Ferrocious Fliers
Subsystem Testing Review
February 25th, 2015

Amelia Gear
Tessa Rundle
Justin Barhite
Jordan Rice
Presentation Outline

• Section 1: Mission Overview
• Section 2: Final Design Description
• Section 3: Project Management Update
• Section 4: Hardware Procurement Status
• Section 5: Subsystem Testing Results
• Section 6: Full System Testing Plan
• Section 7: User Guide Compliance
Mission Overview

Jordan Rice
Mission Objectives

The objective of our mission is to observe the onset of normal field instability (NFI) in a ferrofluid suspension as a function of applied magnetic field and characterize the role of gravity in stabilizing the surface of the ferrofluid against deformation driven by magnetization.

Ferrofluid experiencing normal field instability (NFI)
Expected Results

- We expect the onset of NFI to occur at an applied magnetic field of less than 15 gauss
  - Any applied magnetic field above 0 gauss should cause surface deformation in microgravity conditions
- We expect the peak height to be increased in a microgravity environment relative to the peak height in earth-gravity conditions, as the critical wavenumber goes to zero
Mission Requirements

- Record video of ferrofluid response to changing external magnetic field during microgravity portion of flight
- Measure the effect of the centripetal acceleration of the payload on the ferrofluid
- From experimental data, calculate the net magnetization of a ferrofluid in microgravity
Concept of Operations

- T = 0 seconds
  G-switch triggered
  Systems powered on

- T + 45 seconds
  Power is triggered to cameras, data collection begins

- T + 38 seconds
  End of Orion Burn
  Altitude: 52 km

- T + 174 seconds
  Apogee
  Altitude: 119 km

- T + 461 seconds
  Chute deploys

- T + 465 seconds
  Payload powers down

- T + 900 seconds
  Splash down
Final Design Description

Tessa Rundle and Justin Barhite
Functional Block Diagrams
Payload

Dimensions in inches.
Functional Block Diagrams
Structural Subsystem

Dimensions in inches.
Functional Block Diagrams
Electronics Subsystem

- Gyroscope
- Accelerometer
- LEDs
- Batteries
- Latch Circuit
- Arduino
- Magnetometer
- Relays
- Voltage Regulator
- Helmholtz Coils
- Cameras

Power: solid line
Data: dashed line
Control Signal: dotted line
Functional Block Diagrams
Software Subsystem

- G-switch activates Arduino
- Initialization
  - Wait until microgravity is reached
- Signal cameras to stop recording
- Scan over range of fields levels
- Signal cameras to start recording
Changes from CDR

- Magnetic field shielding has been completed
  - 3 shielding plates will be used above and below secondary containment
Structural Design
Side View

Dimensions in inches.
Structural Design
Angled Views

Dimensions in inches.
Structural Design
More Angled Views
Used as base plate for ferrofluid capsule and base plates for the mounting of electronics.
Structural Design Elements: Aluminum Threaded Rods

Used to hold inner structure together and to mount structure to Secondary Containment.
Dimensions in inches.
Entire structure will be placed in secondary containment, which we will be re-using from last year.
Side view of secondary containment shown above (dimensions in inches).
Structural Design Elements: Secondary Containment

Mounted to Rocksat-C can on the bottom and top. Dimensions in Inches.
Base plate for secondary containment vessel. Mounted to bottom of Rocksat-C can. Dimensions in Inches.
Polycarbonate LED/Magnetometer mounting plate

Aluminum mounts for HackHD cameras

Dimensions in Inches
Structural Design Elements: Magnetic Shielding Plates

# Detailed Mass Budget

<table>
<thead>
<tr>
<th>Part</th>
<th># required</th>
<th>Mass (grams)</th>
<th>Total Mass (grams)</th>
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<tr>
<td>Rocksat-C Canister</td>
<td>1</td>
<td>2721.55</td>
<td>2721.55</td>
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<tr>
<td>Secondary Containment (w/base)</td>
<td>1</td>
<td>2059.19</td>
<td>2059.19</td>
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<td>Magnetic shielding plates</td>
<td>6</td>
<td>178.703</td>
<td>1702.22</td>
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<td>Coil Holder</td>
<td>2</td>
<td>96.66</td>
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<tr>
<td>Inner Threaded Rods</td>
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<td>Outer Threaded Rods</td>
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<td>Ferrofluid Base Plate</td>
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<tr>
<td>Ferrofluid Capsule</td>
<td>1</td>
<td>178.3</td>
<td>178.3</td>
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<tr>
<td>Electronics*</td>
<td>1</td>
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<td>TBD</td>
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<td>Electronics Plates</td>
<td>2</td>
<td>136.8</td>
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<td>Nuts</td>
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<td><strong>Total (pounds)</strong></td>
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<td><strong>16.42</strong></td>
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Materials List

