Flight Readiness Review
Tuskegee University
USLI 2009

Summary of Flight Readiness Review

Team Summary

School Name	Tuskegee University
Location	Tuskegee, Alabama
Mentors	Eldon Triggs, Aerospace Science Eng. Arbin Ebrahim, Electrical Engineering

Launch Vehicle Summary

Size	L = 120 inches, D = 4.5 inches
Motor Choice	K – 250LW
Recovery System	Parachute (1 x 36 inch diameter) + 30.0 in drogue parachute
Rail Size	100 inches (est.)

Payload Summary

Transmitter/Receiver	900 MHz TX-900G (Ozark Aerospace) with associated receiver ground station.
Altimeter(s)	1. ARTS2 barometric/accelerometer 2. Perfectflite MINIALT/WD
GPS	Garmin Module (part of TX-900G package)
Sensors	1. Carbon Monoxide module (USB package) 2. Temp/Humidity/Dew Point module (USB package)
Power	Li-polymer battery (11.2 volt)

The sensors will be packaged so that they will be able to download via a single USB cable mounted into the structure of the payload section. The GPS data, altitude, and wind speed will be sent via 900MHz wireless communications to a ground station to verify altitude and final location. The sensors will take measurements of the atmospheric Carbon Monoxide levels, atmospheric temperature, dew point, and humidity to detect level of moisture/water vapor. This will assist in determining the viability of colonization of other planets.

Changes made since Critical Design Review

1. Changes made to Vehicle Criteria

   - The vehicle has changed in overall size from 4.75 inch diameter to 4.5 inch diameter due to the availability of commercially made bodies.
   - At this point, no changes have been made to the Vehicle Criteria

2. Changes made to Payload Criteria

   - At this point, no changes have been made to the payload items. All items presented in the proposal are part of the current plan.

3. Changes made to Activity Plan

   - The following changes have been made to the Activity Plan:

     a. Flight Testing has been rescheduled due to severe weather on the planned launch date, and re-rescheduled due to tragic events in the immediate vicinity of the launch site

     b. Electrical testing has not been completed on the Sensors for CO/Temp because they have not been delivered yet.

     c. Rocket body build has been completed, but is awaiting its weather coating

Vehicle Criteria

Testing and Design of Vehicle

The rocket design was

USLI 2009 - Simulation results

Engine selection

[K250-LW-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: 0.00000 Ft.
- Relative humidity: 50.000 %
- Temperature: 59.000 Deg. F
- Pressure: 29.9139 In.

  Wind speed model: Calm (0-2 MPH)
  - Low wind speed: 0.0000 MPH
  - High wind speed: 2.0000 MPH

  Wind turbulence: Fairly constant speed (0.01)
  - Frequency: 0.010000 rad/second
- Wind starts at altitude: 0.00000 Ft.
- Launch guide angle: 0.000 Deg.
- Latitude: 0.000 Degrees

Launch guide data:

- Launch guide length: 36.0000 In.
- Velocity at launch guide departure: 49.5639 ft/s
- The launch guide was cleared at : 0.129 Seconds
- User specified minimum velocity for stable flight: 43.9993 ft/s
- Minimum velocity for stable flight reached at: 27.7250 In.

Max data values:

- Maximum acceleration:Vertical (y): 489.791 Ft./s/sHorizontal (x): 1.615 Ft./s/sMagnitude: 489.791 F
- Maximum velocity:Vertical (y): 779.2179 ft/s, Horizontal (x): 0.0000 ft/s, Magnitude: 779.4839 ft/s
- Maximum range from launch site: 479.19292 Ft.
- Maximum altitude: 8539.76161 Ft.

Recovery system data

Time data

- Time to burnout: 7.001 Sec.
- Time to apogee: 22.791 Sec.
- Optimal ejection delay: 15.790 Sec.

Landing data

- Crash landing!
- Time to impact: 49.977 Sec.
- Range at impact: -479.19292
- Velocity at impact: Vertical: -483.4150 ft/s , Horizontal: -4.0370 ft/s , Magnitude: 483.4319 ft/s

Competition settings

Competition conditions are not in use for this simulation.

developed using Apogee Rocksim Model Rocket Design & Simulation Software. The software provide us with the following

Recovery Subsystem

We will be utilizing a 36 inch diameter main parachute and 30 inch drogue. Our initial design called for using two parachutes in order to recover the rocket in two sections, however we later decided against this because we felt the rocket would be more visible as one large assembly and substantially lower recovery times in the event that the two sections should drift a large distance from one another. Three grams of black powder, detonated by the main motor burnout, will deploy the parachute at a design pressure of 20 pounds per square inch. All hazmat/safety procedures will be followed in regards to the explosive materials.


