WV SPACE

Subsystem Testing Review

WVU MU FSU BRCTC WVU-TECH BVCTC SU WVWC WVSU NASA IV&V

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2/24/2016

Presentation Outline

- Section 1: Mission Overview
- Section 2: Final Design Description
- Section 3: Subsystem Status & Testing Results
  - 3.0a: West Virginia University
  - 3.0b: Marshall University
  - 3.0c: West Virginia State University
  - 3.0d: Shepherd University
  - 3.0e: West Virginia University Institute of Technology
  - 3.0f: Bridge Valley Community & Technical College
  - 3.0g: Blue Ridge Community & Technical College
  - 3.0h: Fairmont State University
  - 3.0i: West Virginia Wesleyan College
- Section 4: Full System Testing Plan
- Section 6: Project Management Update
- Section 7: User Guide Compliance

1.0 Mission Overview

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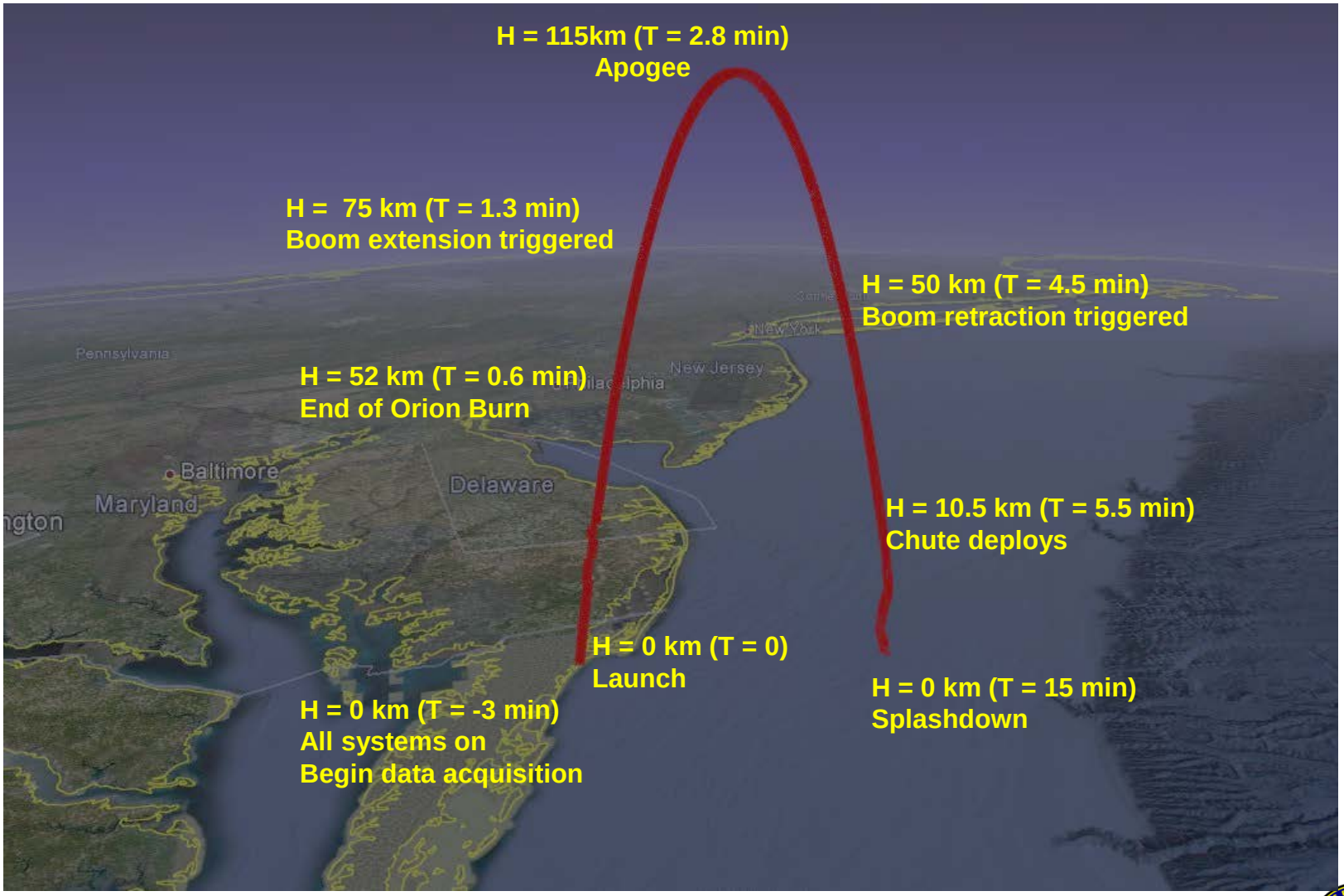
WV RSC'16 Mission Overview

- Goal: Develop and test several science and engineering experiments for space operations
- Objectives:
  - Capture NIR Earth images from space
  - Measure plasma density in upper atmosphere
  - Measure atmospheric pressure and magnetic field of Earth
  - Gather redundant flight dynamics data
  - Determine attitude in space relative to sun
  - Strain of ABS plastic in space
- Port Access: Optics port (1) and Multipurpose port (2)
- Benefits SmallSat community
  - Develop COTS orientation estimation techniques
  - Develop low-cost Langmuir probe package for plasma studies
  - Prove feasibility of 3D printed structural elements