- Aluminum (Secondary containment, threaded rods, camera mounts)
- Galvanized Steel (Shielding plates)
- Stainless Steel (Nuts, bolts)
- Polycarbonate Plastic (Coil holders, electronics and ferrofluid base plates, LED mounting plate)
- Copper Wire (Coils)
- Glass (Ferrofluid capsule)
Hazardous Structural Items

- Glass ferrofluid capsule
  - Capsule is secured between Helmholtz coils and polycarbonate plates
  - Capsule survived vibe testing, launch, and recovery in 2014
- Two (2) NiMH 6-volt battery packs and One (1) NiMH 12-volt battery pack will be used
## Updated Power Budget

<table>
<thead>
<tr>
<th>Part</th>
<th>Voltage (V)</th>
<th>Current (mA)</th>
<th>Time Running (min)</th>
<th>Time On (sec)</th>
<th>Watts</th>
<th>Ah</th>
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<td>Microcontroller</td>
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<td>60</td>
<td>20</td>
<td>0</td>
<td>0.42</td>
<td>0.02</td>
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<td>Voltage regulator</td>
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<td>1000 (max)</td>
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<td>HackHD (2)</td>
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<td>1100</td>
<td>20</td>
<td>45</td>
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<td>Helmholtz coils</td>
<td>5 (max)</td>
<td>1000 (max)</td>
<td>20</td>
<td>55</td>
<td>5</td>
<td>2</td>
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<td>Magnetometer</td>
<td>2.5</td>
<td>0.1</td>
<td>20</td>
<td>45</td>
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<td>Accelerometer</td>
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<td>0.1</td>
<td>20</td>
<td>45</td>
<td>0.0005</td>
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<td>Gyroscope</td>
<td>3.6</td>
<td>6.5</td>
<td>20</td>
<td>45</td>
<td>0.023</td>
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<td>LEDs</td>
<td>3.7</td>
<td>20 (max)</td>
<td>20</td>
<td>45</td>
<td>0.15</td>
<td>0.00005</td>
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<td><strong>Total</strong></td>
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<td><strong>2.36</strong></td>
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<td><strong>Capacity</strong></td>
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<td></td>
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<td><strong>Over/Under</strong></td>
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<td></td>
<td><strong>2.04</strong></td>
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Hazardous Electrical Items:

- We are not using any hazardous electrical items
- We are not using any high voltage components
- We do not foresee any hazards in our electrical design
Software Design:

- **G-Switch Activates Arduino:**
  - Event timer initiated
  - Input/Output pins set to initial values
  - SD Card and I2C devices initialized
  - Power to electronics

- **Once microgravity is reached (rates to be determined during testing):**
  - Signal cameras to begin recording
  - Ramp voltage across Helmholtz coils up and down
  - Read and write magnetometer, gyroscope, and accelerometer values
  - Signal cameras to stop recording
G-Switch Activates Arduino

Initialization

Wait until T+45 seconds (beginning of microgravity portion)

Signal cameras to stop recording

Ramp up/down voltage across Helmholtz coils

Signal cameras to start recording

Continue until T+465 seconds (end of microgravity portion)

System Powers down
Software Design
Function Overviews

● Initialization
  ○ Arduino initialization
  ○ Initialize SD card
  ○ Initialize I2C

● Ramp voltage up
  ○ Set voltage to minimum value
  ○ Increase voltage gradually over specified time
  ○ Read sensors

● Ramp voltage down
  ○ Set voltage to maximum value
  ○ Decrease voltage gradually over specified time
Software Design
Function Overviews

- Read magnetometer
  - Read values
  - Write to SD card

- Read accelerometer
  - Read values
  - Write to SD card

- Read gyroscope
  - Read values
  - Write to SD card

- Turn cameras on
  - Activate power to cameras
  - Press camera button

- Turn cameras off
  - Press camera button
  - Cut power to cameras
De-Scopes and Off-Ramps

- There have been no changes to the scope of our design
- Off Ramps:
  - We may decrease the range of varying magnetic fields if we cannot implement a continuously varying voltage regulation method
Project Management Update

