University of Delaware

ROCKSAT-C STR

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RockSat-C 2018
STR
STR Presentation Contents

- Section 1: Mission Overview
- Section 2: Subsystem Design
  - INS
  - Mechanical Setup
  - Device under test
  - Power
- Section 3: User Guide Compliance
- Section 4: Project Management Plan
Mission Overview
Mission Statement

Demonstrate the durability and test performance characteristics of a graphene-silicon based optical chip under launch conditions. Additionally, construct and test a reusable inertial navigation system and platform for future ROCKSAT-C missions. Provide a platform for other students to include micropayloads.
Mission Overview

- **Primary payload:**
  - Test silicon-graphene photonic devices for mechanical/electrical reliability under launch conditions
  - Parallel testing being done on radiation resistance of chips
  - Many potential applications

- **Secondary payloads:**
  - Inertial Navigation System - Track position of satellite without use of GPS + outside trackers
    - Need for systems to track position without outside references
  - Reusable payload platform
    - Power buses + vital sensors (3 axis accelerometer + gyroscope)
    - Space for micropayloads designed by other students
Mission Overview

● Project Requirements
  ○ Must be able to accurately measure μA-level currents
  ○ Must be able to track payload position with minimal drift
  ○ Need system to store and offload data
  ○ Must be able to support several micropayloads and their power/data/processing requirements

● Minimum success criteria
  ○ Alternatively: identify time + forces on payload at time of failure

● Comprehensive Success Criteria
  ○ Recover the IV curve data and the intact photonic device
  ○ Measure forces, acceleration, orientation of payload
  ○ Return all collected data to creators of the micropayloads
Mission Overview

● Mission Timeline:
  ○ Systems must record data before, during and after launch and flight
    ■ Will simultaneously be measuring forces/acceleration on payload
  ○ Need to see if forces on payload at launch time cause devices to fail
    ■ Turning on after liftoff means we may not have any usable data in case of failure at launch
  ○ Therefore, systems should be powered on and be recording around t-3 minutes to launch
    ■ Potentially could be closer to launch, depending on how long boot time for systems is
Mission Overview

● Expected Results:
  ○ For the I-V curves of the photonic device we would expect graphs similar to below
De-Scopes and Off-Ramps

Potential Issues:

- May not be able to package photonic devices by launch
  - Will just test device ability to survive flight and only test on ground
- May not have INS board working by flight
  - Have backup INS system to use
- May not enough power to supply to micropayloads
  - Can increase amount of power storage on board, or drop micropayloads
- May not have any micropayloads ready in time
  - Micropayload stack can be removed from the final design
Subsystem Design
Inertial Navigation System
New INS Electrical Diagram

- New accelerometer (H3LIS331DL)
- Connections
  - Data (SDA)
  - Clock (SCL)
  - Power (3.3V)
  - Ground
  - Interrupt
INS Code

- Used open source code as a starting point
- Works at a baseline level
- Needs to be calibrated
- SD card storage code needs to be added

```c
#include <SparkFun_INS303.h>
#include <Wire.h>

L3S01 x1;

void setup()
{
    // put your setup code here, to run once:
    pinMode(9, INPUT); // Interrupt pin input
    Wire.begin();
    x1.begin();
    // This MUST be called BEFORE .begin() so
    // .begin() can communicate with the chip
    x1.begin(L3S01::ONLY_I2C); // Selects the bus to be used and sets
    // the power up bit on the accelerometer.
    // Also zeroes out all accelerometers
    // registers that are user writable.
    // This next section configures an interrupt. It will cause pin
    // INT1 on the accelerometer to go high when the absolute value
    // of the reading on the Z-axis exceeds a certain level for a
    // certain number of samples.
    x1.config(L3S01::INT_SRC, 1); // Select the source of the
    // signal which appears on pin INT1. In
    // this case, we want the corresponding
    // interrupt’s status to appear.
    x1.setThreshold(50, 1); // Number of samples a value must meet
    // the interrupt condition before an
    // interrupt signal is issued. As the
    // default rate of 50Hz, this is one sec.
    x1.enableInterrupt(L3S01::Z_AXIS, L3S01::INT30_ON_HIGH, 1, true); // Enable the interrupt. Parameters indicate
    // which axis to sample, when to trigger
    // (in this case, when the absolute mag
    // of the signal exceeds the threshold),
    // which interrupt source we’re configuring,
    // and whether to enable (true) or disable
    // (false) the interrupt.

    Serial.begin(115200);
}

void loop()
{
    static long loopTime = 0;
    int x, y, z;
    if (millis() - loopTime > 1000)
    {
        loopTime = millis();
        x1.readAxes(&x, &y, &z); // The readAxes() function transfers the
        // current axis readings into the three
        // parameter variables passed to it.
        Serial.print("x: "); Serial.println(x);
        Serial.print("y: "); Serial.println(y);
        Serial.print("z: "); Serial.println(z);
        // Serial.print("\n");
        // Serial.println(x1.convertToG(0, x)); // The convertToG() function
        // Serial.println(x1.convertToG(0, y)); // accept as parameters the
        // Serial.println(x1.convertToG(0, z)); // raw value and the current
        // Serial.print("\n"); // maximum g-rating.
    }
    if (digitalRead(0) == HIGH)
    {
        Serial.println("Interrupt");
    }
}
```
INS Block Diagram