Concept of Operations



2.0 Final Design Description

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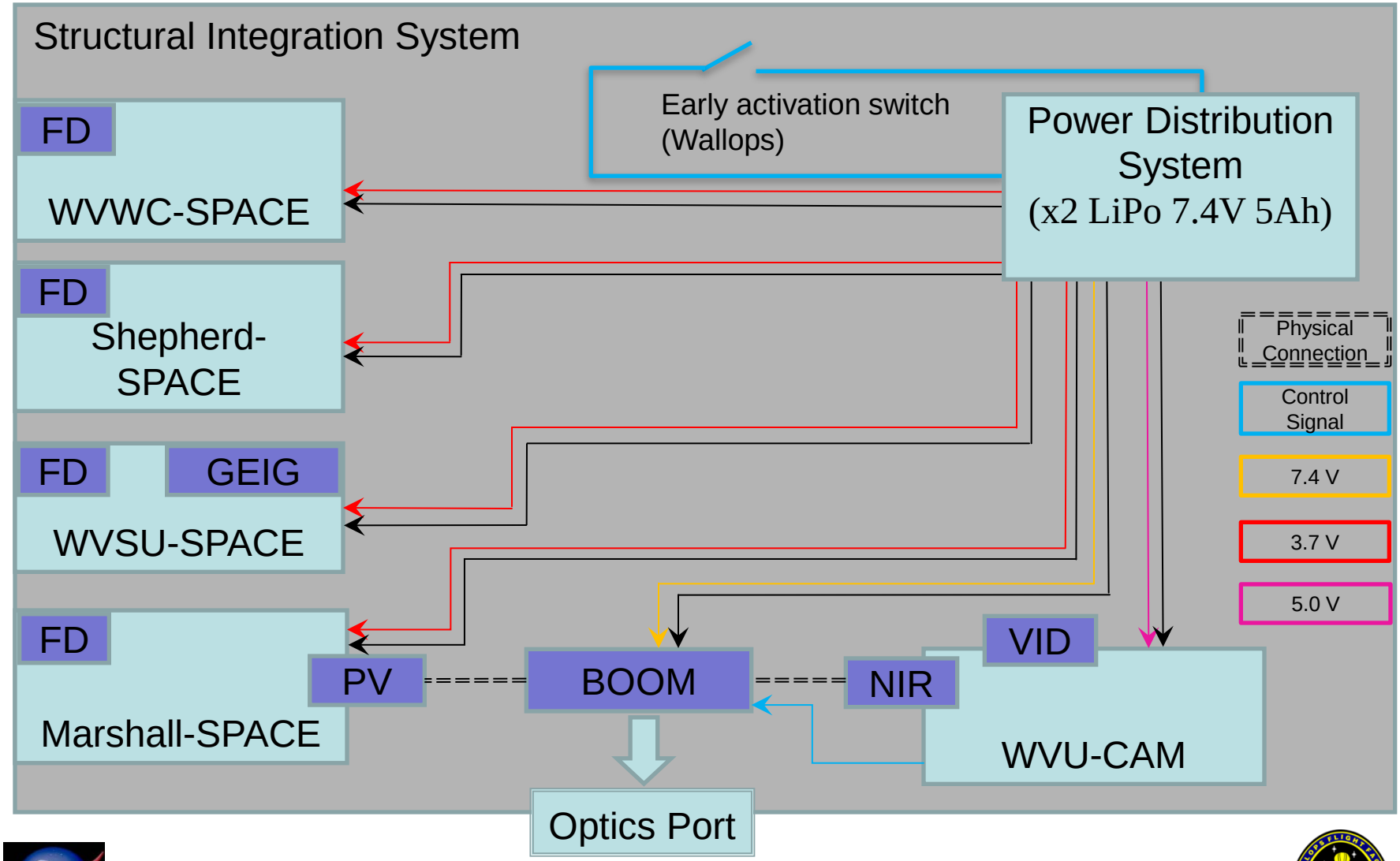
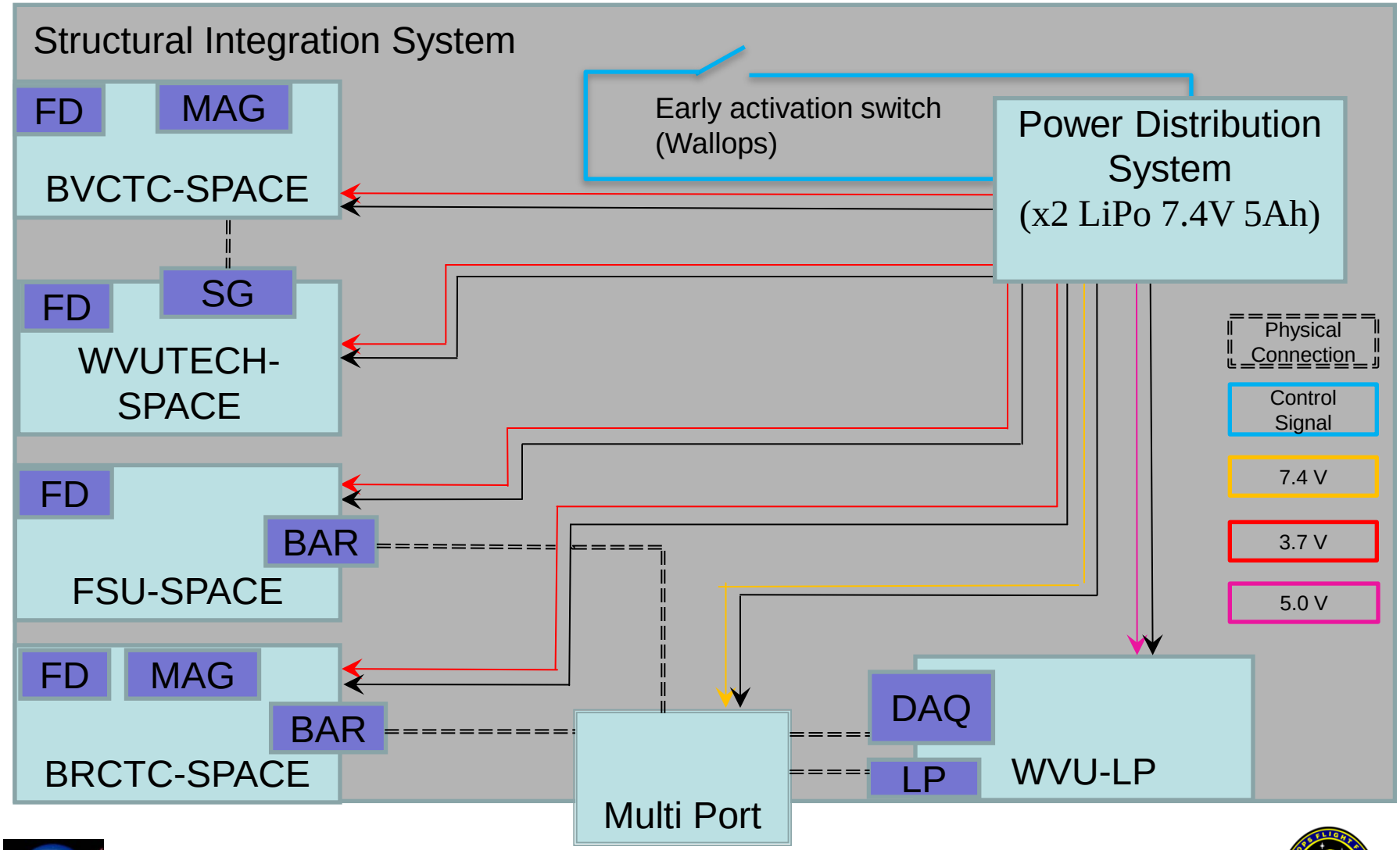
System Level Block Diagram: Lower Section



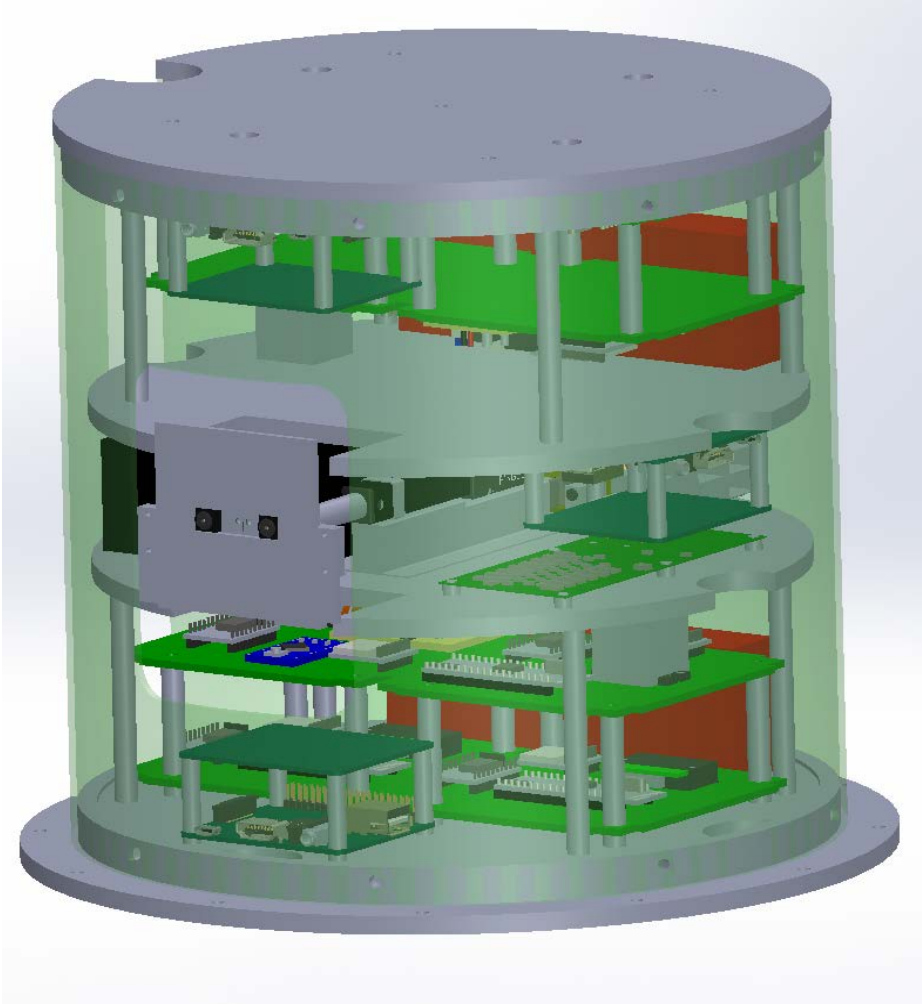
System Level Block Diagram: Upper Section

