Flexible Printed Disposable Airfoil Sensors
Conceptual Design Review

Northwest Nazarene University
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Submitted: 10/14/13
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Mission Overview: Mission Statement

The Northwest Nazarene University (NNU) RockSAT-X 2014 payload will release several 3D printed airfoil shapes into space to test for flight stability in low atmospheric conditions. In addition to simple airfoils, NNU desires to mount flexible sensors onto some of the airfoil structures and store sensor data. The stored data combined with video footage of the airfoils will help determine the optimal airfoil design that minimizes damage to the airfoil on reentry and maximizes stability of the airfoil.
Mission Overview: Mission Statement

Data will be retained through one or more of the following: tethering, RFID, and/or satellites. This data retained from the airfoils including accelerations, temperature, and video footage of flight paths will benefit the Printable Spacecraft program run through NASA Jet Propulsion Laboratory (JPL) program directed by Dr. Kendra Short. This data will help determine ideal structures and sensor capabilities for a data reconnaissance of an extraterrestrial body.

Program description
Source: JPL Printable Spacecraft
Mission Overview: Mission Objectives

- Deploy several 3D printed airfoils
  - Some airfoils equipped with sensors
- Retrieve sensor data from sensor enabled airfoils
- Obtain video footage of airfoil deployment

Minimum success criteria
- Deploy one sensor enabled airfoil
- Retrieve sensor data from sensor
Mission Overview: Theory and Concepts

- NNU RockSAT-X 2013 and RockSAT-C 2012: Testing flexible electronics
  - FleX Silicon-on-Polymer from American Semiconductor Inc.
  - RS-X tested durability of flexible assemblies in open environment of space
- Proved flexible electronic assemblies can survive launch and exposure to space without sacrificing electrical qualities
Mission Overview: Theory and Concepts

- NASA JPL program: Printable Spacecraft
  - Atmospheric Confetti
  - Battery, memory, antenna, integrated circuits, solar cell, gas sensor
  - Conformably mounted to 3D printed airfoils

Maturity and Functionality of Sensors
JPL Printable Spacecraft
Mission Overview: Theory and Concepts

- Maple seeds are formed in shapes similar to helicopter blades and create stability and orientation of flight
- Iconic spinning descent as opposed to straight down plummet
  - Reduced speed
- NNU has designed and printed some maple seed structures to begin testing
Mission Overview: Expected Results

- Video of airfoil deployment
- Airfoils orient themselves in the sparse atmosphere
- Airfoil design restricts descent to smooth controlled float rather than plummet
- Temperature and pressure sensor data coincide with onboard sensor
Design Overview: Engineering Design

- The deployment device, “Revolver”, is a rotating fan inside a cylinder that pushes the airfoils out a port.

- The system utilizes an inner track on the top and bottom of the cylinder to guide the airfoils, ensuring a controlled launch through the port.

- The rotation of the walls will be controlled through a motor by the controller (Arduino, Raspberry Pi, etc.)
Design Overview: Science Design

• Sensors/Devices to be used
  – Optical sensor, two cameras, and a shaft encoder
  – Deployable sensors: flexible accelerometer, tethering/RFID data recon, pressure sensors

• The optical sensor notifies control unit the skin is off.

• A camera or optical sensor will guide the revolver to deploy towards Earth.

• Finally the shaft encoder will check the success of the deployment while the controller communicates with the sensors aboard the airfoils.
Functional Block Diagram

I/O Legend
- Data
- Power (6v-28v)
- Input Signal
Design Overview: Payload Layout
Design Overview: Revolver Deployment Layout
Design Overview: RockSAT-X User’s Guide Compliance

- Rough Order of Magnitude (ROM) weight estimate **15 lb.**
- Estimate on payload dimensions (will it fit in the payload space?) **YES**
- Deployables/booms? **YES**
- How many ADC lines? **TBD**
- Asynchronous/Parallel use? **TBD**
  - Do you understand the format? **YES**
- Power lines and timer events use? **TBD**
- CG requirement
  - Do you understand the requirement? **YES**
- Are you utilizing high voltage? **NO**
- Hazardous Procedures?
- RF? **YES**
- Bolt heads on bottom of deck flush mount? **YES**
- US Persons for whole team? **YES**
- ITAR?
Management

