GREEN ROCKETRY

2011-12

NASA

University Student Launch Initiative

Tuskegee University

Critical Design Review

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School Information

Team Summary	
School	Tuskegee University
Location	Tuskegee, Alabama
Team Official	Dr. Vascar G. Harris, Aerospace Science Engineering
Safety Officer	Troy Cole

Team Members			
Name	Team Role	Major	Classification
Troy	Team Lead	Aerospace Engineering	Senior
Devin	Assistant Lead	Aerospace Engineering	Freshman
Eldon	Structures Group Lead	Materials Science & Engineering	Doctoral Student
Craig	Payload Group Lead	Aerospace Engineering	Junior
Keith	Aerodynamics Lead	Aerospace Engineering	Freshman
Tungie	Recovery Group Lead	Aerospace Engineering	Freshman
Tiffany	Propulsion Group Lead	Aerospace Engineering	Freshman
Chris Short	NAR/TRA Mentor	SEARS-572	- Prefect, SEARS 573 TRA

Team Lead: Troy is a senior in Aerospace Science Engineering. He currently has a 4.0 GPA, was selected for the Eminent Scholarship Award from Tuskegee University recently. He spent this summer as an intern at Aerojet in California.

NAR/TRA Section: the team is associating with for launch assistance, mentoring, and reviewing.- Chris Short and John Hansel, launches are at Samson, AL.

Facilities/Equipment

The facilities we plan to use for the design, manufacture, and test of the rocket components, the rocket, and the science payload, include the Department of Aerospace Science Engineering Flight Vehicle Design Laboratory (Computer Lab), and Propulsion Laboratory, as well as the South East Alabama Rocket Society (www.sears572.com) launch site in Samson, AL. for test launches. The Flight Vehicle Design Laboratory is open 24/7. The Department of Aerospace Engineering Propulsion Laboratory is open Monday- Saturday 5 A.M.-5 P.M.

The Department of Aerospace Science Engineering requires at least one faculty member present during all fabrication processes and tests. Those faculty members are Eldon Triggs and Bruce Heath.

Facilities Used for Equipment and Supplies –Propulsion Laboratory, Materials Fabrication Laboratory

- Press- 12"x12" 8- ton Press for making flat composite pieces
- Composite Layup Laboratory – VARTM, Autoclave, heated press
- Mandrels- 2"-6" to fabricate motor mounts, body tube, and coupler sections
- Water/Wind Tunnels-for testing Models
- Rocket Test Stand- validate thrust curve of motors
- Mandrel Stand/Sanding Fixture- final sanding of body tube
- CNC Router/Mill- For cutting any flat plate, and engraving flat pieces
- Paint Booth- For painting parts and Mixing resins

Facility used for Teleconferences, modeling, and administrative tasks- Flight Vehicle Design Laboratory

- Teleconferences/Presentations
- Rocksim Simulations
- Drawings, Reports, and Meetings

Computer Equipment

The Department of Aerospace Engineering Flight Vehicle Design Lab has a number of computers that have Microsoft Office and Internet Explorer capabilities. The computers also have MATLAB, ROCKSIM, UNIGRAPHICS NX-5, and SIMULINK. The Team's Website will be located on the University website www.tuskegee.edu, and we will utilize Facebook to provide updates on Outreach initiatives, scheduled launches, presentations, and other important dates and events.

The equipment that will be used for the WebEx Video Teleconferencing will be a monitor, and desktop computer with Windows XP computer system. We will utilize a Logitech webcam C200 for teleconferences. We will have a Broadband internet connection and speakerphone capabilities in close proximity to the computer. Person to contact in case of WebEx/connectivity issues: Mr. Bruce Heath, 334-727-4247

Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194)

39.201 Scope of subpart.

(a) This subpart implements Section 508 of the Rehabilitation Act of 1973 (29 U.S.C. 794d), and the Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194).

(b) Further information on Section 508 is available via the Internet at http://www.section508.gov.

(c) When acquiring EIT, agencies must ensure that—

(1) Federal employees with disabilities have access to and use of information and data that is comparable to the access and use by Federal employees who are not individuals with disabilities; and

(2) Members of the public with disabilities seeking information or services from an agency have access to and use of information and data that is comparable to the access to and use of information and data by members of the public who are not individuals with disabilities.

39.202 Definition.

Undue burden, as used in this subpart, means a significant difficulty or expense.

39.203 Applicability.

(a) Unless an exception at 39.204 applies, acquisitions of EIT supplies and services must meet the applicable accessibility standards at 36 CFR Part 1194.

(b)(1) Exception determinations are required prior to contract award, except for indefinite-quantity contracts (see paragraph (b)(2) of this section).

(2) Exception determinations are not required prior to award of indefinite-quantity contracts, except for requirements that are to be satisfied by initial award. Contracting offices that award indefinite-quantity contracts must indicate to requiring and ordering activities which supplies and services the contractor indicates as compliant, and show where full details of compliance can be found (*e.g.*, vendor's or other exact website location).

(3) Requiring and ordering activities must ensure supplies or services meet the applicable accessibility standards at 36 CFR Part 1194, unless an exception applies, at the time of issuance of task or delivery orders. Accordingly, indefinite-quantity contracts may include noncompliant items; however, any task or delivery order issued for noncompliant items must meet an applicable exception.

(c)(1) When acquiring commercial items, an agency must comply with those accessibility standards that can be met with supplies or services that are available in the commercial marketplace in time to meet the agency's delivery requirements.

(2) The requiring official must document in writing the non-availability, including a description of market research performed and which standards cannot be met, and provide documentation to the contracting officer for inclusion in the contract file.

39.204 Exceptions.

The requirements in 39.203 do not apply to EIT that—

(a) Is purchased in accordance with Subpart 13.2 (micro-purchases) prior to April 1, 2005. However, for micro-purchases, contracting officers and other individuals designated in accordance with 1.603-3 are strongly encouraged to comply with the applicable accessibility standards to the maximum extent practicable;

(b) Is for a national security system;

(c) Is acquired by a contractor incidental to a contract;

(d) Is located in spaces frequented only by service personnel for maintenance, repair or occasional monitoring of equipment; or

(e) Would impose an undue burden on the agency.

(1) *Basis*. In determining whether compliance with all or part of the applicable accessibility standards in 36 CFR Part 1194 would be an undue burden, an agency must consider—

(i) The difficulty or expense of compliance; and

(ii) Agency resources available to its program or component for which the supply or service is being acquired.

(2) Documentation.

(i) The requiring official must document in writing the basis for an undue burden decision and provide the documentation to the contracting officer for inclusion in the contract file.

(ii) When acquiring commercial items, an undue burden determination is not required to address individual standards that cannot be met with supplies or service available in the commercial marketplace in time to meet the agency delivery requirements (see 39.203(c)(2) regarding documentation of non-availability).