Figure 1 - Main Parachute

Mission Performance Predictions

See Testing and Design of Vehicle section above.

Safety and Environment (Vehicle)

The advisor safety officer for the team is Eldon Triggs and the student safety officer is Brandon Williams. The following list encompasses the possible failure modes of the vehicle.

1. Vehicle instability:

    - Vehicle going off-nominal flight path. There is no destruct mechanism for the vehicle, therefore is no possible way to destroy the vehicle before impact. Stability must be maintained through proper design.

2. 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 a sufficient distance to avoid injury.

3. 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 fire unexpectedly.
    - A backup engine will be available for flight.

The following MSDS sheets and files are on hand to give students and faculty the necessary information regarding hazardous materials:

1. Ammonium Perchlorate
2. Kester solder
3. Bondo® Fiberglass resin
4. Owens-Corning Fiberglass fabric
5. Krylon® spray paint
6. Title 14, Part 101, Subpart C
7. NFPA 1127, Code for High Power Rocketry

The actual sheets are not included in this document in order to reduce overall length, but are available upon request.

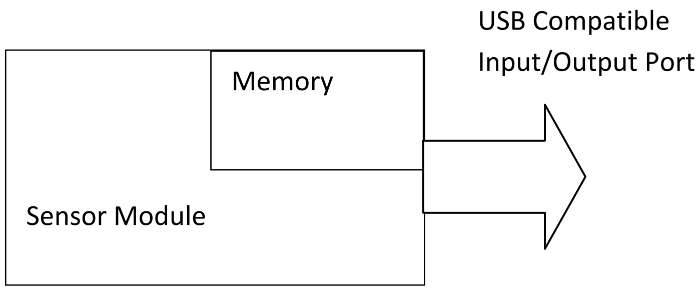
Payload Criteria

Payload

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
standard serial RS-232 format adapter	PC connect data transfer kits for Altimeter
ARTS TX-900G	Altitude, GPS and Wind speed Telemetry transmitter
ARTS RX-900	Receiver for your Telemetry System
Standard Alkaline 9V battery	Altimeter Power supply

Carbon monoxide, Temperature, Humidity and Dew point sensors

The EL-USB-2-LCD and EL-USB-CO sensors have been chosen due to their low weight (0.3lbs each), easy use of usage, and programming. These sensors have inbuilt non volatile memory for storing the measured data and an internal lithium battery.



Altitude, GPS and Wind speed Transmitter and Receiver

Experiment Concept

The concept for the scientific payload is to calculate and determine the surface temperature, humidity, dew point, and Carbon Monoxide levels in the atmosphere as well as wind speed from apogee to landing. These are some of the primary items that would be considered on distant planets to give a good indication of the inhabitability of that particular planet. The goal of our design is to make the systems rugged but inexpensive and easy to retrieve the data once collected.

Science Value

Mission Success Criteria

This will be broken down into three separate areas, Mission Success (Complete), Mission Success (Partial), and Mission Failure.

a. Mission Success (Complete) for vehicle
    i. Completion of flight profile includes:
    ii. Ignition
    iii. Launch and successful separation from launch rail.
    iv. Flight to apogee of approximately 5,280 AGL
    v. Successful deployment of main and lower stage parachutes
    vi. Descent rate of <12 ft/sec for electronics section, descent of <20 ft/sec for lower motor section.
    vii. Maintain structural integrity and be able to refuel, repack parachutes, and prepare to fly within 30 minutes.

b. Mission Success (Complete) for payload
    i. Maintain continuous down link of altitude/GPS data from ascent to retrieval
    ii. Full function of all on board sensors and collection of data during entire flight profile.
    iii. Able to download all data to appropriate computers
    iv. Maintain structural integrity of all sensors and preserve ability to return to flight within 30 minutes.

c. Mission Success (Partial) for vehicle
    i. Achieve parabolic flight, but not to assigned altitude
    ii. Successful retrieval and maintain partial serviceability such that vehicle will return to flight after some repair
    iii. Controlled descent keeping electronics/scientific section intact.

