Agenda

1. Team Overview (1 Min)
2. Changes Since Proposal (1 Min)
3. Educational Outreach (1 Min)
4. Safety (2 Min)
5. Project Budget (2 Min)
6. Launch Vehicle (10 min)
7. AGSE & Flight Systems (13 Min)
8. Questions (15 Min)
Project Hermes - PDR

TEAM OVERVIEW
Georgia Tech Team Overview

• 19 person team composed of both undergraduate and graduate students
  • Graduate Students: 2
  • Undergraduates: 17

• Highly Integrated team across several disciplines
Work Breakdown Structure

Project Manager: Victor

Operations: Lead: Victor
- Launch Operations: Stephen
- Outreach: Ariann Collin
- Budget: Victor
- Structures: Stephen Reed Joe Colin

Rocket: Lead: Chris
- Recovery: Ariann
- Stability: Madeline
- ATS: Ben Nikhil

Flight Systems: Lead: Alfredo
- Camera: Oscar
- Sensors: Matt
- Power: Coulter
- GPS: Alfredo

AGSE: Lead: Lance
- Payload: Gabriel
- Electronics: Rahul
- Rocket Erection: John
- Ignitor Insertion: Eric

Advisor: Dr. Eric Perea
Safety Officer: Stephen
Project Hermes - PDR

CHANGES SINCE PROPOSAL
Changes since Proposal

• Launch Vehicle
  • ATS Finalized Design, utilizing four push-pull solenoids to extend and retract the tabs
  • Drogue and main parachutes relocated
  • Opened possibility for a motor change from an L820 to an L990.

• Autonomous Ground Support Equipment
  • Switched from linear actuators to cable and spool system
  • New robotic arm claw design
  • Narrower base

• Flight Systems
  • No changes

• Project Plan
  • No changes
Project Hermes - PDR

EDUCATIONAL OUTREACH
Educational Outreach

• Atlanta Maker’s Faire

• FIRST Lego League

• CEISMC GT
Project Hermes - PDR

SAFETY
Risk Assessment & Launch Vehicle

- **Hazard Identification**
  - What has the potential to become a safety hazard?

- **Risk and Hazard Assessment**
  - What are the potential consequences of the hazard?

- **Risk Control and Mitigation**
  - What can be done to mitigate the risk?

- **Reviewing Assessments**
  - Are the mitigations working?
Project Hermes - PDR

PROJECT BUDGET
## Project Budget Summary

<table>
<thead>
<tr>
<th>Section</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avionics</td>
<td>$700.00</td>
</tr>
<tr>
<td>AGSE</td>
<td>$808.60</td>
</tr>
<tr>
<td>Launch Vehicle</td>
<td>$963.78</td>
</tr>
<tr>
<td>Testing</td>
<td>$900.00</td>
</tr>
<tr>
<td>Motor</td>
<td>$1,000.00</td>
</tr>
<tr>
<td>Operations</td>
<td>$1,000.00</td>
</tr>
<tr>
<td>Outreach</td>
<td>$500.00</td>
</tr>
<tr>
<td><strong>Total Budget</strong></td>
<td><strong>$5,872.38</strong></td>
</tr>
</tbody>
</table>

### 2015-2016 ARES Projected Budget Distribution

- Avionics: $700.00
- AGSE: $808.60
- Launch Vehicle: $963.78
- Testing: $1,000.00
- Motor: $1,000.00
- Operations: $1,000.00
- Outreach: $500.00
- Total Budget: $5,872.38
Project Hermes - PDR

LAUNCH VEHICLE
Launch Vehicle Summary

- Predicted apogee: 5280 ft
- Stability margin: 1.8 calibers
- Motor: Cesaroni L820
- CP = 184 cm

- Max Mach 0.72
- Total weight: 22.22
- Dual deployment
- CG = 160 cm

= CP
= CG
### Fins

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of Sound, $a$</td>
<td>1105.26 ft/sec</td>
</tr>
<tr>
<td>Pressure, $P$</td>
<td>13.19 lb/in$^2$</td>
</tr>
<tr>
<td>Temperature, $T$</td>
<td>48.32 Fahrenheit</td>
</tr>
<tr>
<td>Shear Modulus, $G$</td>
<td>425,000 psi</td>
</tr>
<tr>
<td>Taper Ratio,</td>
<td>0.3627</td>
</tr>
<tr>
<td>Tip Chord</td>
<td>7 cm or 2.75591 in</td>
</tr>
<tr>
<td>Root Chord</td>
<td>19.3 cm or 7.598 in</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.318 cm or 0.1252 in</td>
</tr>
<tr>
<td>Fin Area</td>
<td>55.23 in$^2$</td>
</tr>
<tr>
<td>Span</td>
<td>13.4 cm or 5.275591 in</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>0.50392</td>
</tr>
</tbody>
</table>
Booster Section

Materials:
Cardboard, Plywood, Aluminum, Fiberglass

Attachment: Nuts, Bolts, Epoxy
Apogee Targeting System (ATS)