Technical Standards

1194.21 Software applications and operating systems.

(a) When software is designed to run on a system that has a keyboard, product functions shall be executable from a keyboard where the function itself or the result of performing a function can be discerned textually.

(b) Applications shall not disrupt or disable activated features of other products that are identified as accessibility features, where those features are developed and documented according to industry standards. Applications also shall not disrupt or disable activated features of any operating system that are identified as accessibility features where the application programming interface for those accessibility features has been documented by the manufacturer of the operating system and is available to the product developer.

(c) A well-defined on-screen indication of the current focus shall be provided that moves among interactive interface elements as the input focus changes. The focus shall be programmatically exposed so that assistive technology can track focus and focus changes.

(d) Sufficient information about a user interface element including the identity, operation and state of the element shall be available to assistive technology. When an image represents a program element, the information conveyed by the image must also be available in text.

(e) When bitmap images are used to identify controls, status indicators, or other programmatic elements, the meaning assigned to those images shall be consistent throughout an application's performance.

(f) Textual information shall be provided through operating system functions for displaying text. The minimum information that shall be made available is text content, text input caret location, and text attributes.

(g) Applications shall not override user selected contrast and color selections and other individual display attributes.

(h) When animation is displayed, the information shall be displayable in at least one non-animated presentation mode at the option of the user.

(i) Color coding shall not be used as the only means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.

(j) When a product permits a user to adjust color and contrast settings, a variety of color selections capable of producing a range of contrast levels shall be provided.

(k) Software shall not use flashing or blinking text, objects, or other elements having a flash or blink frequency greater than 2 Hz and lower than 55 Hz.

(l) When electronic forms are used, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.

1194.22 Web-based intranet and internet information and applications.

(a) A text equivalent for every non-text element shall be provided (e.g., via "alt", "longdesc", or in element content).

(b) Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation.

(c) Web pages shall be designed so that all information conveyed with color is also available without color, for example from context or markup.

(d) Documents shall be organized so they are readable without requiring an associated style sheet.

(e) Redundant text links shall be provided for each active region of a server-side image map.

(f) Client-side image maps shall be provided instead of server-side image maps except where the regions cannot be defined with an available geometric shape.

(g) Row and column headers shall be identified for data tables.

(h) Markup shall be used to associate data cells and header cells for data tables that have two or more logical levels of row or column headers.

(i) Frames shall be titled with text that facilitates frame identification and navigation.

(j) Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz.

(k) A text-only page, with equivalent information or functionality, shall be provided to make a web site comply with the provisions of this part, when compliance cannot be accomplished in any other way. The content of the text-only page shall be updated whenever the primary page changes.

(l) When pages utilize scripting languages to display content, or to create interface elements, the information provided by the script shall be identified with functional text that can be read by assistive technology.

(m) When a web page requires that an applet, plug-in or other application be present on the client system to interpret page content, the page must provide a link to a plug-in or applet that complies with §1194.21(a) through (l).

(n) When electronic forms are designed to be completed on-line, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.

(o) A method shall be provided that permits users to skip repetitive navigation links.

(p) When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required.

1194.26 Desktop and portable computers.

(a) All mechanically operated controls and keys shall comply with §1194.23 (k) (1) through (4).

(b) If a product utilizes touch screens or touch-operated controls, an input method shall be provided that complies with §1194.23 (k) (1) through (4).

(c) When biometric forms of user identification or control are used, an alternative form of identification or activation, which does not require the user to possess particular biological characteristics, shall also be provided.

(d) Where provided, at least one of each type of expansion slots, ports and connectors shall comply with publicly available industry standards.

Safety

The designated NAR/TRA mentor for our USLI Team is Chris Short. The Level 3 (TRA) certification, faculty ID, and Alabama Driver's License is included in the appendix. This person MUST accompany the USLI Team to the Launch in April.

The following section is the Lab and Site Safety Guidelines as established by the Aerospace Science Engineering Department on March 29, 2010.

Aerospace Science Engineering

Lab Safety and Travel Protocol

Implementation: 3-29-2010

Each student participating in laboratory activities, off-campus Tuskegee University-sponsored activities, and non-TU sponsored activities will read this, sign and initial the signature page at the back of this list, and will be given a copy to keep in their records. This must happen BEFORE any student will be allowed to use lab facilities or be permitted to travel to events.

1. In Lab procedures – All persons using the facilities/lab must adhere to the following policies:
   a. Safety Attire
      i. Safety eyeglasses/protective eyewear: Must be worn when any machining, cutting, or use of chemicals is underway.
      ii. Hearing protection: Must be worn when machining or cutting by means of power tools.
      iii. Protective garments: Must be worn when using chemicals such as epoxy resin or fiberglass, or when machining such materials. This includes lab coats and gloves.
      iv. Breathing apparatus: Dust masks must be worn when using machining or using epoxy resin. The mask must be rated for the type of activity, i.e. dusk mask when machining MDF boards.
      v. Loose clothing will not be permitted around cutting equipment to prevent injuries.

   b. Use of band saws, circular saws, and drill presses will be monitored by a faculty member in ALL circumstances, no unsupervised use will be allowed.

   c. Chemical handling:
      i. All chemicals will be handled using the procedures above and will be disposed of in a proper manner. No dumping of epoxy resin or other volatile chemicals down any drain in the building.
      ii. Excess material will be left in the disposable container, filled with proper filler material, and disposed of in the red hazmat container.
      iii. If unsure of proper handling of chemicals, refer to the MSDS sheets posted on the wall. If one is not available, contact faculty to obtain a copy of the appropriate MSDS sheet.

d. Heating equipment. Any equipment used for heating will be used in a manner that prevents overheating of surrounding material or burning users. Any heating equipment will be monitored at ALL times when used. This includes heat guns, heat lamps, or electric stoves.

e. Dust mitigation/disposal
   i. Use of the CNC router on any material will create dust. This dust must be collected by use of the supplied Shop-Vac. When the Shop-Vac is full, it must be emptied into the approved container and a dust mask will be worn by person dumping.
   ii. Use of any cutting item in the Models Fabrication Lab will require the use of the shop dust collector. Make sure the dust collection machine is turned on BEFORE using the cutting equipment.