Amelia Gear
Program Management and Team Updates

Our team structure is unchanged.
Organizational Chart

Adviser: Dr. Kevin M. Crosby

Team Lead: Amelia Gear

Conceptual: Jordan Rice Amelia Gear

Structural: Tessa Rundle Jordan Rice

Electrical: Justin Barhite Amelia Gear

Software: Justin Barhite Tessa Rundle

Data Analysis: Amelia Gear Tessa Rundle
Schedule Update

- Due to delays in ordering electrical components, our testing plan has been delayed.
- Integration of software and electronics subsystems will begin immediately.
- Subsystem integration is projected to be completed in early April.
- Full Mission Simulations are projected to begin following integration in April.
## Schedule

<table>
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<th>Milestone</th>
<th>Projected Completion Date</th>
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<tr>
<td>Integrate sensors</td>
<td>3-3 through 3-10</td>
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<tr>
<td>Build voltage regulator</td>
<td>2-27 through 3-4</td>
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<tr>
<td>Voltage regulation testing</td>
<td>3-4 through 3-11</td>
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<tr>
<td>Assemble payload</td>
<td>Early April</td>
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<tr>
<td>ISTR</td>
<td>4-8</td>
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<tr>
<td>Full mission simulations</td>
<td>April</td>
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<td>FMSTR</td>
<td>5-20</td>
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# Budget

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<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Total Cost</th>
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<tr>
<td>RockSat-C Can and Registration</td>
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<td>$12000</td>
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<tr>
<td>Travel and lodging</td>
<td>$1800/person</td>
<td>$7200</td>
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<td>Electronic components</td>
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<td>$300</td>
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<td>Structural components</td>
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<td>$200</td>
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<td>Total</td>
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# Funding

<table>
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<th>Budget Item</th>
<th>WSGC Support Requested</th>
<th>Carthage</th>
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<td>Flights Milwaukee to Norfolk, VA ($350/student x 4 students)</td>
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<td>1400</td>
<td>1400</td>
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<tr>
<td>Rental Car Wallops Flight Facility</td>
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<td>Hotel near Wallops Flight Facility (9 nights x 2 rooms x $130/night)</td>
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<td>2340</td>
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<tr>
<td>Meals at Wallops Flight Facility (9 days x 4)</td>
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<td>900</td>
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<tr>
<td>Student Summer Stipends x 2 ($3500 per student)</td>
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<td>Student Summer Housing x 2 ($1500 per student)</td>
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<td>3000</td>
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<tr>
<td>Student Summer Meal Plan x 2 ($550 per student)</td>
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<td>1100</td>
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<tr>
<td>Experiment Development Costs</td>
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<td>RockSat Participation and Launch Costs</td>
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<tr>
<td>Project Total</td>
<td>14340</td>
<td>14900</td>
<td>29240</td>
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Hardware Procurement Status

Jordan Rice
Structural Elements

● Additional polycarbonate plates (Qty: 6)
  ○ Once new electronics are finalized, they will be attached to new electronics plates
  ○ Received 2/13

● Magnetic shielding plates (Qty: 6)
  ○ Currently have three plates, the remaining three will be procured by March 3rd
Electrical Elements

● All electronics have been ordered
  ○ Final components are projected to arrive by 2/28
● Magnetometers, accelerometer, gyroscope, and MOSFET have arrived
Subsystem Testing Results

Jordan Rice and Justin Barhite
New polycarbonate plates were fit-checked with existing structure

Magnetic shielding plates were fit-checked with Rocksat-C can and structure (in the location they will be mounted for flight).
Data was taken with a supplied voltage of 4.5 V, which is the maximum voltage that will be supplied to the coils.
Electronics

- Electronics testing has not advanced
  - Ordering of components was delayed
  - All components should arrive by 2/28
- Testing of sensors will occur next week, as software and electronics are integrated
Software

- Arduino has been used successfully in magnetometer testing
- Magnetometer has been successfully operated with testing code
- Gyroscope and accelerometer have not yet been tested with Arduino
Plan for Full System Testing

Amelia Gear
Plan for Subsystem Integration

- Testing will begin with software and electronics integration, 3-4
- Our largest hurdle will be building and testing the voltage regulator, (2/27-3/4)
- Most electronics and software integration should occur by the end of March
- Following electronics and software integration, structural should be fully integrated prior to the ISTR
User Guide Compliance

Amelia Gear
User Guide Compliance

- Our payload will meet the 20±2 lbf weight requirement
- Our payload’s center of gravity will lie within the 1 x 1 x 1 inch envelope of the payload’s geometric center
- Our payload will be built to withstand 25 G on ascent
- Our payload will meet the activation requirements outlined in section 5.2.2.1
- Sharing logistics do not apply
Worries and Concerns

- Electronics testing has not been completed
  - All components have been ordered
  - Testing will commence as soon as parts arrive
Conclusions

- Testing the electronics is our main concern
- Our schedules projects we will be on track by the ISTR