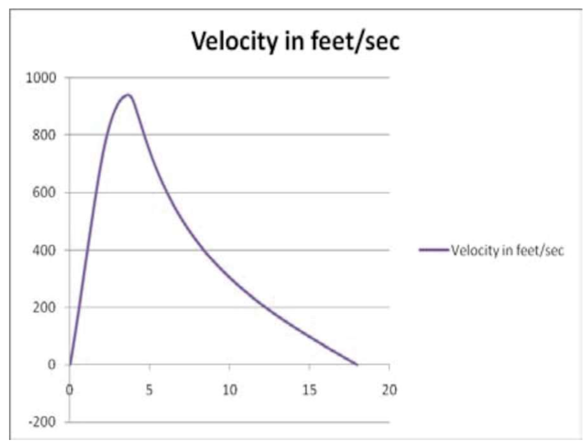

Figure 4. Predicted velocity of 2008-09 rocket versus time in seconds.

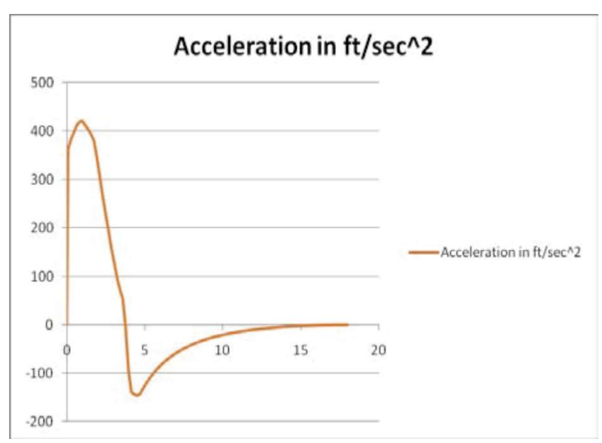

Figure 5. Predicted acceleration of 2008-09 rocket versus time in seconds.

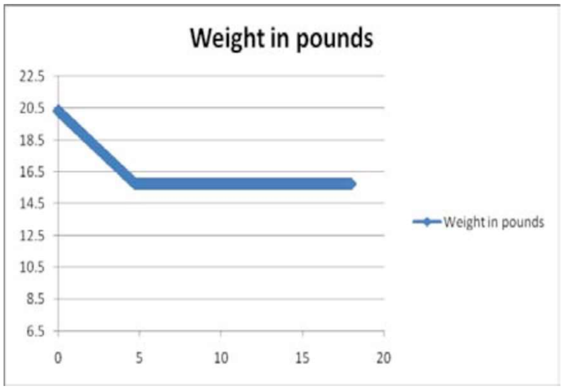

Figure 6. Predicted weight loss of 2008-09 rocket versus time in seconds.

The payload (see Table 1) consisted of two modules, a digital temperature data logger and humidity/dew point data logger. The flight profile was monitored, collected, and transmitted via an ARTS2 altimeter and TX-900G 900MHz wireless transmitter. The ground location, wind drift, and final position were monitored by an on-board Garmin GPS module. Changes were made to the fin design as the initial sizing and shape of the fins made the rocket overly stable and would cause "weathervane" effects during ascent. The initial stability margin was over 5.0 calibers but was reduced to 1.6 calibers for the final configuration.

Table 1. Scientific and Communication Payload of 2008-09 Rocket.

Item	Function
EL-USB-2-LCD	Humidity, Temperature and Dew Point Data Logger
EL-USB-CO	Carbon Monoxide Data Logger
MiniAlt/WD	Dual Logging Event Altimeter
ARTS TX-900G	Altitude, GPS and Wind Speed Telemetry Transmitter
Standard Alkaline 9V battery	Altimeter Power Supply

Initial flight was made in early April 2009 but the vehicle was lost. Failure analysis was minimal due to the rocket not being found, but the students were able to formulate several possibilities. These possibilities included premature detonation of separation charges for the drogue parachute, main parachute charge initiation before drogue parachute deployment, main parachute deployment at apogee, or failure of all separation charges causing the rocket to return on a ballistic trajectory. Initial sizing of the motor was given a higher total impulse than needed by simulation due to the simulation program providing best-case numbers. Usually, the actual altitude tends to be 10% lower than predicted.