SD Card → Teensy 3.5
   Analog I/O

+5V → Teensy 3.5
SDA (Data) → 3 Axis Accelerometer
SCL (Clock) → 3 Axis Gyroscope

PWR Board

+5V → PWR Board
GND → Teensy 3.5

INS Tasks to Complete

- Better calibrate the accelerometer
  - Should read all zeros at rest

- Design and fabricate PCB
  - Very simple design
  - Already know necessary connections

- Write code to save data to SD card
  - Hardest part
  - Have some reference code as a starting point
Mechanical Drawing for Support Platform
In Progress New CAD Drawing

- Red represents the micro payloads
- Blue represents the DUT
- Yellow represents the accelerometer
- Everything is in Inches
Current Part list

- The Circular Plate we plan to custom purchase or build.
  - The remaining parts will be bought from McMaster Carr.
- 48 Phillips Head screws (shorter)
  - 48 Washers [https://www.mcmaster.com/#washers/=1b8fq69](https://www.mcmaster.com/#washers/=1b8fq69)
  - 48 Nuts [https://www.mcmaster.com/#nuts/=1b8fqr1](https://www.mcmaster.com/#nuts/=1b8fqr1)
- 32 Phillips Head screws (Longer)
  - 32 Washers [https://www.mcmaster.com/#washers/=1b8fq69](https://www.mcmaster.com/#washers/=1b8fq69)
  - 32 Nuts [https://www.mcmaster.com/#nuts/=1b8fqr1](https://www.mcmaster.com/#nuts/=1b8fqr1)
- 32 Right Angle Brackets [https://www.mcmaster.com/#angle-brackets/=1b8fr32](https://www.mcmaster.com/#angle-brackets/=1b8fr32)
- 32 Right Angle Brackets [https://www.mcmaster.com/#angle-brackets/=1b8fr32](https://www.mcmaster.com/#angle-brackets/=1b8fr32)
- 8 Rectangular Prisms [https://www.mcmaster.com/#hollow-bars/=1b8g5dz](https://www.mcmaster.com/#hollow-bars/=1b8g5dz)
- Spec sizes have yet to be finalized.
Future Plans for Finishing the AutoCAD Drawing

- The only thing that needs to be learned is to how to accurately position objects on one another.
  - This will be learned by asking Mechanical Engineering friends for help.
  - Once this is learned we will be able to make a full AutoCAD drawing and can begin assembly.
Device Under Test
Current Status

- Awaiting device from Dr. Gu
  - Looking to move forward with device in coming weeks
- Hardware + software nearly ready to go
- Looking for final answer in next few weeks
Device Under Test Board
Electrical Schematic - Device Under Test Board
Electrical Schematic - Device Under Test Board
Future Plans

● Confirm device availability with Dr. Gu in the next week or so
  ○ Transition to backup plan if we are unable to acquire device soon

● If proceeding with the current plan:
  ○ Test devices and package
  ○ Integrate into flight system

● Otherwise:
  ○ Switch to backup plan
Backup Plan

- Build inexpensive muon detector as primary payload
  - Use plastic scintillator + silicon photomultipliers to detect presence of muons
  - Record data using Teensy 3.5
- Plan to replicate work described here:
  The Desktop Muon Detector: A simple, physics-motivated machine- and electronics-shop project for university students
Power Board
Power/Micropayload Board

Figure 1: 1.SYS.1 Activation Diagram

Figure 2: Power and M.P. boards
Electrical Schematic - Power Board

VCC Power Supply (5V and 3.3V)
Electrical Schematic - Power Board

DUT Bias Power Supply
Electrical Schematic - Power Board

Power Board Combined Schematic
Micropayload Stack

- Top Board (white)
  - Arduino Pro
  - Storage
  - Micropayload occupies top board (and potentially free space on bottom board)

- Bottom Board (red)