2. Travel

a. <u>Travel Documentation:</u> During travel to and from competitions, test flights, etc., it will be mandatory that the names of all individuals involved in the trip be given in list form to the accompanying faculty member seven (7) working days prior to the travel event. A travel document will be prepared to ensure all students, faculty involved in the travel will be covered on TU insurance, and that the university is notified of such travel. Each vehicle traveling to the destination will have a copy of the travel document, which will remain in the possession of the driver of the vehicle. Copies of registration with the TU police department, valid parking permit, DMV vehicle registration, and insurance must be on file with the Aerospace Science Engineering office BEFORE travel.

b. <u>Travel Safety:</u> Depending on type of travel, students may travel unaccompanied by faculty, but must maintain proper safety practices. This includes no alcohol consumption during travel, maintain proper speed limits and wear seat belts at ALL times.

   i. The person(s) who operate the vehicle will have sufficient rest before travel to prevent accidents. This will be a minimum of six (6) hours the night before travel with a recommendation of no less than eight (8) hours.

   ii. No student may consume alcohol or permanently depart from the vehicle during the trip, such as leaving to ride with a different person. For students and faculty, no driver may operate the vehicle if alcohol has been consumed within eight (8) hours of travel.

   iii. If a student begins a trip in a university-supplied vehicle, that student will finish the round-trip in the same vehicle. Do not depart the travel accommodations without proper authorization by the attending faculty member. If a student is to stay overnight at a place other than the reserved accommodations, the faculty member must be notified and provided the address/contact information for that location.

c. <u>Travel with HAZMAT:</u> Traveling with rocket motors/separation charges. The motors will be encased in the proper container and labeled as such. The separation charges will be placed in the appropriate static-electricity –free container and the e-match ends will be wrapped appropriately to ensure no chance of accidental ignition. Any hazardous material will be properly stored and transported according to DOT regulations.

d. <u>Travel behavior:</u> Most importantly, as you travel to and from your activity and while you participate in the activity, you are regarded as ambassadors of Tuskegee University and will act accordingly. **<u>Your behavior will reflect on Tuskegee University and proper etiquette, attire, and actions will be followed at all times.</u>** Failure to do so may result in a student(s) removal from the activity, barring from future events, and in extreme incidents involve academic actions upon return to Tuskegee University.

3. On-site safety.
    a. Each person traveling to the launch sites MUST have read the rules and regulations provided by Tripoli Rocket Association, NASA, the on-site Range Safety Officer (RSO), or other safety officer depending on the type of event. A copy of those rules and regulations will be given to each student. The student will then sign the appropriate form acknowledging that he or she has read, understand, and agree to fully comply with the regulations presented.

    b. Only persons performing assembly, testing, or preparations will be in the rocket vicinity. Spectators are encouraged, but will be restricted to the area designated for spectators or more than 50 feet from the preparation facility/table.

    c. No horseplay will be permitted. Each student participating in activities is a representative of Tuskegee University and will act accordingly. Professional attitudes and actions will be expected during all interactions with persons outside the university.

    d. No alcohol will be permitted on site, and no student will participate after consuming alcohol in the previous 12 hours. Zero alcohol means zero blood alcohol content. Period. As stated above, each student is a representative of Tuskegee University and will act as such.

    e. If at any time the RSO requests that students perform a task or action, those students will do so. Failure to do so will be grounds for the student(s) to be asked to leave the launch site and potential barring from future activities.

    f. Handling of explosive charges: Students will wear protective eyewear and gloves when handling charges. Altimeters may be switched on to check continuity but must be turned OFF when reassembling the rocket. Switches must be accessible from the outside of the rocket and will not be turned on until the rocket is in position for launch.

g. Motor assembly: Only persons certified at the appropriate level will assemble motors. Level 1 certification needed for H and I Class motors, Level 2 for J, K, or L motors, and Level 3 for anything above. Motors will be assembled by the certified person with supervision by certified faculty member.
h. ALL students are responsible for safety at all times. If at any time you feel something is unsafe, alert those around you and the appropriate faculty member or RSO if at a launch site.

This is required to be read by every student and faculty member before entering any laboratory facility or engage in off-site travel. A list with the individual signatures is maintained by the department administrative assistant, Ms. Susie Stenson.

Material Safety Data Sheets (MSDS)

See attached file for a complete printing of the applicable sheets.

FAA Federal Aviation Regulations, 14 CFR, Subchapter F, Part 101, Subpart C

See Appendix B for the printed version of Subpart C.

Risk Assessment – Pre-Launch and Launch

Risk Assessment - Pre-Launch/Launch				
Risk	**Result**	**Safety Risk**	**Likelihood**	**Prevention/Mitigation**
Separation Charge/Igniter Arming				
Detonation of separation charges at arming	Injury to ground crew and vehicle	High	Low	Ensure static charges do not build up/proper use of arming switches
Premature ignition of motor	Injury to ground crew and vehicle	High	Low	Ensure igniter is properly grounded before insertion and insert igniter just before launch
Unstable platform	Injury to ground crew and vehicle	Medium	Low	Ensure ground equipment is stable before loading vehicle on pad.
FFFFg Black Powder Charge Construction				
Accidental detonation of separation charge	Injury to ground crew and vehicle	High	Medium	Ensure proper grounding of e-match before encasing in FFFFg
Underpowered separation charges	Incomplete deployment of parachute - vehicle damage	Medium	Low	Measure FFFFg carefully and ensure no spillage
Overpowered separation charge	Excessive pressure on vehicle components - vehicle damage	Medium	Low	Measure FFFFg carefully and ensure no spillage

Risk Assessment – Recovery

Risk Assessment - Recovery				
Risk	**Result**	**Safety Risk**	**Likelihood**	**Prevention/Mitigation**
Separation Charge / FFFFG Assessment				
Failure to ignite/ detonate	Ballistic return - loss of vehicle	High	Medium	Utilize redundant altimeters with charge detonation capability
Premature detonation - in flight	Early separation of sections - catastrophic loading on vehicle	Medium	Medium	Ensure proper wiring and settings on altimeters
Ground detonation prior to launch	Injury to ground crew and vehicle	High	Low	Altimeters will not be armed until vehicle is on launch pad just prior to launch

Parachute - Drogue				
Failure to fully deploy - entangled	Lack of stabilization and increased descent velocity	Medium	High	Ensure proper packing, use of parachute bag, use of swivel on parachute/shock cord interface
Tearing or burning	Lack of stabilization and increased descent velocity	Medium	Medium	Use of parachute bag, ensure deployment at apogee
Riser line breakage	Lack of stabilization - increased descent velocity	Medium	Low	Use of parachute bag, ensure deployment at apogee

Parachute - Main				
Failure to fully deploy - entangled	Increased descent velocity - impact with ground causes significant damage to vehicle	Medium	High	Ensure proper packing, use of parachute bag, use of swivel on parachute/shock cord interface
Tearing or burning	Increased descent velocity - impact with ground - significant damage to vehicle	Medium	Medium	Use of parachute bag, ensure deployment at apogee for minimum velocity deployment
Riser line breakage	Increased descent velocity - impact with ground causes significant damage to vehicle	Medium	Low	Use of parachute bag, ensure deployment at apogee for minimum velocity deployment

Electronics				
Altimeter failure	Ballistic return - loss of vehicle	High	Low	Dual fault tolerant system with three altimeters
Wiring Failure	Ballistic return - loss of vehicle	High	Low	Dual fault tolerant system with three altimeters
Battery failure	Ballistic return - loss of vehicle	High	Low	Dual fault tolerant system with three altimeters

Technical Design

Airframe Fabrication

In the current move towards composites made from renewable sources, the construction of the airframe will be done using bio-sourced fiber and resins. The goal of the structural development is to maintain the structural rigidity and toughness found through E-glass/epoxy resin composites but have the airframe constructed of flax and jute fiber and partially renewable polyester resins. Jute and flax fibers have a strength-to-weight ratio comparable to E-glass fibers. The use of natural fibers significantly reduces the exposure to irritant/hazardous fibers during the course of manufacturing, testing, and disposal. This also allows the rocket to be "carbon-neutral" concerning the CO_2 emissions in manufacture.