The students prepared a detailed failure probability based on those assumptions. Those reports were submitted to NASA as part of the Post Flight Review process. The failure modes are listed below in Table 2. The students prepared a detailed failure probability based on those assumptions. Those reports were submitted to NASA as part of the Post Flight Review process.

Table 2. Possible Failure Modes at Launch and Remedy.

Failure Mode	Remedy
Vehicle instability	Vehicle going off-nominal flight path. There is no destruct mechanism for the vehicle, therefore, there is no possible way to destroy the vehicle before impact. Stability must be maintained through proper design.
Parachute failure to deploy	Spotters will maintain visual sighting of vehicle during ascent, apogee, and descent. Verification of vehicle location will be maintained at all times. If vehicle does not deploy parachutes, the safety officers will notify the participants immediately of parachute failure and give location of vehicle descent location. The ascent phase of the vehicle will be such that the vehicle moves away from any participants and all participants will be at a sufficient distance to avoid injury.
Motor failure	If the motor fails to ignite, on-site procedures will be followed regarding the Fail-to-fire. Personnel will approach only after a sufficient time has elapsed to verify that the motor is not "cooking off" and does not fire unexpectedly. A backup engine will be available for flight.

Responding to the USLI Request for Proposals, the students are conducting literature reviews and trade studies to narrow the design for the 2009-2010 year. The students are proposing a design that uses a launch vehicle and separate remotely operated vehicle (ROV). This vehicle would descend under a separate parachute system and would move under radio remote control. The vehicle would contain the scientific payload including a video camera, temperature and other atmospheric sensors, as well as telemetry systems designed to transmit position and wind drift during descent. The current rocket design and flight profile for the 2008-2009 competition is shown in Figs.7 and 8, respectively.

The launch vehicle would be a six-inch diameter fuselage of approximately 100 inches in length. The motor would be a NAR-rated Loki Research K-250 Moon Burner with tracking smoke motor capable of 1700 N-s over a 7 second burn. This would produce approximately 250 pounds of thrust at a relatively constant rate over the burn time (see Table 3 and Fig. 9). The students will use a variety of tools to calculate the needed parameters, including Rocksim™, Unigraphix™ with Nastran™, Matlab™, and other mathematical analysis and design tools.

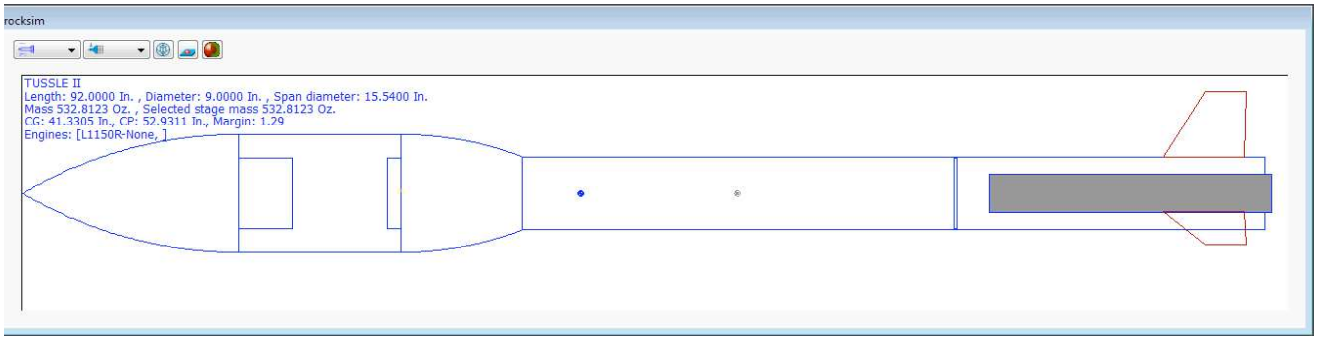

Figure 7. Current design for 2009-10 USLI Competition.