Materials:
- Acrylic
- Aluminum
- Solenoids

Attachment:
- Nuts
- Bolts
- Brackets
- Hinges
# Motor Selection

<table>
<thead>
<tr>
<th>MOTOR NAME</th>
<th>Cesaroni L820</th>
<th>Cesaroni L990</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAMETER</td>
<td>75mm</td>
<td>54mm</td>
</tr>
<tr>
<td>LENGTH</td>
<td>48.6cm</td>
<td>64.9cm</td>
</tr>
<tr>
<td>PROP WEIGHT</td>
<td>1.760kg</td>
<td>1.369kg</td>
</tr>
<tr>
<td>TOTAL WEIGHT</td>
<td>3.420kg</td>
<td>2.236kg</td>
</tr>
<tr>
<td>AVG THRUST</td>
<td>819.9N</td>
<td>991.0N</td>
</tr>
<tr>
<td>MAX THRUST</td>
<td>948.8N</td>
<td>1702.7N</td>
</tr>
<tr>
<td>TOTAL IMPULSE</td>
<td>2,945.6 N-s</td>
<td>2771.6</td>
</tr>
<tr>
<td>BURN TIME</td>
<td>3.6s</td>
<td>2.8s</td>
</tr>
<tr>
<td>PROPELLANT TYPE</td>
<td>Skidmark</td>
<td>Blue Streak</td>
</tr>
</tbody>
</table>
Avionics Bay

Materials: Plywood, Fiberglass

Attachment: Screws, Nuts, Epoxy
Payload Bay

Materials:
Plywood, Fiberglass, Polycarbonate

Attachment:
Epoxy, Nuts, Screws
Recovery System

<table>
<thead>
<tr>
<th>Requirement Number</th>
<th>Requirement Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>The launch vehicle shall stage the deployment of its recovery devices in the following order, drogue parachute, main parachute</td>
</tr>
<tr>
<td>2.2</td>
<td>Teams must perform a successful ground ejection test for both the drogue and main parachute</td>
</tr>
<tr>
<td>2.3</td>
<td>At landing, each independent section’s kinetic energy shall not exceed 75 ft-lbf</td>
</tr>
<tr>
<td>2.4</td>
<td>The recovery system electrical circuits shall be completely independent of any payload electrical circuits</td>
</tr>
<tr>
<td>2.5</td>
<td>The recovery system shall contain redundant, commercially available altimeters</td>
</tr>
<tr>
<td>2.6</td>
<td>A arming switch shall arm each altimeter, which is accessible from the exterior of the rocket airframe</td>
</tr>
<tr>
<td>2.7</td>
<td>Each altimeter shall have a dedicated power supply</td>
</tr>
<tr>
<td>2.8</td>
<td>Each arming switch shall be capable of being locked in the ON position for launch</td>
</tr>
<tr>
<td>2.9</td>
<td>Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment</td>
</tr>
<tr>
<td>2.10</td>
<td>An electronic tracking device shall transmit the position of the rocket</td>
</tr>
<tr>
<td>2.11</td>
<td>The recovery system will by shielded from magnetic waves and all onboard devices, and placed in separate compartments within the vehicle</td>
</tr>
</tbody>
</table>
Mass Breakdown

Total Mass: 22.22lbm
Stability Calculation

Table 13: Terms and their Respective Values

<table>
<thead>
<tr>
<th>Term</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L∞</td>
<td>45.7</td>
</tr>
<tr>
<td>D</td>
<td>12.7</td>
</tr>
<tr>
<td>d_a</td>
<td>12.7</td>
</tr>
<tr>
<td>d_e</td>
<td>12.7</td>
</tr>
<tr>
<td>L_τ</td>
<td>45.7</td>
</tr>
<tr>
<td>X_r</td>
<td>96.5</td>
</tr>
<tr>
<td>C_a</td>
<td>19.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C_r</td>
<td>7.1</td>
</tr>
<tr>
<td>S</td>
<td>13.4</td>
</tr>
<tr>
<td>R</td>
<td>6.35</td>
</tr>
<tr>
<td>X_e</td>
<td>11.9</td>
</tr>
<tr>
<td>X_a</td>
<td>209.3</td>
</tr>
<tr>
<td>N</td>
<td>4 Fins</td>
</tr>
</tbody>
</table>

\[
\bar{X} = \frac{(C_N)_N X_N + (C_N)_T X_T + (C_N)_F X_F}{(C_N)_R}
\]

\[
\bar{X} = 182.7957184\text{cm}
\]
Mission Performance – Flight Profile
Mission Performance - Drift Profile