Typical properties of natural fibers:

Jute

Density: 1.50 g/cm3

Mechanical Properties:

- **σ= 466-850 Mpa**
- **E = 64 GPa**
- **ε at break = 0.7 %**

Flax

Density: 1.54 g/cm3

Mechanical Properties:

- **σ= 1035 Mpa**
- **E = 27.6 GPa**
- **ε at break = 3.2 %**

Typical properties of glass fibers:

Type	Density (g/cm3)	σ - Tensile Strength (GPa)	E - Young's Modulus (GPa)
E-glass	2.54	1.7-3.5	69-72
S-glass	2.48	2.0-4.5	85
C-glass	2.48	1.7-2.8	70

Theory of Columns Calculations – Euler's Method (Long Column):

$$P_{cr} = \frac{EI\pi^2}{L^2}$$

Assuming a drag force of 1,330.0 lbf maximum, the Pcr = 1,330.0 lbf. Solving for the maximum length of airframe section with a 0.10-inch thick wall (I = 5.211 in^4):

P critical	Length
1330_lbf x 1.5 (Fac. Of Saf.)	489.17 in (max)
132,604 lbf (theoretical)	60 in (actual design)

Using these assumptions, the loading the vulnerable section of rocket airframe can handle is 132,604 lbf in direct linear force. The assumptions above do not include the inertial effects of launch and side loading from Y-direction free-stream velocity. The importance of including a coupler section long enough to stiffen the center section where the airframe joins together is of utmost importance. The issue of manufacturing also plays of significant importance in that the coupler section needs to be a snug fit with no defects along the surface. The interface between the coupler and airframe needs to be continuous and stiff. The purpose of the coupler is to prevent lateral movement of the airframe off axis relative to the thrust vector. This movement will induce an oscillation, which will eventually destroy the airframe as has been seen previously. Extreme caution has been taken to ensure proper manufacturing and fitting of the coupler section between the upper section containing the science package and main parachute and the motor section.

Rocksim 9 Simulation Results (final)

Engine selection

[L930-LM-None]

Simulation control parameters

Flight resolution: 800.000000 samples/second
Descent resolution: 1.000000 samples/second
Method: Explicit Euler
End the simulation when the rocket reaches the ground.

Launch conditions

Altitude: 600.00000 Ft
Relative humidity: 50.000 %
Temperature: 80.000 Deg. F
Pressure: 0.00 Mi
Wind speed model: Slightly breezy (8-14 MPH)
Low wind speed: 8.0000 MPH
High wind speed: 14.9000 MPH
Wind turbulence: Some variability (0.04)
Frequency: 0.040000 rad/second
Wind starts at altitude: 0.00000 Ft.
Launch guide angle: 0.000 Deg.
Latitude: 34.730 Degrees

Launch guide data:

Launch guide length: 84.0000 In.
Velocity at launch guide departure: 47.1284 ft/s
The launch guide was cleared at : 0.309 Seconds
User specified minimum velocity for stable flight: 43.9993 ft/s
Minimum velocity for stable flight reached at: 73.0666 In.

Max data values:

Maximum acceleration: Magnitude: 10.128 gee
Maximum velocity: Magnitude: 583.8847 ft/s
Maximum range from launch site: 1396.44878 Ft.
Maximum altitude: 5281.57639 Ft.

Recovery system data

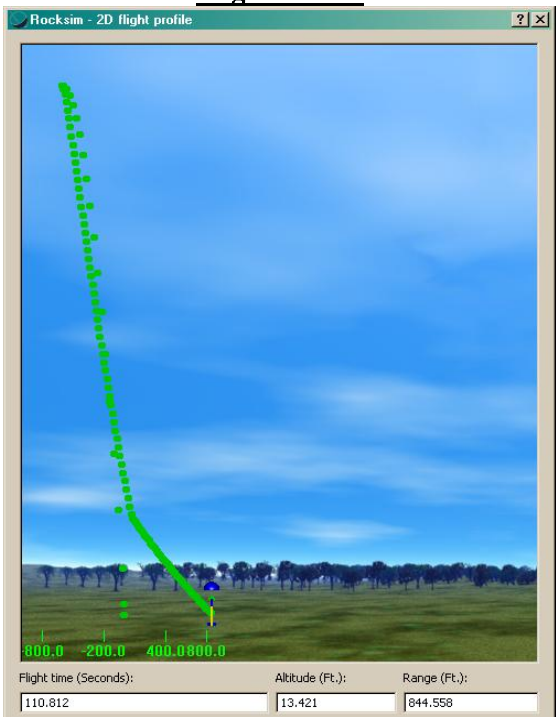
P: Parachute - Drogue Deployed at: 19.213 Seconds
Velocity at deployment: 83.1812 ft/s
Altitude at deployment: 5281.57634 Ft.
Range at deployment: -1396.44878 Ft.

P: Parachute - Main Deployed at: 76.014 Seconds
Velocity at deployment: 76.3306 ft/s
Altitude at deployment: 999.99412 Ft.
Range at deployment: -551.27191 Ft.