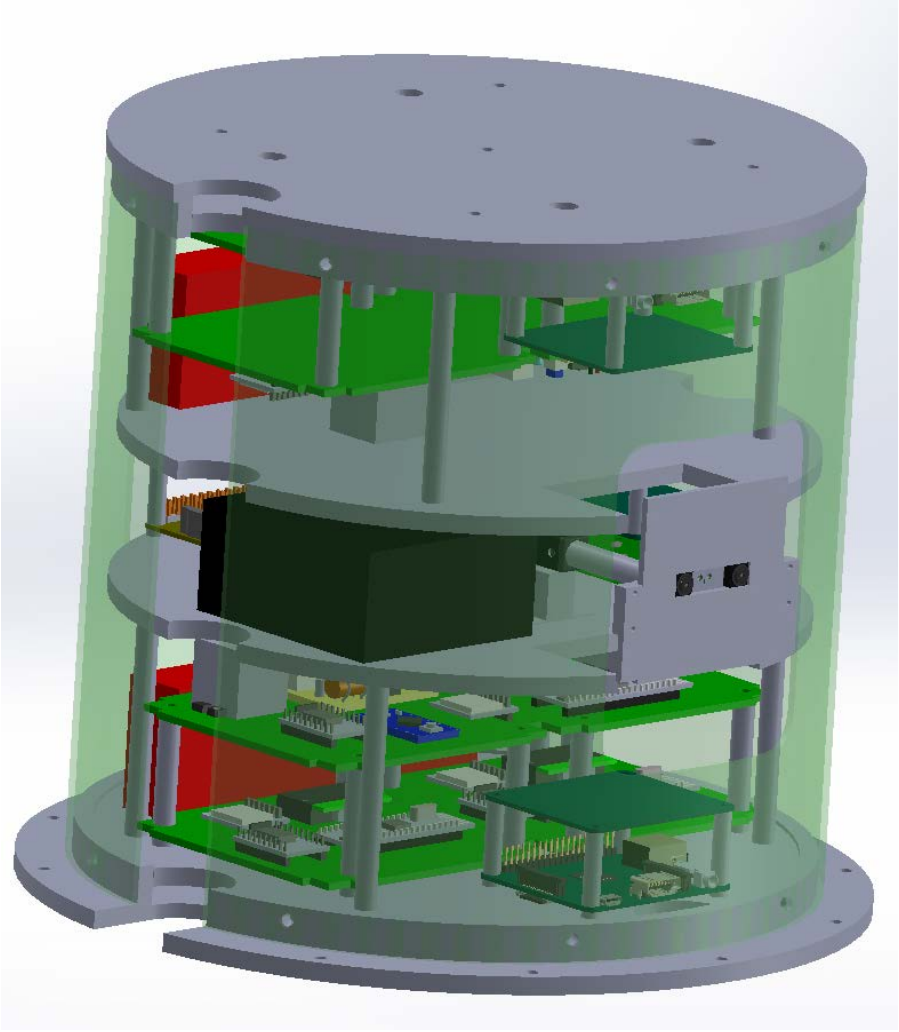


Changes from CDR

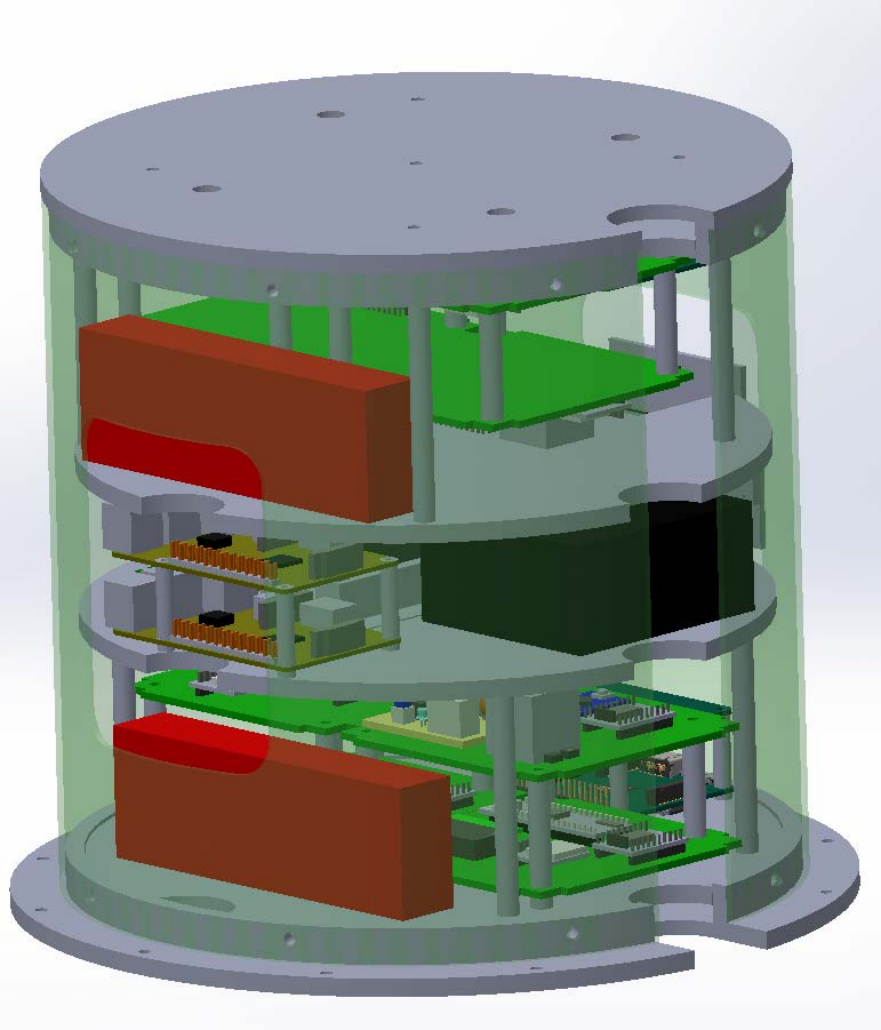
- WVU
  - Link Raspberry pi cameras (network)
- FSU
  - Now implementing a Honeywell HMC2003 Sensor to help with error correction
- BVCTC
  - Eliminated through-hole on printed structure (strength requirements)
  - Removed 2nd redundant IMU (limited by available Arduino pins)

