Flexible Flyers
Preliminary Design Review

Northwest Nazarene University
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November 12th, 2012
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  – Concept of Operations
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  – System/Project Level Requirement Verification Plan
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  – Structures
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Mission Overview
Mission Overview

• Our mission is a combination of two missions. One is to determine the durability of flexible electronics in the cryogenic environment of space. The second, is a test to create a de-spun video of the rocket flight.

• A flexible board will need to be tested in a variety of ways. A roll test, and a bend test in two directions will be performed and the experiment will be recorded by onboard video.
Misson Successes and Benefits

• A successful mission would show that the electronics would be able to unroll in space and be flexible without breaking. A successful flight for the de-spun video would have a resulting program that could be used again.

• The results of these experiments are that ASI will have tested flexible electronics, students will have gained engineering experience, and a program to de-spin video of spinning flight will have been developed.
Theory and Concepts

• Flexible solar panels have been put up into space but we are testing the flexibility of electronic chips and their ability to function in the cryogenic environment.
Mission Requirements:

- De-spun video
  - Cameras
  - Data recovery
    - Telemetry
    - SD card
  - Processed video

- Flexible electronics
  - Flexing mechanism
    - Motors
    - Case
  - Electronic input
    - Arduino

- Temperature
  - Thermometer
  - Infrared thermometer
  - Arduino as data collection
Mission Requirements:

• Minimum success criteria
  – De-spun video
    • A couple of seconds of video that has been de-spun would be the least amount of success for this subsystem to be considered a success.
  – Flexible electronics
    • The minimal amount of success for this subsystem to be considered a success is if data is gathered to prove or disprove the working of a flexible electronic board.
Expected Results

• **De-spun video**
  – At 30 fps during spin, a max of 5Hz, 6 pictures per rotation should be acquired.
  – Field of view angle must be greater than 60° to acquire overlapping images which can be combined on an updated panorama.

• **Flexible electronics**
  – Bending may short components or break fragile connections. The polymer may develop micro cracks or cracks large enough to be visible. Resistance of the wires may decrease due to cold but increase due to stretched connections.
**Concept of Operations**

**Altitude**

- **t = 0 min**
  - G switch triggered
  - All systems on
  - Begin data collection

- **t ≈ 1.25 min**
  - Altitude: 81 km
  - *Open container to space*

- **End of Orion Burn**
  - t ≈ 0.6 min
  - Altitude: 52 km

- **Chute Deploys**
  - t ≈ 7.5 min
  - Altitude: 54 km
  - Experiments Off

- **Apogee**
  - t ≈ 3.3 min
  - Altitude: ≈150 km

- **Shut Container**
  - t ≈ 5.25 min
  - Altitude: 91 km

- **Splash Down**
  - t ≈ 15 min
  - Altitude: 81 km

- **t ≈ 5.75 min**
  - Altitude: 54 km
  - Experiments Off

**Note:** The diagram includes annotations indicating key timeline points and associated actions.
System Overview
Design Overview

• Necessary items
  – Motors
  – GoPro or other video camera
  – Arduino
  – Custom PCB
Functional Block Diagram

Blue - Signal
Red - Power

GSE1
GSE2
GND
Parallel bits

Power

Motors
Motor Controller
ASI PCBs

Arduino

Go Pros
Go Pro Controller
## Critical Interfaces

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>Brief Description</th>
<th>Potential Solution</th>
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<tr>
<td>PB/STR</td>
<td>The power board will need to mount to the RockSat-X deck to fix them rigidly to the launch vehicle. The connection should be sufficient to survive 20Gs in the thrust axis and 10 Gs in the lateral axes.</td>
<td>Standoffs used in previous experiments under similar conditions will be used for mounting.</td>
</tr>
<tr>
<td>ARD/STR</td>
<td>The Arduino will need to mount to the RockSat-X deck rigidly. The connection should be sufficient to survive 20Gs in the thrust axis and 10 Gs in the lateral axes.</td>
<td>Standoffs used in previous experiments under similar conditions will be used for mounting.</td>
</tr>
<tr>
<td>MTR/STR</td>
<td>The motors must rigidly connect to the inside of the FleX box. The connection should be sufficient to survive 20Gs in the thrust axis and 10 Gs in the lateral axes.</td>
<td>Mounting brackets will be used to hold the motor in place in the x, y, and z-plane.</td>
</tr>
<tr>
<td>CMR/STR</td>
<td>The Go Pro cameras will need to mount to the RockSAT-X deck rigidly. The connection should be sufficient to survive 20Gs in the thrust axis and 10 Gs in the lateral axes.</td>
<td>Cases will be made for the Go Pro Cameras to mount them to the deck.</td>
</tr>
<tr>
<td>MTR/EPS</td>
<td>The motors will be need power separate from the uC as to further protect back emf from the Arduino. The motor controller will be controlled by the Arduino.</td>
<td>A JST Female to Molex Power Adapter will connect the PB to the motors. They will be connected through the motor controller.</td>
</tr>
<tr>
<td>ARD/EPS</td>
<td>The Arduino requires 5-9V DC to run. It will also need a common GND to our board.</td>
<td>The 9V battery connector will be connected from the Arduino to the PB.</td>
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## Requirement Verification