Landing data

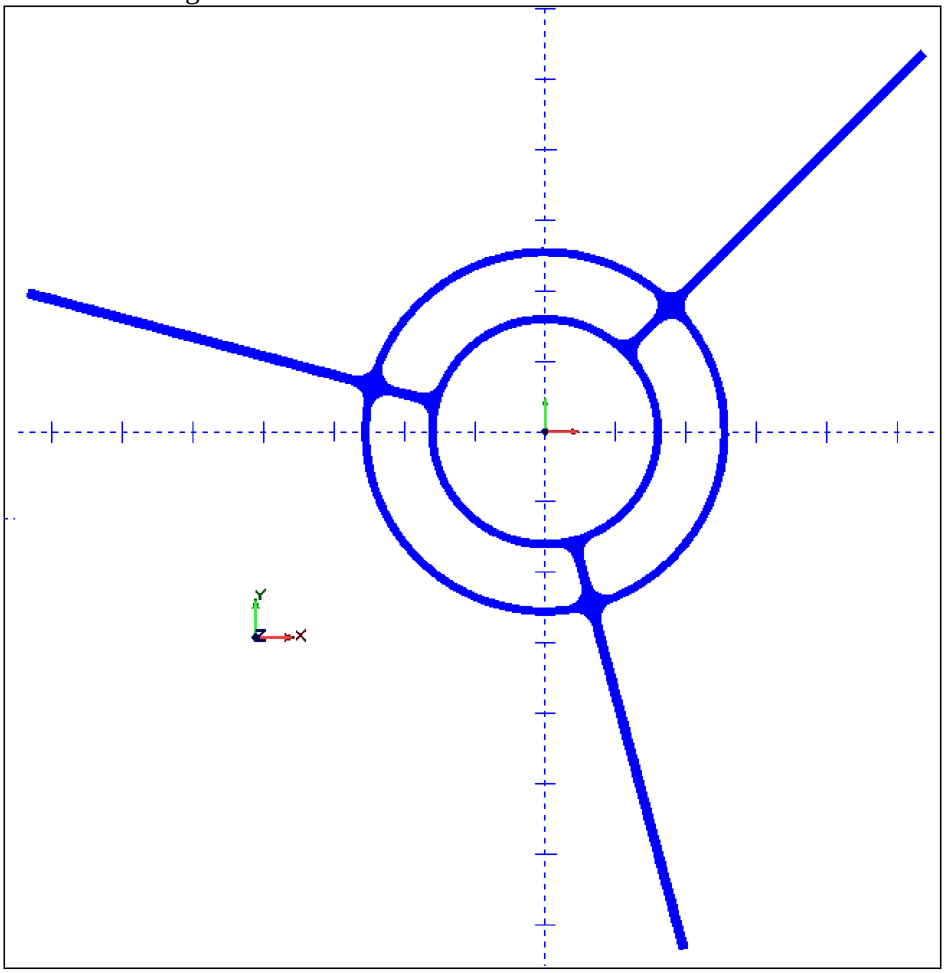
Time to landing: 120.031 Sec
Range at landing: 72.74851
Velocity at landing: Vertical: -22.2866 ft/s

Flight Profile



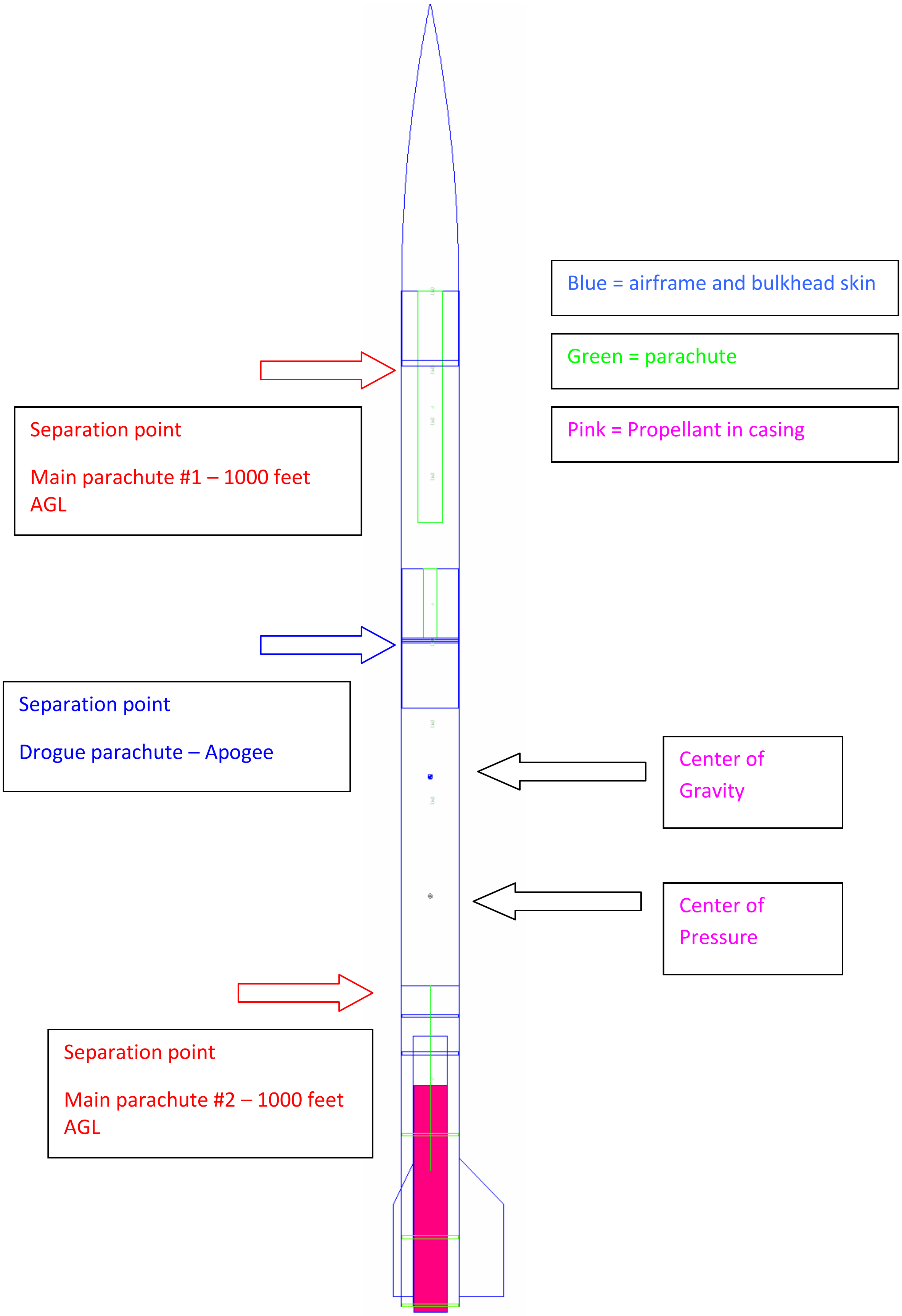
Motor section CAD/Schematics

- Fin – to – tube fillet design



Motor tube installation with fillets to ensure proper fin retention. The fillet radius is .25 inches on three surfaces on each side of the fin. This will ensure minimal oscillation and prevent fin pull out during high g-loading and aerodynamic drag.

All fins will have a sharp leading edge taper of 10° along the edge parallel to the free-stream velocity. This will minimize drag, prevent any induced lift on the side of the fin, and cause unintended roll about the Z-axis. Fins will be flat surface with no camber or varied thickness along the chord length. The fins are 0.25 inches thick and will be surface machined to ensure both sides are parallel.