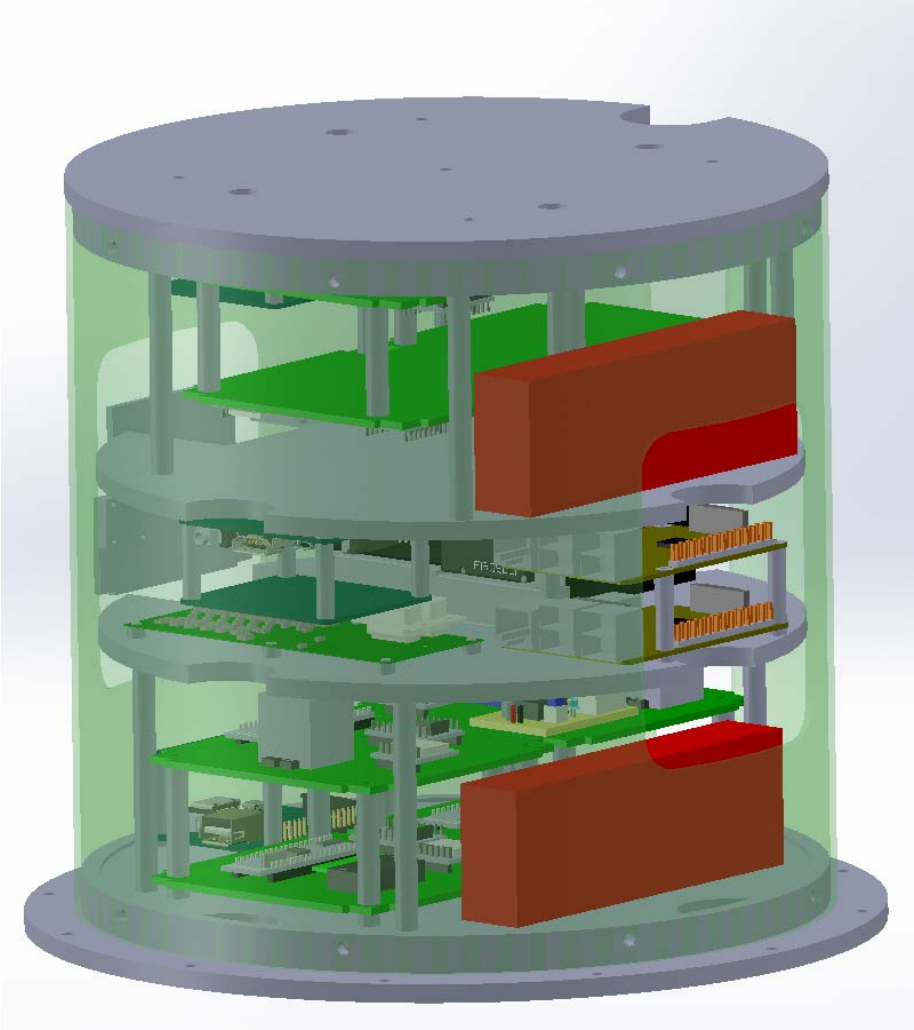
Mechanical Model: Isometric Front



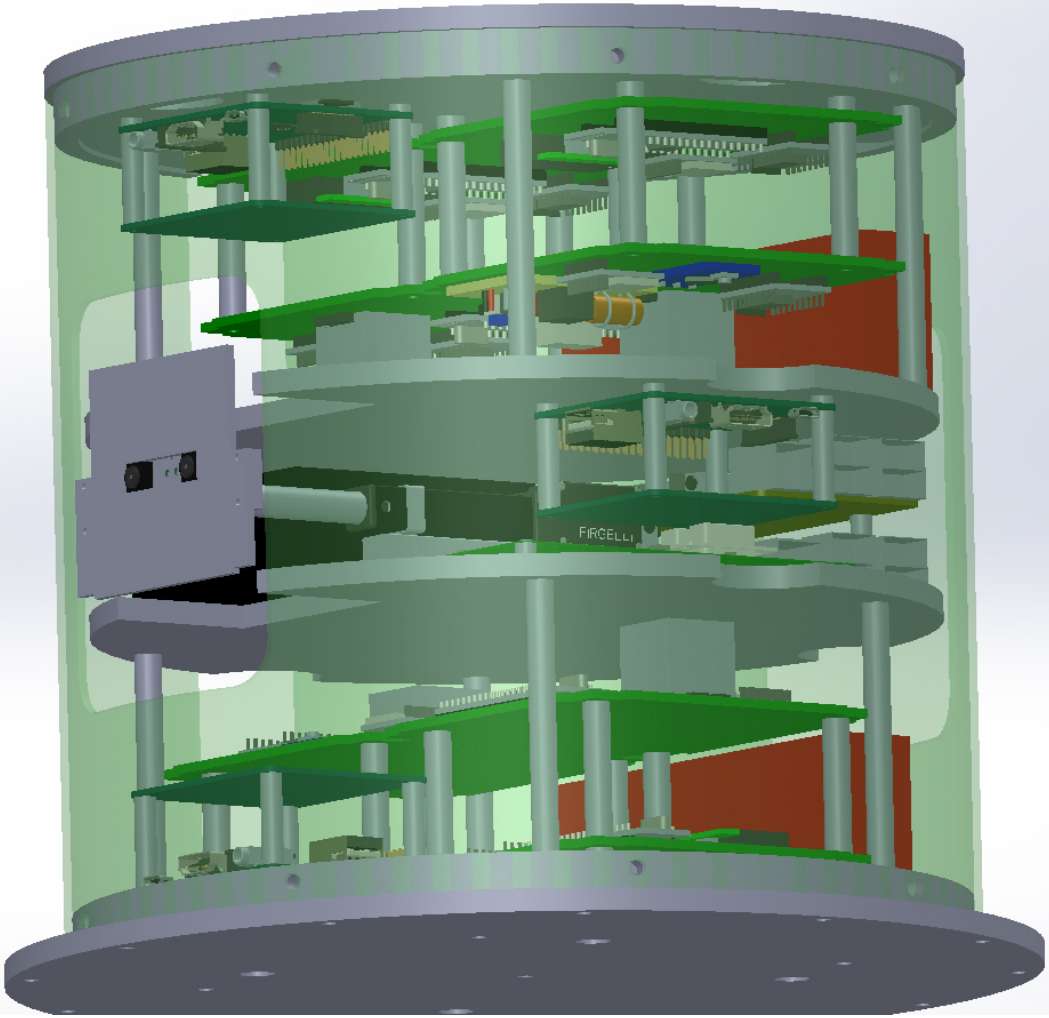


Mechanical Model: Isometric Back





Mechanical Model: Isometric Up



Detailed Mass Budget

WV-SPACE		
RSC 2016 Mass Budget		
Subsystem	**Component**	**Total Mass (lbf)**
WVWC-SPACE	PCB	0.1
	Sensors/DAQ	0.04
WVUTech-SPACE	PCB	0.1
	Sensors/DAQ	0.05
Marshall-SPACE	PCB	0.1
	Sensors/DAQ	0.12
Shepherd-SPACE	PCB	0.1
	Sensors/DAQ	0.3
WVSU-SPACE	PCB	0.05
	Sensors/DAQ	0.05
FSU-SPACE	PCB	0.1
	Sensors/DAQ	0.1
BRCTC-SPACE	PCB/Housing	0.1
	Sensors/DAQ	0.08
BVCTC-SPACE	PCB	0.4
	Sensors/DAQ	0.12