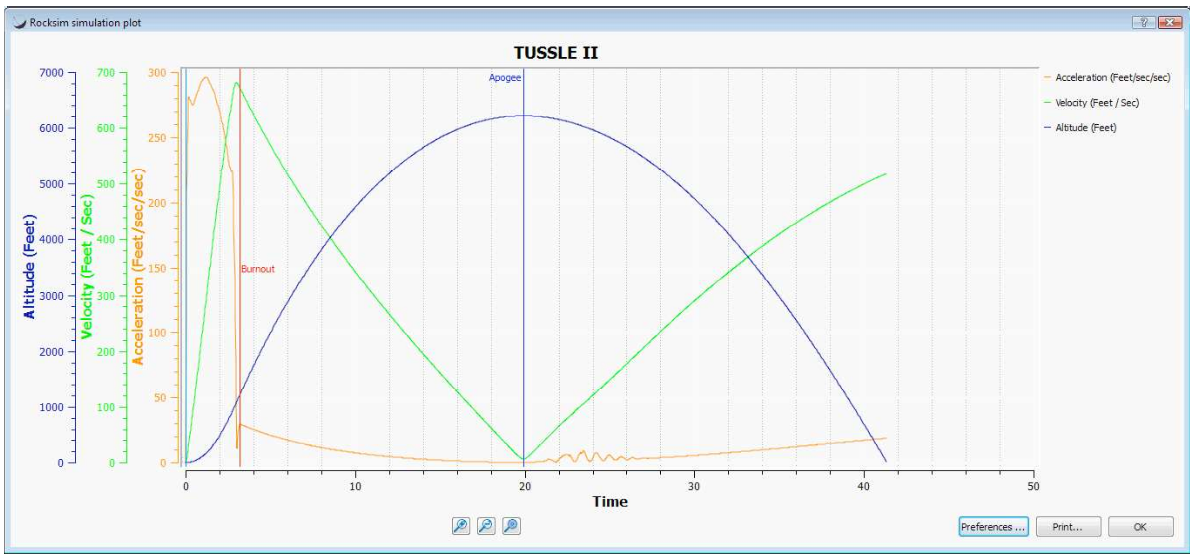

Figure 8. Flight profile for 2009-10 Rocket.

Table 3. Motor certification – Tripoli Rocketry Association [5].

Motor Manufacture	AeroTech	Test Date	27 May 2001
Motor Designation	K250W-P	Samples per Second	400
TMT Metric Designation	K286 (94% K)	Burn Time	9.27 seconds
Metric Dimensions	54 mm x 673 mm	Total Impulse	2484 NS
Propellant Weight	1543 grams	Maximum Thrust	545.8 N.
Nozzle Throat Diameter	0.21"	Average Thrust	286.23 N
Certified Until	30 June 06	Specific Impulse	164

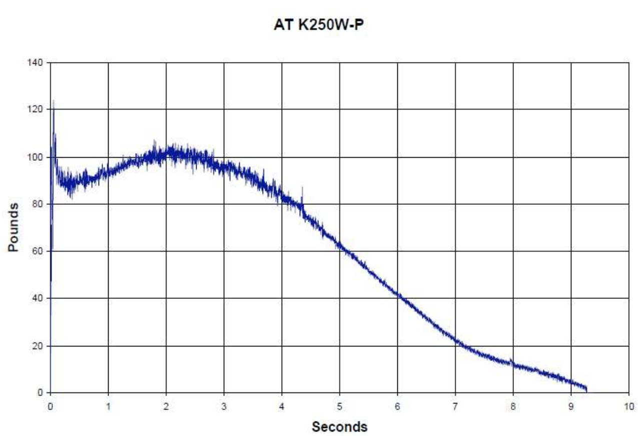

Figure 9. Thrust curve certification for K-250 motor [5].

The students will need to calculate the material properties of the rocket body through tension/compression machines, fin flexure, flow visualization over the nose section using a Particle Image Velocimetry laser/camera, and motor burn data in the rocket test stand.