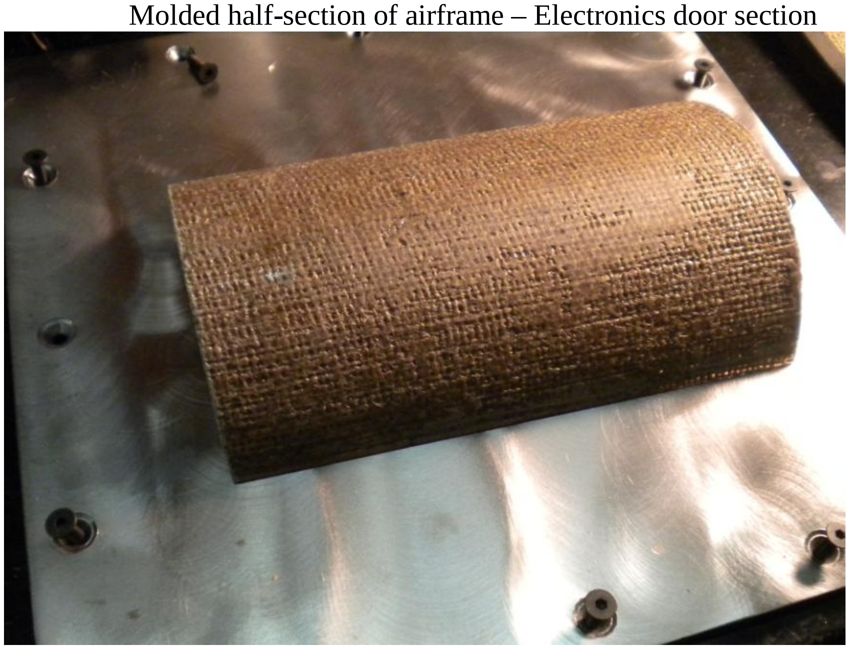


Blue = airframe and bulkhead skin
Green = parachute
Pink = Propellant in casing
Separation point
Main parachute #1 – 1000 feet AGL
Separation point
Drogue parachute – Apogee
Center of Gravity
Center of Pressure
Separation point
Main parachute #2 – 1000 feet AGL

Airframe fabrication techniques:

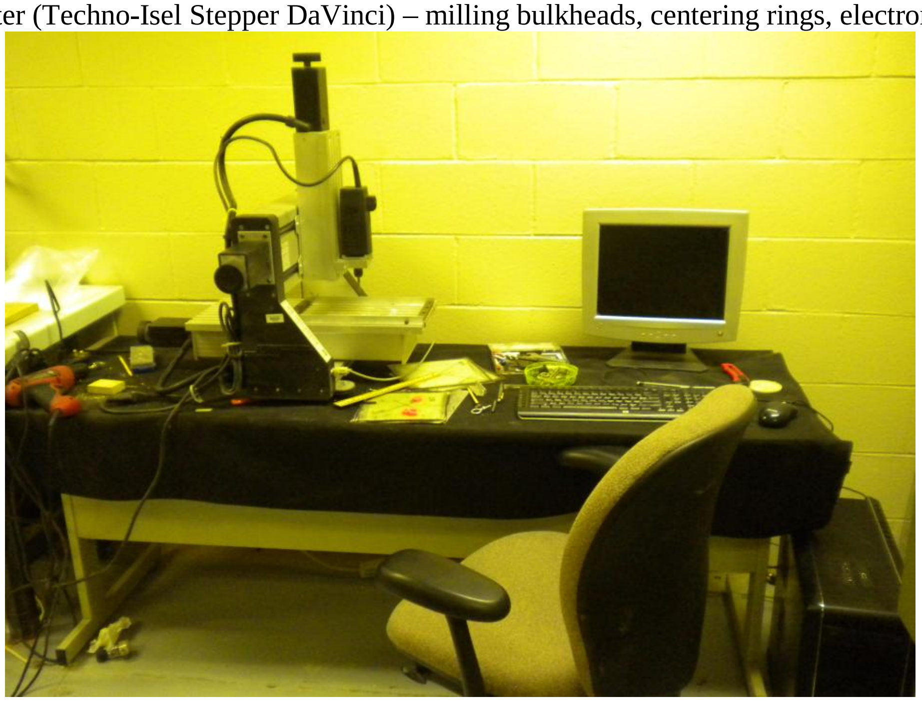
Flat panel VARTM (Vacuum-Assisted Resin Transfer Molding) layup
Epoxy and flax fiber (bulkhead, electronics plate)

Molded half-section of airframe – Electronics door section



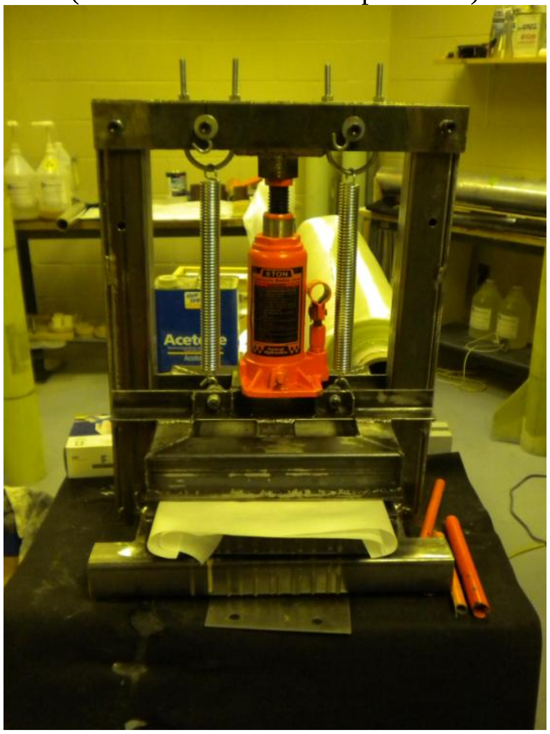
Aluminum Mandrel – 5 inch OD for fabricating airframe tubular sections

CNC Router (Techno-Isel Stepper DaVinci) – milling bulkheads, centering rings, electronics plates



Compression molding of bulkhead parts

(Minimize delamination problems)



Material Testing of Samples – Tinius Olsen Tensile Testing Machine

<u>Projected Payload and Purpose:</u>

The purpose of this payload is to determine the stress on the launch vehicle, monitor that stress/strain in a real-time manner, and use that data to validate computer models for the bio-sourced fiber and matrix composite structure. This will provide the necessary performance information so that others may pursue high power rocketry with biodegradable and bio-sourced materials. Complete testing of the materials to provide information to NASA will include, Dynamic Mechanical Analysis (DMA), Thermo-gravimetric Analysis (TGA), X-ray Diffraction (XRD), IR analysis of bond between matrix and fiber (FTIR), and SEM/Optical Microscopy of fracture. The lab testing of the materials coupled with the stress/strain measurements from the launch vehicle will aid in development of finite element models, which will accurately match actual performance.