WV-SPACE		
RSC 2016 Mass Budget		
Subsystem	**Component**	**Total Mass (lbf)**
WVU-CI	Sensors	1.4
	Single Board Computer	0.3
	Actuator	0.1
WVU-LP	PCB	0.2
	Probe	0.1
	Sensors/DAQ	0.2
PDS	Batteries	1.3
	PCB	0.1
	Components	0.3
SIS	Makrolon Plates	2.7
	Standoffs/Fasteners	1
	Mounting Brackets	1
	Ballast	3.65
Canister	Full Can	6.65
Target Weight (lbf)		20
Total		20
Over(+)/Under(-)		0

Hazardous Mechanical Items

- WVU-CI linear actuator
  - Hazard mitigation plan to mount actuator such that the physical limits do not exceed hazard area (optics port)
- WVU-LP Langmir probe
  - Rod protruding 3” will be covered with rigid foam block at all times during integration
- WVU-CI 3D printed camera mounts
  - FEA to ensure strength & rigidity
- BVCTC-SPACE 3D printed housing
  - FEA to ensure strength & rigidity
- BRCTC-SPACE 3D printed housing
  - FEA to ensure strength & rigidity
- MU-SPACE 3D printed solar panel
  - FEA to ensure strength & rigidity

Power Budget

WV Rocketeers - RSC2015 Power Budget					
12/8/2014					
Subsystem	Voltage (V)	Max Current (A)	Time On (min)	Watts	Ah
WVWC-SPACE	3.7	0.03	30	0.10	0.01
WVUT-SPACE	3.7	0.13	30	0.47	0.06
MU-SPACE	3.7	0.65	30	2.41	0.33
SU-SPACE	3.7	0.19	30	0.69	0.09
WVSU-SPACE	3.7	0.10	30	0.35	0.05
FSU-SPACE	3.7	0.10	30	0.37	0.05
BRCTC-SPACE	3.7	0.11	30	0.39	0.05
BVCTC-SPACE	3.7	0.14	30	0.52	0.07
WVU-CI	7.4	0.60	3	4.44	0.03
	5.0	2.00	30	10.00	1.00
WVU-LP	7.4	0.80	30	5.92	0.40
	Total	3.04		16.07	2.15
	Total Power Capacity				10.00
	Over (+)/Under (-)				7.86
			# of Flights Margin		4.7

Hazardous Electrical Items:

- PDS LiPo batteries
  - Will not charge at wallops
  - Using fresh batteries for launch
- WVSU-SPACE Geiger counter high voltage regulator
  - Taking precautions to guard high voltage area from touch
  - Keep away labeling around the high voltage supply

Descopes/Off-ramps

- WVU-CAM
  - Off-ramp if necessary
    - Audio Data collection from built in microphones on payload cameras
    - Include a rigid mount for NIR lens instead of including the linear actuator
  - Impact
    - No audio data to accompany video indication data
    - Cause image degradations with the NIR imaging experiment
- FSU-SPACE
  - Off-ramp if necessary
    - Barometric/Temperature sensor with BRCTC
  - No impact on objectives
- BVCTC-SPACE
  - Off-ramp if necessary
    - Use Arduino pro-mini microcontroller instead of Parallax Propeller ASC+
- WVUTech-SPACE
  - Descope
    - No longer including tensile apparatus for ABS strain experiment
    - Working with BVCTC to place strain gauge on their ABS container
  - Impact
    - No longer get yield stress data on ABS plastic in space
  - Off-ramp if necessary
    - Strain gauge experiment all together to focus on flight dynamics

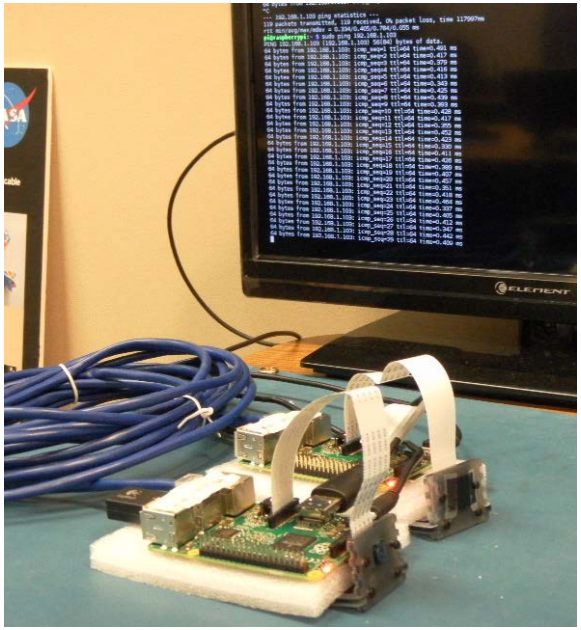
Descopes/Off-ramps (Cont)

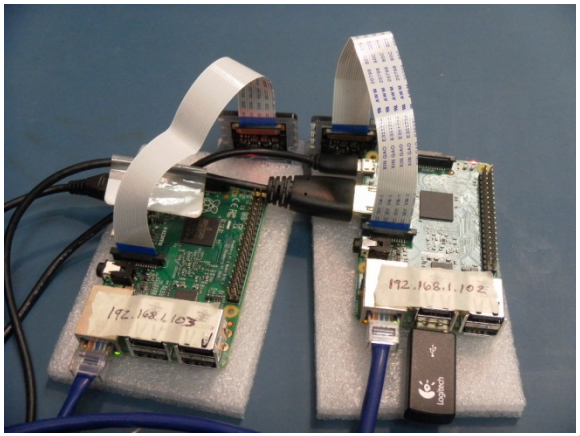
- BVCTC-SPACE
  - Off-ramp if necessary
    - Redundant sensors
    - 3D printed case
  - Impact
    - No cost vs. performance comparison on COTS IMUs and magnetometers
- WVWC-SPACE
  - Off-ramp if necessary
    - Only use one inertial measurement unit
    - Only use gyroscope information from the inertial measurement unit
    - Only measure and respond to one degree of rotational freedom
  - No impact on objectives
- WVState-SPACE
  - Off-ramp if necessary
    - Use Micro-Geiger kit instead of building from scratch using LND 713 tube
  - No impact on objectives
- SU-SPACE
  - Off-ramp if necessary
    - To use NCP1402 voltage regulator in place of designing our own
    - To use iSensor board with ADIS instead of working proper connections into custom PCB design
  - No impact on objectives