Bird-eye view of Drift Profile
Test Plan Overview

❖ **Solenoids**: Extension force test

❖ **ATS**: Wind tunnel testing to confirm Cd simulations

❖ **Thrust Plate**: Bend test and pressure test to test rigidity

❖ **Payload Bay**: Payload retention force test

❖ **Avionics Bay**: Altimeter performance test

❖ **Recovery System**: Recovery system test fire

❖ **Fins**: Fin attachment robustness test
Project Hermes - PDR

FLIGHT SYSTEMS
# Flight System Responsibilities

## Outline of Success Criteria

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Design Feature to Satisfy Requirement</th>
<th>Requirement Verification</th>
<th>Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>The vehicle shall not exceed an apogee of 5,280 feet</td>
<td>Drag from the ATS system</td>
<td>Subscale flight test</td>
<td>Apogee within 1% of target</td>
</tr>
<tr>
<td>The vehicle will be tracked in real-time to locate and recover it</td>
<td>GPS module will be used in the vehicle and base station</td>
<td>Subscale flight test</td>
<td>The vehicle will be located on a map after it lands for recovery</td>
</tr>
<tr>
<td>The data of the vehicle’s flight will be recorded</td>
<td>Sensors will save data into a memory card</td>
<td>Subscale flight test</td>
<td>The data will be recovered and readable after flight</td>
</tr>
</tbody>
</table>
## Flight Systems: Avionics

### Avionics Components

<table>
<thead>
<tr>
<th>Part</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratologger SL100</td>
<td>Altimeter - used to receive and record altitude</td>
</tr>
<tr>
<td>MMA8452Q</td>
<td>Accelerometer - used to receive and record acceleration</td>
</tr>
<tr>
<td>mbed LPC 1768</td>
<td>Microcontroller - used to receive sensor data to compute and control the ATS system</td>
</tr>
<tr>
<td>Eggfinder TX/RX Module</td>
<td>GPS module - used to track the rocket in real time</td>
</tr>
<tr>
<td>9V Alkaline Batteries</td>
<td>Used to power all Avionics components</td>
</tr>
<tr>
<td>3.7V Lithium-Polymer Batteries</td>
<td>High discharge batteries used for the solenoids</td>
</tr>
</tbody>
</table>
Flight Systems: Avionics

General connection of main components
Flight Systems: Avionics

Eagle CAD schematic of main components
Flight Systems: Ground Station

Equipment:

- Eggfinder TX (Transmitter)
- Eggfinder RX (Receiver)
Dynamic drag adjustment by changing the geometry exposed to the flow to increase the vehicle’s aerodynamic properties.
Flight Systems: Testing Overview

**Wind Tunnel:** Test Cd of flaps against simulation, and ability for solenoids to withstand the given pressures

**Flight Simulation:** Forged flight data will be fed to the sensors and the response efficacy will be analyzed.

**Power Consumption:** Full charged power supply will be connected to flight systems to see its maximum lifespan.
Project Hermes - PDR

AUTONOMOUS GROUND SUPPORT EQUIPMENT
AGSE: Initial Design

• 10 ft. by 2 ft. base constructed from aluminum t-slotted rails
• 3 subsystems
  • Robotic Payload Delivery System (RPDS)
  • Rocket Erection System (RES)
  • Motor Ignition System (MIS)
• Weight: 60 lbs
• Estimated time for completion of all tasks: 8 minutes
AGSE: RPDS

- Will locate payload using IR sensors
- Grab payload using gripping claw
- Constructed of wood and plastic parts
AGSE: RPDS

- Arm will move payload into payload bay
- Secure payload through plastic clips
- Raise the rocket through a cable and spool system
- Spool will pull in steel cable that is attached to hinged rail
- Ratchet system will keep launch vehicle in place
• Rack and pinion system will move the electronic match 12 inches into the motor cavity
• Will be fixed to bottom of guide rail
# AGSE: Safety

<table>
<thead>
<tr>
<th>Potential Failure</th>
<th>Effects of Failure</th>
<th>Failure Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload is not secured in bay</td>
<td>Payload will bounce inside payload bay, disrupting flight</td>
<td>Test various plastic clip dimensions to find best fit</td>
</tr>
<tr>
<td>RES is not stable while raising</td>
<td>Rocket will not be raised, and potentially the motors will be broken</td>
<td>Test subsystem, add counterweights to reduce necessary force from motor, and add more framing to increase stability</td>
</tr>
<tr>
<td>RES does not stay upright</td>
<td>Launch vehicle will fall unpredictably</td>
<td>Perfect ratchet system, ensure tension in steel cable</td>
</tr>
<tr>
<td>Electronics short circuit or are overloaded</td>
<td>System will lose control</td>
<td>Fuses</td>
</tr>
</tbody>
</table>
AGSE: Electronics

- 4 servo motors for RPDS
- 1 unipolar stepper motor for RES
- 1 bipolar stepper motor for MIS
- 2 LEDs as indicators
- 1 button to start and stop the program
- Controlled by Arduino Uno-R3
AGSE: Power

- System will be powered by 12V- 10.5Ah lead acid battery
- System can run for up to 45 minutes
AGSE: Test Plan Overview

- RES: cable and spool stability test
- RPDS: Arm strength test
- MIS: Insertion speed test
Questions