Our primary payload is an onboard stress recording system designed to collect and relay the necessary data points to a ground station. This system will monitor the stress/strain in real-time, and allow a comparison of the stress during flight with NASTRAN analytical models. Data will be collected through the used of Arduino hardware. The Uno is a microprocessor board that will accept digital and analog input from the strain gauges. An Op-Amp will be used to boost the signal from the strain gauges to the Uno board.

Flight profile events will be performed by a triple fault tolerant system:

1. Transmitter/Receiver: Ozark Aerospace 900MHz TX-900G with Associated Ground Station Receiver - GPS
2. One (1) PerfectFlite MINIALT/WD (Official Competition use only)
3. One (1) StratoLogger SL-100 Altimeters (Dual fault tolerant)
4. One (1) ARTS2 (Ozark) altimeter (remaining fault tolerance)

Vehicle Mass and Kinetic Energy Calculations (at landing and main deployment)

Section 1 – At Main deployment				
Component	Mass (lbf)	Velocity (ft/sec)	KE (ft-lbf)	Notes
Nose	4.3	83.18	462.35	

Section 2– At Main deployment				
Upper 1	10.88	83.18	1169.85	

Section 3– At Main deployment				
Upper 2	5.41	83.18	581.70	

Section 4– At Main deployment				
Motor - fins	12.07	83.18	1297.80	

Section 1 – At Landing				
Component	Mass (lbf)	Velocity (ft/sec)	KE (ft-lbf)	Notes
Nose	4.3	12.28	10.07	

Section 2 – At Landing				
Upper 1	10.88	12.28	25.49	

Section 3 – At Landing				
Upper 2	5.41	12.28	12.67	

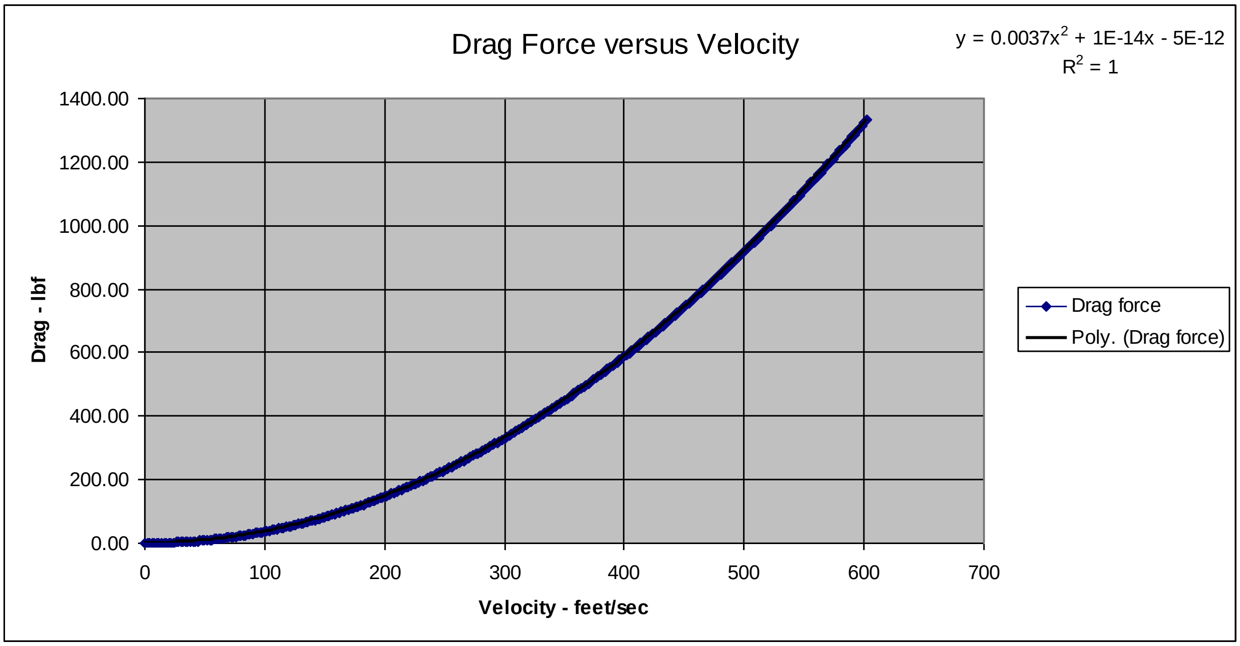
Section 4 – At Landing				
Motor - fins	12.07	12.28	28.28	

All sections are within the 75 ft-lb kinetic energy limitation set forth in the statement of work (SOW).

Rocket Dimensions					
Section	Section Description	Length (inches)	Diameter - Inner	Wall Thickness	Notes
1	Nose	25	4.8 in	0.1 in	Performance Rocketry 5.0 in 5:1 ogive nose
2	Main Parachute/Science Package Section	24	5.0 in	0.1 in	Main parachute section – Science Package
3	Lower Electronics	36	5.0 in	0.1 in	Flight Electronics and Drogue Parachute
4	Motor Core	27.75	5.0 in	0.1 in	Motor section with fins – Motor section with parachute
	Total Length	112.75			

Propulsion Trade Study – Generated by ThrustCurve.org									
	Liftoff Mass (Kg)	Guide Vel. (m/s)	Burn out Mass (Kg)	Burn out Time (s)	Burn out Alt. (m)	Max Acc. (g)	Max Vel. (m/s)	Apogee Time (s)	Max Altitude (m)
AT K1499	17.163	23.108	16.559	0.871	32.479	9.294	69.350	7.621	259.800
ATK780	18.356	15.047	17.088	3.020	166.450	4.392	101.430	12.383	612.390
AT K1000	18.024	17.584	16.790	2.490	161.320	5.555	115.540	12.990	730.040
AMW L1111	18.939	15.705	17.297	3.130	257.670	6.700	154.810	16.280	1181.000
AT L1150	19.096	18.575	17.194	3.118	265.090	6.158	154.180	16.230	1181.200
Loki L930	18.960	15.516	17.055	3.990	329.240	5.146	148.770	16.740	1189.400
GR L1150	18.924	17.370	17.174	3.100	281.670	8.692	158.560	16.500	1244.500
AT L850	19.164	16.946	17.069	4.680	455.920	5.436	149.650	17.030	1260.000
AT L1520	19.073	21.305	17.219	2.590	253.400	8.283	175.000	16.890	1363.500
Loki L1482	18.960	19.502	17.121	2.590	239.280	8.487	182.280	17.340	1425.100
AT L1390	19.301	19.789	17.328	2.910	287.950	7.906	177.670	17.410	1434.000
AT L1170	20.412	18.737	17.612	3.660	374.540	6.402	175.750	17.910	1475.100
GR L1065	20.785	19.221	18.092	3.940	468.320	7.887	177.550	18.290	1583.100
AT L1420	19.984	20.086	17.424	3.230	356.470	7.753	202.990	19.030	1745.300
AT L1120	20.080	19.638	17.302	4.993	653.720	7.048	194.660	19.855	1860.600

Drag force calculations – Using a drag coefficient of 0.75



The estimation for drag at maximum velocity is 1,330.95 lbf. The equation fitted to the line is shown on the graph and can be used to extrapolate drag at any point in the subsonic region below Mach 0.75. The curve fit to the data points has a R^2 value of 1.0, which means the data and curve have no error between the two.