3.0a Subsystem Testing Results WVU-CI

Subsystem Overview

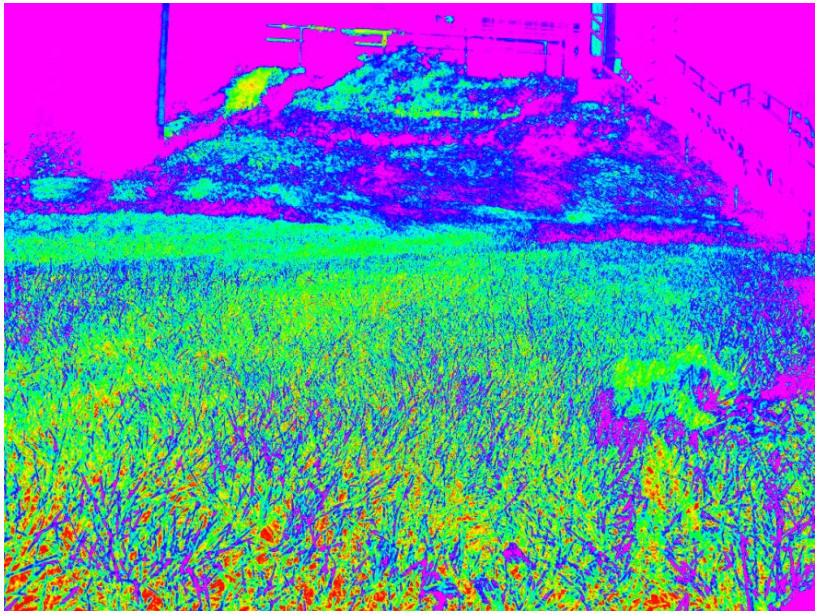
- NDVI
  - Pi NO-IR Camera + RGB filter
  - Pi Camera
  - Raspberry Pi 2 Board x2
- VID
  - USB Macro Web Camera x3
  - Raspberry Pi A+ Board x3





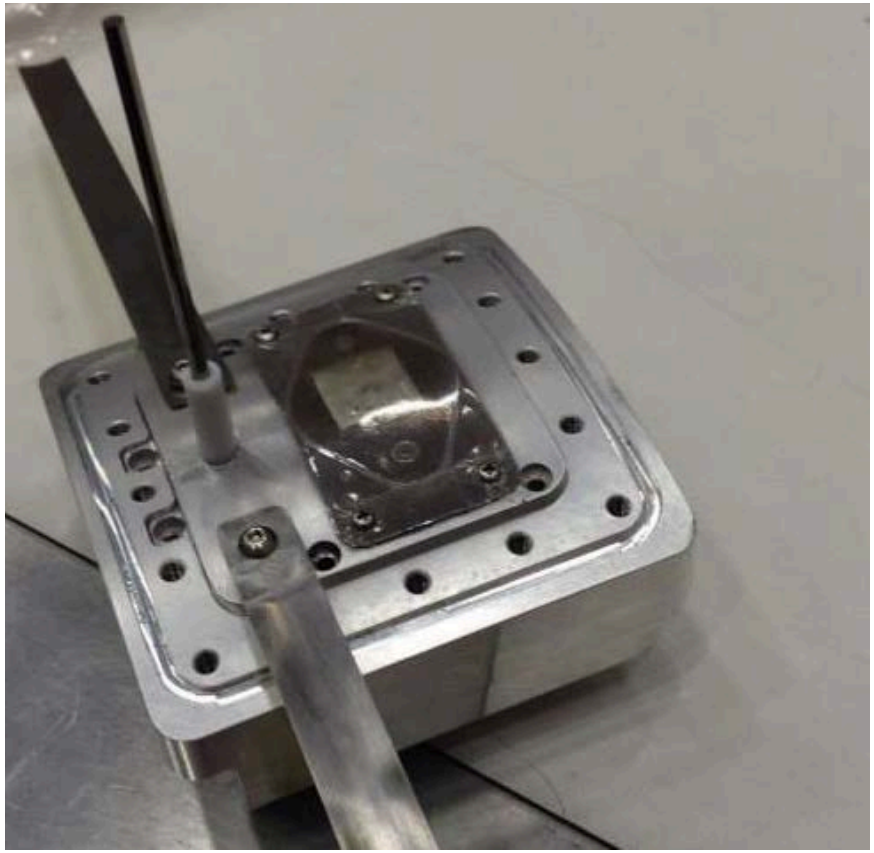
Subsystem Testing

- Quick Status
  - Pictures captured on Hardware
  - NDVI Analysis w/ GIMP image processing
- What has not yet been checked out
  - Networking to sync image capture
  - Setup of linear actuator
  - Setup of VID cams