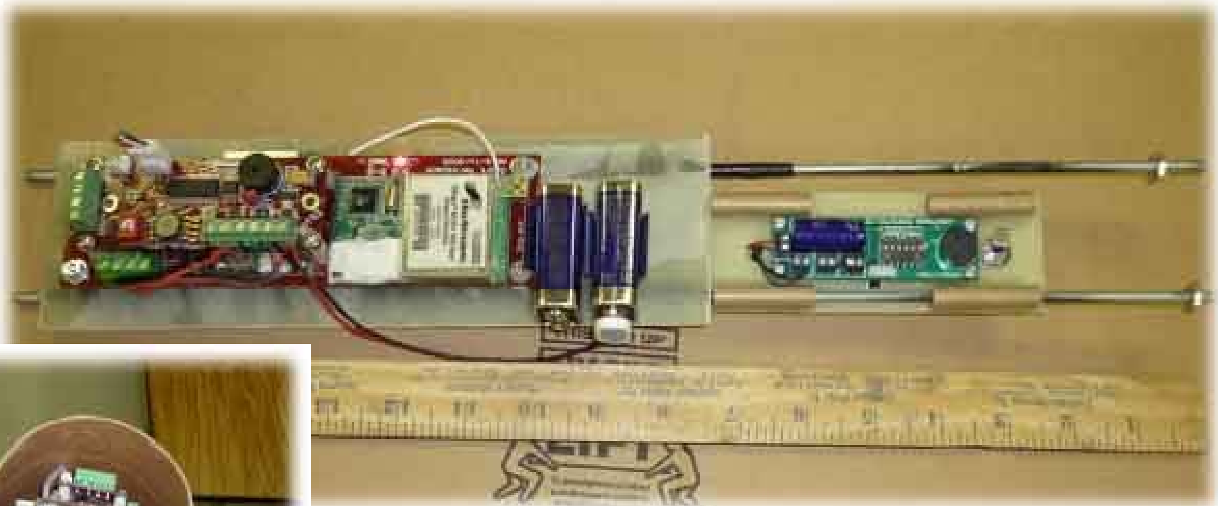
d. Mission Success (Partial) for payload
    i. Transmit during >50% of flight
    ii. Download a minimum of 3 of 4 parameters and flight hardware reusable

e. Mission Failure (complete) for vehicle
    i. Failure to launch
    ii. Failure to reach 1,000 feet AGL altitude
    iii. Failure of main/lower stage parachutes to deploy
    iv. Structure too badly damaged to return to flight

f. Mission Failure (complete) for payload
    i. Failure to transmit data for more than 50% of the flight
    ii. Failure of batteries to prove power during entire flight
    iii. Failure of sensors to record data on more than 3 of 4 parameters

Assembly

The flight hardware is mounted to a fiberglass board which is then secured to two steel coil rods that are bolted to the bulkheads at each end of the payload section.



Safety and Environment (Payload)

The safety officers will be the same mentioned in the vehicle section. The failure modes mention on page 7 will have the following mitigation plan:

1. Battery
   a. The potential problems with the lithium-polymer battery pack include fire and contact with skin.
   b. The battery will be charged in a Nomex sock with proper charging techniques in a safe area.
2. Motor
   a. The motor has the potential catch fire due to malfunction.
   b. The motor(s) will be placed in approved containers and transported in accordance with Federal, State, and local laws. The motors will only be handles by NAR Level 2 certified personnel on site and during testing.

The items above are the most hazardous items when the vehicle is not in flight. The MSDS sheets and appropriate NFPA/NAR regulations are posted in a binder and are provided to students and faculty every time work is performed and are kept with the equipment as it is transported to/from launch sites.   Equipment is kept on hand to clean up any spill or contamination to keep the environment from being harmed.

Launch Operations Procedures

All launches will be held at NAR/TRA sanctioned sites. The launch rail will be provided and the overall length will be determined by the final length of the rocket. The minimum length is at least the length of at which the rocket becomes stable, such that the overall length of the rail will be close to 15 feet in length. The assembly of the vehicle prior to launch will have the following sections:

a. Fuselage

b. Motor

c. Avionics/Science Package

The motor will be assembled before arrival at launch site. The fuselage will be assembled before arrival at launch site. The only parts that will need to be assembled on site is the parachute to shock cord, shock cord to aft end, shock end to nose cone and avionics package. The science package will be enclosed in the fiberglass structure such that the switch will be accessible from the outside. Time to assemble will require a maximum of 30 minutes. The rail lugs will be compatible with the rail constructed. All safety precautions and guidelines will be followed in accordance with the NAR/TRA, BATFE, and NPFA regulations.