Milestone Review Flysheet			
PDR, CDR, FRR			
Institution Name	Tuskegee University	**Milestone**	PDR

Payload/Science	
Succinct Overview of Payload/Science Experiment	Develop a launch vehicle made from biodegradable and bio-renewable materials and test the stress and strain during flight profile and compare to predicted models from NASTRAN
Identify Major Components	Stress/strain computer (Arduino hardware and 900 MHz transmitter); TX-900G GPS/transmitter; ARTS2 altimeter; Stratologger SL-100 altimeter; MAWD altimeter; Rocketvision Camera
Mass of Payload/Science	3.5 pounds (electronics + batteries)
Test Plan Schedule/Status	
Ejection Charge Test(s)	14-Jan-11
Sub-scale Test Flights	14-Jan-11
Full-scale Test Flights	5-Feb-11

Educational Engagement

Outreach programs will be a collaborative effort between the team and the Tuskegee University Chapter of the American Society of Engineering Education (ASEE). There are outreach opportunities in the planning stage for the USLI team and ASEE to visit the Tuskegee Institute Middle School and Phenix City Intermediate School with the events targeted toward promoting active academic involvement in minority youth. We also plan to participate in the Tuskegee University Open House during the Spring Semester. High School juniors and seniors tour the campus while learning about what the college has to offer. We will have a booth at the fair displaying footage of past launches, prototypes, and presentations.

Project Plan

See attached MS Project GANTT Chart – Appendix D for specific scheduling of tasks. For overview of critical events, see chart below.

Task #	Task	Time to Accomplish	Depends On (has prerequisites)	Needed For (is prerequisite)
1	Proposal	Sep 26	Design - Payload Concept	School Selection for Competition
2	Outreach Initiative St. Joseph's Catholic School	Oct 7	-	-
3	USLI Team Teleconference	Oct 21	Selection of Schools	-
4	Fabrication of Prototype	Oct 1- Nov 5	Design	Test Launch SEARS
5	Website	Nov 4	IT accessibility	Displaying Team photos, documents, and important dates
6	Test Launch SEARS	Nov 6	Design Fabrication of prototype	Test Results Improvements on Design PDR data/results
7	Design Improvement Any Changes to Rocket	Nov 7-Nov 28	Test Results Improvements on Design	Dialing in rocket design to meet prescribed criteria

8	PDR Report and Presentations Posted on Team website	Nov 28	Designs, Changes From Proposal, Test Launches	PDR Presentations
9	PDR Presentations	Dec 5-14	PDR Report and Presentations Posted on Team website	CDR
10	CDR Reports and presentation Slides Posted on Team Website	Jan 23	PDR Report and Presentation Feedback Changes Since PDR	CDR Presentations
11	CDR Presentations	Feb 1-10	CDR Reports and presentation Slides Posted on Team Website	Flight Readiness Review
12	FRR Reports and Presentation Slide Posted on Team Websites	Mar 26	CDR Presentations Feedback	FRR Presentations
13	FRR Presentations	Mar 2-11	FRR Reports and Presentation Slide Posted on Team Websites	Travel to Huntsville Flight Hardware and Safety Checks Launch Day
14	Travel to Huntsville	Apr 18	-	-
15	Flight Hardware and Safety Checks	Apr 19-20	FRR Presentations Feedback	Launch Day
16	Launch Day	Apr 21	Flight Hardware and Safety Checks	Post-Launch Assessment Review (PLAR) Report and Presentation

17	Post-Launch Assessment Review (PLAR) Report and Presentation Posted on website	May 7	Launch Day	Announcement of winning USLI team
18	Announcement of winning USLI team	May 18		

Outreach Initiative Spring Open House Tentative

Appendix A: MATERIAL SAFETY DATA SHEET(s)

- see attached file labeled "TU-USLI-MSDS.doc" sent with this electronic document

Appendix B

TITLE 14 - AERONAUTICS AND SPACE

CHAPTER I - FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

SUBCHAPTER F - AIR TRAFFIC AND GENERAL OPERATING RULES

PART 101 - MOORED BALLOONS, KITES, UNMANNED ROCKETS AND UNMANNED FREE BALLOONS

subpart c - UNMANNED ROCKETS

101.21 - Applicability.

This subpart applies to the operation of unmanned rockets. However, a person operating an unmanned rocket within a restricted area must comply only with 101.23(g) and with additional limitations imposed by the using or controlling agency, as appropriate.

101.22 - Special provisions for large model rockets.

Persons operating model rockets that use not more than 125 grams of propellant; that are made of paper, wood, or breakable plastic; that contain no substantial metal parts, and that weigh not more than 1,500 grams, including the propellant, need not comply with 101.23 (b), (c), (g), and (h), provided: (a) That person complies with all provisions of 101.25; and (b) The operation is not conducted within 5 miles of an airport runway or other landing area unless the information required in 101.25 is also provided to the manager of that airport.

101.23 - Operating limitations.

No person may operate an unmanned rocket (a) In a manner that creates a collision hazard with other aircraft; (b) In controlled airspace; (c) Within five miles of the boundary of any airport; (d) At any altitude where clouds or obscuring phenomena of more than five-tenths coverage prevails; (e) At any altitude where the horizontal visibility is less than five miles; (f) Into any cloud; (g) Within 1,500 feet of any person or property that is not associated with the operations; or (h) Between sunset and sunrise.

101.25 - Notice requirements.

No person may operate an unmanned rocket unless that person gives the following information to the FAA ATC facility nearest to the place of intended operation no less than 24 hours prior to and no more than 48 hours prior to beginning the operation: (a) The names and addresses of the operators; except when there are multiple participants at a single event, the name and address of the person so designated as the event launch coordinator, whose duties include coordination of the required launch data estimates and coordinating the launch event; (b) The estimated number of rockets to be operated; (c) The estimated size and the estimated weight of each rocket; and (d) The estimated highest altitude or flight level to which each rocket will be operated.

(e) The location of the operation.

(f) The date, time, and duration of the operation.

(g) Any other pertinent information requested by the ATC facility.