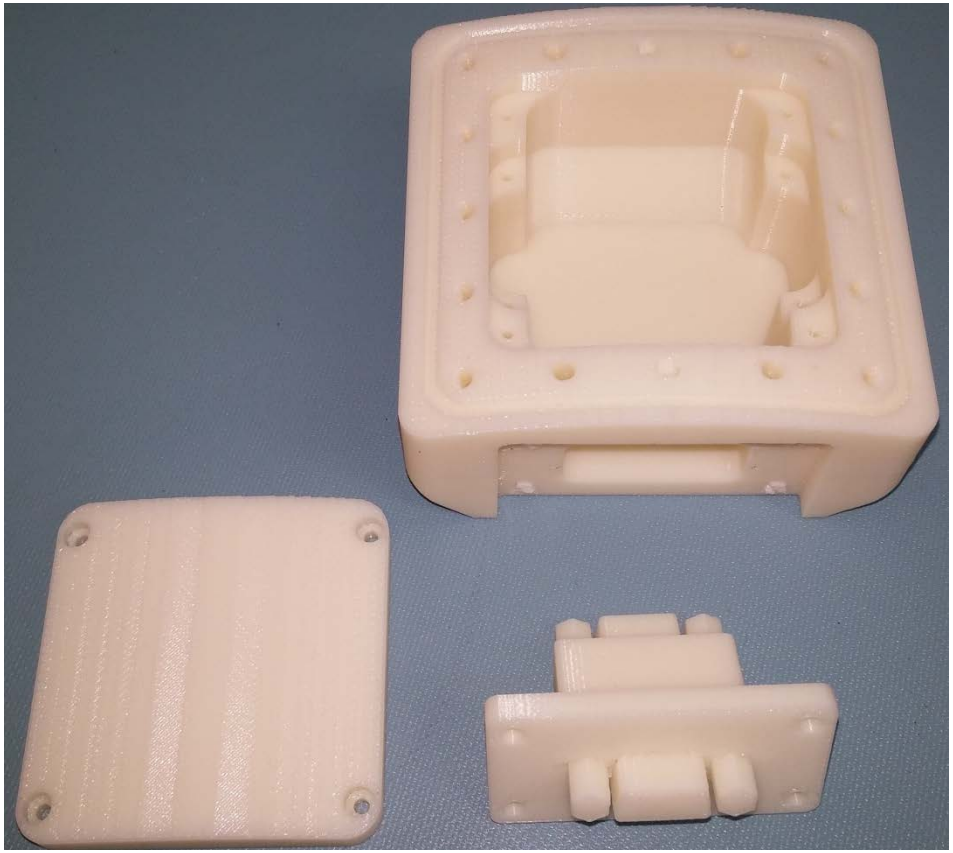


3.0b Subsystem Testing Results WVU-LP

Mechanical Design



Langmuir Probe – RockSat-C 2014



3D Printed “Mock-up” Multipurpos

LP: 4” Stainless Steel Rod (3” uninsulated length), 1/8” Diar

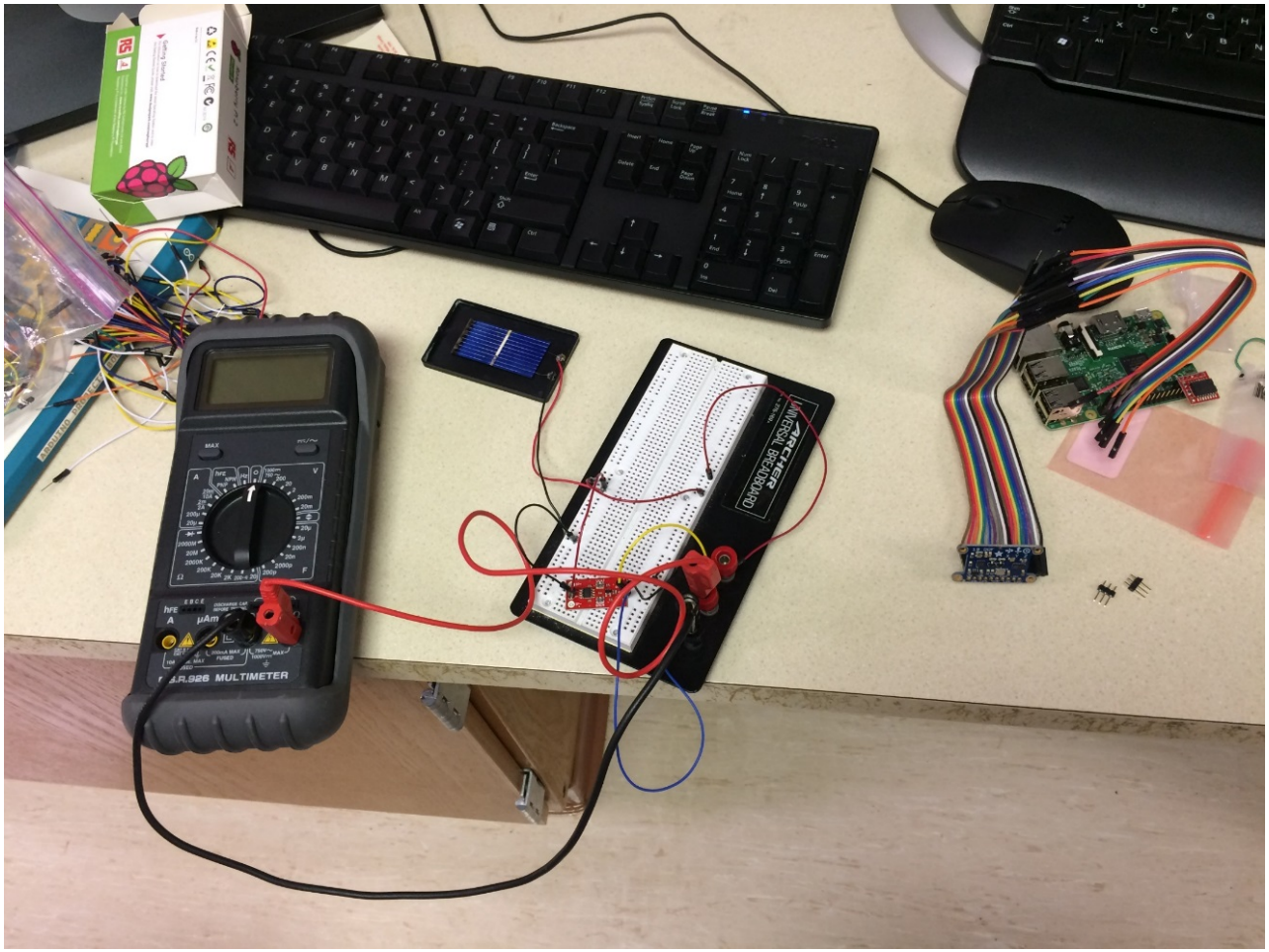
WVU-LP Testing

- Change transimpedance gain for testing
  - ~100μA – 15mA range
  - Test electronics with Zener diode
    - Plot I-V curve
  - Test in WVU plasma chamber
    - ~100μA – 15mA range

3.0c Subsystem Testing Results MU-SPACE

MU-SPACE Subsystem Overview

- Power, Data Collection, and Storage

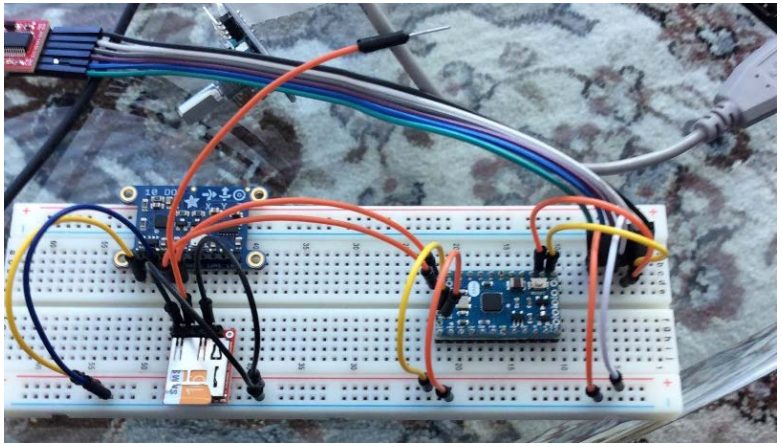


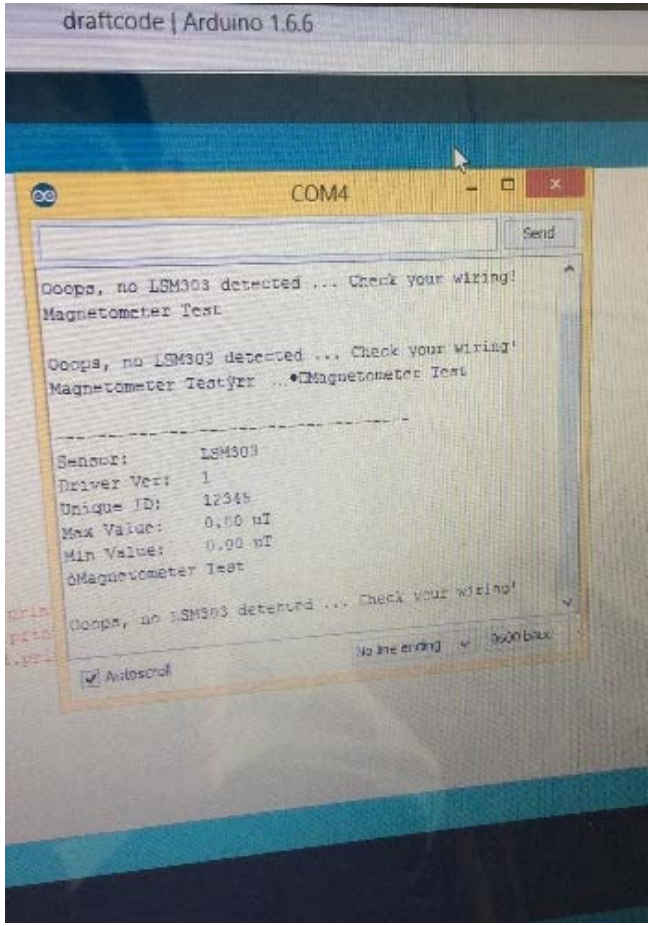
MU-SPACE Testing

- Quick Status:
  - Power
    - The power will be handled by the Pi
    - Will test total power consumption
  - Data Collection
    - The data collection will be handled by the Pi
    - Trans-impedence amplifier needed to measure current values
  - Data Storage
    - The data storage will be handled by the Pi
    - Will verify proper data collection