Activity Plan

Budget

TUSSLE Rocket Construction Est. Budget

Item	Cost each
Fiberglass tube sections	$50.00
Nose cone	$45.00
Fin sections	$51.00
PerfectFlite Altimeter	$100.00
CO detector	$92.00
Temp/Humidity/DP	$82.00
Parachute	$40.00
Bolts/Hardware	$50.00
Motors (6 est.)	$1,350
Shock cord	$50
Rail materials	$120
Wire	$20
Expendables***	$200
GPS module	$220
PC Board	$400
Total	**$2,870.00**

*** Expendables include batteries, soldier, paint, etc.

On the following page is a breakdown of the actual funding as presented to the Alabama Space Grant Consortium (ASGC) for fund matching.

Tuskegee University

Cost Estimate for 1 year USLI Competition

Funding Agencies: Alabama Space Grant Consortium, Tuskegee University, External Sources

1. PI Salary /Fringe

Faculty Advisor/PI	Months	Time & Effort	Annual Salary	Fringe	Overhead	Total
Eldon Triggs, Instructor Aerospace Science Eng.	10	10%	$ 42,000.00	$ 756.00	$ 1,974.00	$ 6,930.00

2. Travel/Lodging/Transportation

Competition Time

Item	Number	Cost each	Provider	Days/Nights	Rooms	Total
Lodging	6	$82.00	Beville Conf.	4	4	$1,312.00
Per Diem for food	6	$40.00	Tuskegee	4	n/a	$240.00
Van rental	1	$346.14	Enterprise			$346.14
Fuel		$200.00				$200.00
Total						$2,098.14

3. Travel/Lodging/Transportation

Testing

Item	Number	Cost each	Provider	Days/Nights	Rooms	Total
Lodging (2 trips)	4	$62.00	Holiday Inn	4	4	$992.00
Per Diem for food	4	$30.00	Tuskegee	4	n/a	$120.00
Van rental	2	$149.00	Enterprise			$298.00
Fuel		$300.00				$300.00
Total						$1,710.00

4. Rocket/Payload Construction

Item	Number	Cost each	Provider	Total
Cost for construction items	1	$2,870.00	various	$2,870.00
Ground station (estimated)	1	$300.00	various	$300.00

ASGC 9/1/2008-7/30/2009	Tuskegee Cost Share 9/1/2008-7/30/2009	External Funding 9/1/2008-7/30/2009	Project Total 9/1/2008-7/30/2009
$1,312	$7,366	$992	
$240		$120	
$346		$298	
$200		$300	
$2,098		$1,710	
$2,870			
$300			
$7,366	**$7,366**	**$3,420**	**$14,732**

Timeline

Event	September	October	November	December	January	February	March	April
Initial Teleconference	12th							
Proposal Due		8th						
USLI Workshop		10th-11th						
Electrical study	15th through	31st						
Fiberglass testing					10-16			
Water tunnel test				canceled				
Electrical test					15	15		
PDR Due				5th				
Rocket body build					15	10		
CDR Due					22nd			
CDR presentations						3rd		
Test flights							7th	
Flight Readiness Rev.							18th	
Flight Read. Present.							25th thru	3rd
Launch								15th thru 19th

Outreach summary

The students are planning a seminar with Booker T. Washington High School in Tuskegee and will work to encourage students to stay in STEM areas. There is at least one seminar planned for March.

Test Flight Results

At this time, we have been unable to test our rocket and its systems in an actual flight. The original date for the test flight was 7 March 2009 but was scrubbed due to severe weather (tornadic activity, lighting, rain, snow) in the immediate area of the launch site. The make-up date, 14 March 2009 was scrubbed by the launch site owner. The new flight test date is set for 21 March 2009.

Conclusion

At this time, the schedule of events has been delayed to back to back unforeseen occurrences, severe weather being the first and a scrubbed flight by the launch site owner being the later. There are a few electrical components that still have yet to arrive, but are due within the next two weeks. Upon their arrival final construction and flight testing will be completed.