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<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
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<tr>
<td>No more than ½ amp hour</td>
<td><strong>Analysis</strong></td>
<td>All electronics will use less than half of a “canister’s” allotted power over the entirety of the flight</td>
</tr>
<tr>
<td>The full system shall fit on a single RockSat-X deck</td>
<td><strong>Inspection</strong></td>
<td>Visual inspection will verify this requirement</td>
</tr>
<tr>
<td>The sytem shall survive the vibration characteristics prescribed by the RockSat-X program.</td>
<td><strong>Test</strong></td>
<td>The system will be subjected to these vibration loads in June during testing week.</td>
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</table>
RockSat-X 2013 User’s Guide Compliance

- Rough Order of Magnitude (ROM) mass estimate 3lbs
- Estimate on payload dimensions (will it fit in the payload space?) Yes
- Deployables/booms? No
- How many ADC lines? None as of now.
- Asynchronous use? None as of now.
- Parallel use? Yes
- Power lines and timer use? Yes.
- CG requirement
  - Yes and we will follow the requirement
- Are you utilizing high voltage? No.
Sharing Logistics

• We need a partner and would like to be paired up. Our experiment could be on top or underneath a plate.
Subsystem Design
Flexible Electronics

- Two motors will rotate, flexing the electronic substrate in multiple directions.
- Another flexed substrate will run electronic tests during the flight
- A GoPro will record the flight
De-spun video

• A GoPro will record video away from the rocket. This will be controlled by an Arduino through the pins on the connector socket

• The GoPro will hold data on an SD card until it can be recovered

• Weight ~ 1.5lb
Organizational Chart

Dr. Lawrence
Dr. Parke
Team Advisors

Benjamin Gordon
Team Leader

Drew Johnson
Mechanical Lead

Jameson Krueger
Lukas Rieke
Aaron Ewing
Dakota Martin
Patrick Richardson

Seth Leija
Electrical / Software Lead

David Vinson
Darrell Leber
Alex Hanson

Ryan Lofthouse
Jon Hamilton

Chad Larson
Mentor
Test/Prototyping Plan
Test/Prototyping Plan

• Going to ASI for flex electronics within the next two weeks and can get a prototype

• We have access to a 3d printer to prototype the cases and can get access to motors
Project Management Plan
Schedule

- Design
- Manufacturing/Assembly
- Subsystem Testing
- Integrated Testing
- Post-test Correctios
- Wallops Trip #1
- Final Preparations
- Launch
- Post-flight Analysis
- Final Report
## Budget

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<th>Parts list</th>
<th>Supplier</th>
<th>Estimated cost</th>
<th>Quantity</th>
<th>Total Cost</th>
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<td>Motors</td>
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<td>$0.00</td>
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$595.00
# Team Availability Matrix

## Team Name/School Here: NNU

### Fall 2012 RS-X Team Availability Matrix

<table>
<thead>
<tr>
<th>Time</th>
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<th>Tuesday</th>
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<th>Thursday</th>
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Team Name/School Here: Northwest Nazarene University

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Phone</th>
<th>Email</th>
<th>Citizenship</th>
<th>OK to Add to Mailing List?</th>
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<tbody>
<tr>
<td>PM</td>
<td>Benjamin Gordon</td>
<td>541-852-1662</td>
<td><a href="mailto:bendoo02@gmail.com">bendoo02@gmail.com</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Elec Lead</td>
<td>Seth Leija</td>
<td>208-703-2592</td>
<td><a href="mailto:sleija@nnu.edu">sleija@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Mech Lead</td>
<td>Drew Johnson</td>
<td>253-970-7899</td>
<td><a href="mailto:drewjohnson@nnu.edu">drewjohnson@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Elec</td>
<td>David Vinson</td>
<td></td>
<td><a href="mailto:dvinson@nnu.edu">dvinson@nnu.edu</a></td>
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<tr>
<td>Elec</td>
<td>Darrell Leber</td>
<td></td>
<td><a href="mailto:dleber@nnu.edu">dleber@nnu.edu</a></td>
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</tr>
<tr>
<td>Software</td>
<td>Alex Hanson</td>
<td></td>
<td><a href="mailto:ahanson@nnu.edu">ahanson@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Software</td>
<td>Ryan Lofthouse</td>
<td></td>
<td><a href="mailto:rlofthouse@nnu.edu">rlofthouse@nnu.edu</a></td>
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<tr>
<td>Software</td>
<td>Jon Hamilton</td>
<td></td>
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<tr>
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<td>Yes</td>
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<tr>
<td>Mech</td>
<td>Lukas Rieke</td>
<td></td>
<td><a href="mailto:trieke@nnu.edu">trieke@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<td>Yes</td>
</tr>
<tr>
<td>Mech</td>
<td>Dakota Martin</td>
<td></td>
<td><a href="mailto:austinmartin@nnu.edu">austinmartin@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mech</td>
<td>Patrick Richardson</td>
<td></td>
<td><a href="mailto:prichardson@nnu.edu">prichardson@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mentor</td>
<td>Chad Larson</td>
<td></td>
<td><a href="mailto:chadlarson@nnu.edu">chadlarson@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Conclusion

• What are non-redundant timers?
• How could outgassing affect our experiment?
• How could we contain our experiment yet not vacuum seal it?
• How will the electronics survive in the vacuum of space?