- Team organization chart
- Preliminary schedule for the semester
- Monetary budget
- Contact Matrix
- Team Availability (MDT) Matrix
## Budget

### NNU RockSAT-X 2014 Team Budget

<table>
<thead>
<tr>
<th>Category</th>
<th>Item</th>
<th>Cost</th>
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<tr>
<td><strong>Hardware:</strong></td>
<td>Controller</td>
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<tr>
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<td>Camera(s)</td>
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<td>Electronics</td>
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# Contact Matrix

## Team Name/School Here: Northwest Nazarene University

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<tr>
<th>Role</th>
<th>Name</th>
<th>Day Phone</th>
<th>Cell Phone</th>
<th>Receive Texts?</th>
<th>Email</th>
<th>Citizenship</th>
<th>OK to Add to Mailing List?</th>
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<tbody>
<tr>
<td>Team Leader</td>
<td>Andrew Johnson</td>
<td>253-970-7899</td>
<td>253-970-7899</td>
<td>Yes</td>
<td><a href="mailto:drewjohnson@nnu.edu">drewjohnson@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical Lead</td>
<td>Alex Hanson</td>
<td>509-690-8021</td>
<td>509-690-8021</td>
<td>Yes</td>
<td><a href="mailto:ahanson@nnu.edu">ahanson@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Mech Team</td>
<td>Connor Back</td>
<td>NA</td>
<td>503/991/2316</td>
<td>Yes</td>
<td><a href="mailto:cback@nnu.edu">cback@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Mechanical Lead</td>
<td>Lukas Rieke</td>
<td>509-845-9833</td>
<td>509-845-9833</td>
<td>Yes</td>
<td><a href="mailto:lrieke@nnu.edu">lrieke@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical Team</td>
<td>Matthew Spires</td>
<td>208-553-3540</td>
<td>same</td>
<td>Yes</td>
<td><a href="mailto:mspires@nnu.edu">mspires@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Mech/Electrical Team</td>
<td>Jordan Poundstone</td>
<td>208-477-7636</td>
<td>Yes</td>
<td></td>
<td><a href="mailto:jpoundstone@nnu.edu">jpoundstone@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Mech Team</td>
<td>Caleb Wolf</td>
<td>253-820-7527</td>
<td>253-820-7527</td>
<td>Yes</td>
<td><a href="mailto:Cwolf@nnu.edu">Cwolf@nnu.edu</a></td>
<td>U.S.</td>
<td>Yes</td>
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<tr>
<td>Lead Programmer</td>
<td>Devon Ellis</td>
<td>NA</td>
<td>208-859-5446</td>
<td>Yes</td>
<td><a href="mailto:Dellis@nnu.edu">Dellis@nnu.edu</a></td>
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## Team Availability Matrix (MDT)

### Northwest Nazarene University

Fall 2013 RS-X Team Availability Matrix

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<th>Time</th>
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PLEASE USE MOUNTAIN TIME ZONE TIMES
Risks/Worries:

• Government shutdown will restrict NASA collaboration
• Tethering method will restrict flight of airfoils
• Airfoils will break/move around during launch
• Orientation of rocket could inhibit trajectory of airfoils
Conclusion

• By flying in the RockSAT-X 2014 program, the NNU team will gain information vital to NASA JPL’s Printable Spacecraft program. The proof-of-concept airfoils must be tested in the environment of space to better understand their behavior in high and ultrahigh cryogenic situations. By allowing NNU to act as a delivery method for the Printable Spacecraft program, JPL does not have to spend hundreds of thousands of dollars on performing its own rocket launch and can speed up the program timeline.

• Next steps
  – Determine orientation of rocket at apogee
  – Progress collaborative working relationship with Dr. Kendra Short, head of Printable Spacecraft program
  – Test airfoil shapes
  – Focus down design ideas