Inputs:
- +5V
- TX/RX
User’s Guide Compliance

- Predicted weight: 5 lbs.
  - Will need to increase weight with plates/additional batteries
- Size:
  - No large components on DUTB or INS boards
- CG will be within 1 in. x 1 in. 1 in. of center of canister
- Will need to coordinate with canister partner to verify CG
  - Still need canister partner
  - No preference to top or bottom
- Will not need port
- Will be well under 1A current limit for wires
User Guide Compliance
Weight Budget

- Estimate that each board will be similar in weight
- Consists of entirely solid state components
- Significantly underweight
- Will add ballast of lead weights

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Mass (g)</th>
<th>Mass (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Board</td>
<td>180 (estimate)</td>
<td>0.397 (estimate)</td>
</tr>
<tr>
<td>INS Board</td>
<td>180</td>
<td>0.397</td>
</tr>
<tr>
<td>DUBT Board</td>
<td>180 (estimate)</td>
<td>0.397 (estimate)</td>
</tr>
<tr>
<td>Batteries</td>
<td>90</td>
<td>0.198</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>630</strong></td>
<td><strong>1.39</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>1637</strong></td>
<td><strong>3.61</strong></td>
</tr>
</tbody>
</table>
## Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage</th>
<th>Max Current</th>
<th>Time on (min)</th>
<th>mAh</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micropayloads</td>
<td>3.3V - 5V</td>
<td>100 uA * 3 payloads</td>
<td>180</td>
<td>0.9</td>
<td>1.5 mW</td>
</tr>
<tr>
<td>DUT</td>
<td>5V</td>
<td>100 mA</td>
<td>180</td>
<td>300</td>
<td>500 mW</td>
</tr>
<tr>
<td>INS</td>
<td>5V</td>
<td>50 mA</td>
<td>180</td>
<td>150</td>
<td>250 mW</td>
</tr>
</tbody>
</table>

All subsystems will remain on for the entire flight and recovery process.
Project Management Plan
Team Organization

● Jingcheng Lu - Student Project Team Leader - ariclu@udel.edu
  ○ Co-designer of the DUT board
  ○ Main contact with ROCKSAT-C program
● Ryan Beneck - Team Member - rbeneck@udel.edu
  ○ Designer of the INS board
● Benjamin Steenkamer - Team Member - bsteen@udel.edu
  ○ Designer of the power/micropayload board
● Anton Vasilyev - Team Member - vasilyev@udel.edu
  ○ Co-designer of the DUT board
● Dr. Chase Cotton - Faculty Supervisor - ccotton@udel.edu
Team and Project Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/31/2017</td>
<td>Preliminary Design Review (CoGSC)</td>
</tr>
<tr>
<td>11/3/2017</td>
<td>Fall Midterm Report (UDEL)</td>
</tr>
<tr>
<td>11/30/2017</td>
<td>Schematics + Mechanical Diagrams Finished</td>
</tr>
<tr>
<td>12/4-12/8/2017</td>
<td>Critical Design Review (CoGSC)</td>
</tr>
<tr>
<td>12/5-12/7/2017</td>
<td>Fall Final Presentation (UDEL)</td>
</tr>
<tr>
<td>12/10/2017</td>
<td>Fall Final Report and Software (UDEL)</td>
</tr>
<tr>
<td>12/5/2017</td>
<td>Begin building subsystems (continue over winter break)</td>
</tr>
<tr>
<td>12/5/2017</td>
<td>Finalize micro-payload selection</td>
</tr>
<tr>
<td>1/22-1/25/2018</td>
<td>Subsystem Testing Review (CoGSC)</td>
</tr>
<tr>
<td>3/19/2018</td>
<td>Finish Building Subsystems + Integration</td>
</tr>
<tr>
<td>3/30/2018</td>
<td>Vibration Testing</td>
</tr>
<tr>
<td>4/9/2018</td>
<td>Begin integrating payload into launch canister</td>
</tr>
<tr>
<td>6/13/2018</td>
<td>Travel to WFF for pre-launch testing</td>
</tr>
<tr>
<td>6/21/2018</td>
<td>Launch Day</td>
</tr>
</tbody>
</table>
Budget

- Funding secured from Delaware Space Grant Consortium
  - Will verify procedure for payment
Conclusion

● Future Plans
  ○ Build/complete prototypes
  ○ Test INS code
  ○ Collaborate with CVORG to complete wire bonding of the photonic chip to a platform
    ■ Measure I-V curves
  ○ Finding students willing to design micropayloads
    ■ Create backup systems on payloads if no one submits a design
  ○ Design redundant power supply
  ○ Have PCBs designed and fabricated