Students are required to prepare several reviews and present via web-conference. The students will present these reviews to members of NASA, Tuskegee Aerospace Alumni Association, and members of industry. These will give students the opportunity to receive feedback from those who currently work in positions parallel to the program. The students present these reviews to NASA employees based at Marshall Space Flight Center (MFSC), which is responsible for the competition.

3 Moonbuggy Program

The development of the Moonbuggy program is in response to another competition sponsored by NASA Marshall Space Flight Center. This calls for a vehicle that is capable of being stored in a 4ft x 4ft x 4ft container, be assembled by two persons, one male and one female, and transport those two persons around a specified rough terrain course. The vehicle must be human powered and be carried by the two persons from the container to the start of the road course. This challenge and competition has more of a mechanical engineering focus, but it allows the Aerospace Science Engineering students to design, build, and test a vehicle that must remain rigid, is collapsible, and of minimum weight with sufficient efficiency to negotiate an obstacle course.

At this point, the students have begun the initial trade studies and literature reviews necessary to develop a novel design. Students will select the material, gearing apparatus, and any shock attenuation devices needed for crew comfort and stability of the vehicle. Two separate designs are being investigated. One design is a standard four-wheel design similar to an automobile. The other design is a two-wheeled design that will place the occupants/astronauts side by side with geared wheels on the outside. This will create the need for a gyroscopic system to balance the crew module while the wheels are turning and negotiating the obstacle course. Currently, gyroscopic designs are in development but a second possibility for vehicle pitch stability is a small wheel moved forward or aft of the crew seats.

4 Cubesat Program

The Cubesat program is an open-ended project that is not defined by certain time constraints. This project is developed in conjunction with California Polytechnic State University, San Luis Obispo (Cal-Poly), and Stanford University's Space Systems Development Lab and the efforts of Dr. Robert Twiggs. The students are working on the development of a scientific payload that would measure the incoming radiation and reflected radiation. This measurement would provide a baseline for the radiation being reflected off/out of the atmosphere. By using this baseline the students will make calculations to determine the percentage of radiation being absorbed by the atmosphere and establish trend lines as to increases or decreases in absorbed radiation.

The structure of the Cubesat will be a Commercial-Off-The-Shelf (COTS) package [7] from Pumpkin, Inc. that allows students to focus on the scientific aspects of the build as opposed to the structural portion. This will ensure integration with the launch vehicle and component compatibility. Power supply, regenerative power capability, communications, and payload specific tasks and issues will be addressed by the students as they arise. Students will be required to go though many different processes that mirror real-world experience as well as participate in valuable scientific research.

Integration of the Cubesat will be handled by Cal-Poly as part of the agreement with the launch providers [8]. Cal-Poly supplies the specifications for the structure and the deployment vehicle. Proper integration is needed because of the high cost of launch and construction. Many other universities and corporate entities are involved in each launch. Failure of an individual Cubesat could potentially affect future deployment of many other Cubesats and cause a loss of Cubesat usage. To ensure proper specifications are met, an approved source for the structure will be used.

This project is currently not funded but is scheduled to be funded through the Alabama Space Grant Consortium. The students will also have the opportunity to contact corporate sponsors, present the work and designs, and engage in fundraising. As said before, this project is an ongoing venture and will persist through successive classes of students.

5 Conclusions

Students will have the ability to use skills and theory developed in undergraduate courses throughout their matriculation. This will culminate in a project that is sponsored by NASA or other agency and will have real-world application. The students will also have the ability to prepare reports and presentations based on supplied criteria, submit those presentations to the vendor, and get feedback through the responses of the vendor and results of testing and flights.

Curriculum enhancement will be defined by the knowledge gained by the students on specific areas. Those areas include topics not normally covered in the required curriculum but are subject to technical elective areas or capstone design research.

Acknowledgment

The author acknowledges contributions from the following persons affiliated with the Tuskegee University Department of Aerospace Science Engineering and involved in research/activities discussed here: Mr. Bruce Heath, Instructor; Dr. Vascar Harris, Department Head; Ms. Raquel Faulkner, Student–Senior; and Christopher Coleman, Student–Senior.

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