3.0d Subsystem Testing Results WVSU-SPACE

WVSU-SPACE Subsystem Overview





- IMU, Accelerometer and Magnetometer
  - Working
- Geiger Counter
  - Parts received
  - Currently assembling

WVSU-SPACE Testing

- Magnetometer
  - Code and prototyping complete. Functional and Tested
  - Calibration with Hem-Holtz coils this week
- Accelerometer
  - Accelerometer code and hardware complete
  - Functional and tested
- Geiger Counter
  - Assembling prototype for testing
  - Code is ready

WVSU-SPACE Test Code

STATE1_Prototype_IMU_Test_11_24_2015 | Arduino 1.6.6

File Edit Sketch Tools Help

STATE1_Prototype_IMU_Test_11_24_2015

```
{
  Serial.begin(9600);
  Serial.println("Accelerometer Test"); Serial.println("");

  /* Initialise the sensor */
  if(!accel.begin())
}

void loop(void)
{
  /* Get a new sensor event */
  sensors_event_t event;
  accel.getEvent(&event);

  /* Display the results (acceleration is measured in m/s^2) */
  Serial.print("X: "); Serial.print(event.acceleration.x); Serial.print("  ");
  Serial.print("Y: "); Serial.print(event.acceleration.y); Serial.print("  ");
  Serial.print("Z: "); Serial.print(event.acceleration.z); Serial.print("  ");Serial.println("m/s^2 ");
  delay(500);
}
```

COM4 (Arduino/Genuino Uno)

Send

```
Accelerometer Test

------------------------------------
Sensor:       LSM303
Driver Ver:   1
Unique ID:    54321
Max Value:    0.00 m/s^2
Min Value:    0.00 m/s^2
Resolution:   0.00 m/s^2
------------------------------------

X: -0.16  Y: -0.12  Z: 11.38  m/s^2
X: -0.20  Y: -0.20  Z: 11.45  m/s^2
X: -0.16  Y: -0.08  Z: 11.45  m/s^2
X: -0.16  Y: -0.12  Z: 11.41  m/s^2
```

Autoscroll | No line ending | 9600 baud

Done uploading.

```
Sketch uses 8,288 bytes (25%) of program storage space. Maximum is 32,256 bytes.
Global variables use 693 bytes (33%) of dynamic memory, leaving 1,355 bytes for local variables. Maximum is 2,048 bytes.
```

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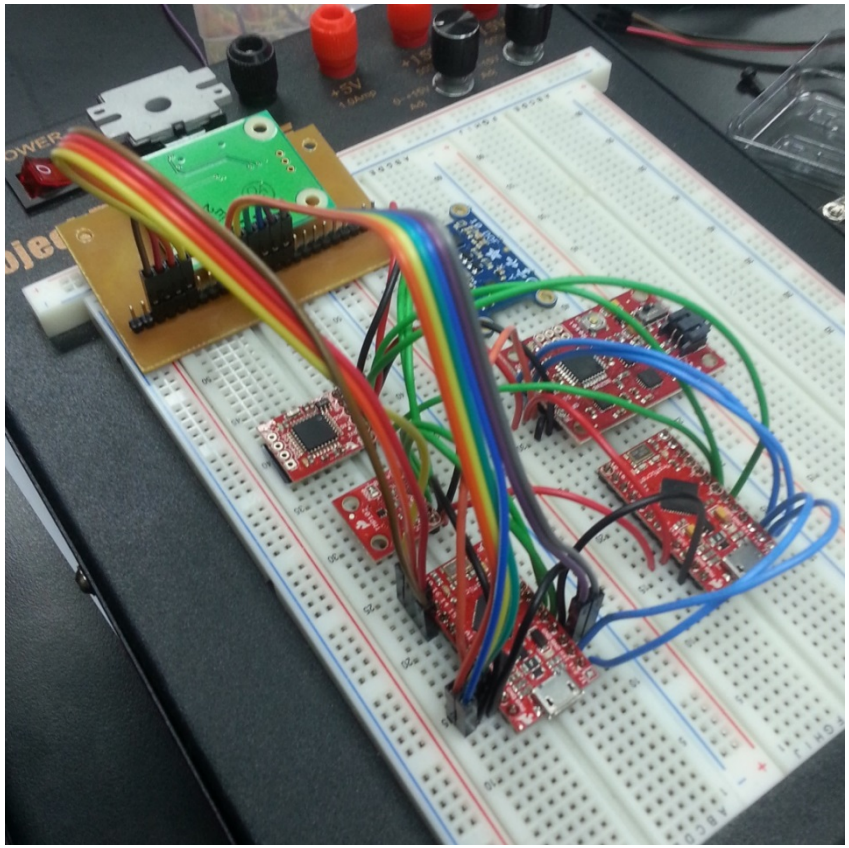
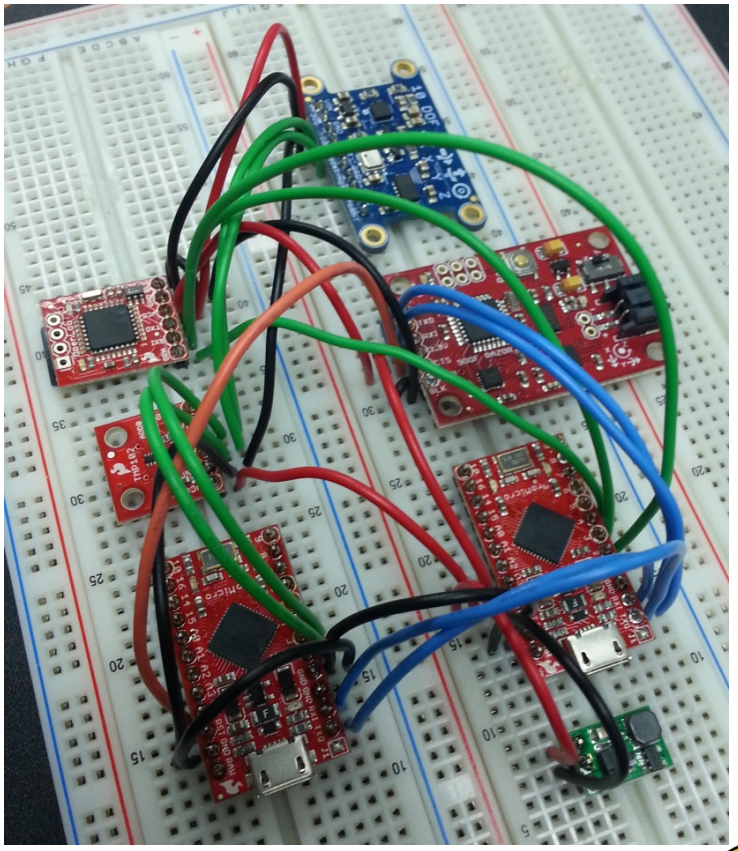
3.0e Subsystem Testing Results SU-SPACE

SU-SPACE Subsystem Overview

- List of subsystems:
  - ADIS, Adafruit, Razor, tmp102, Openlog





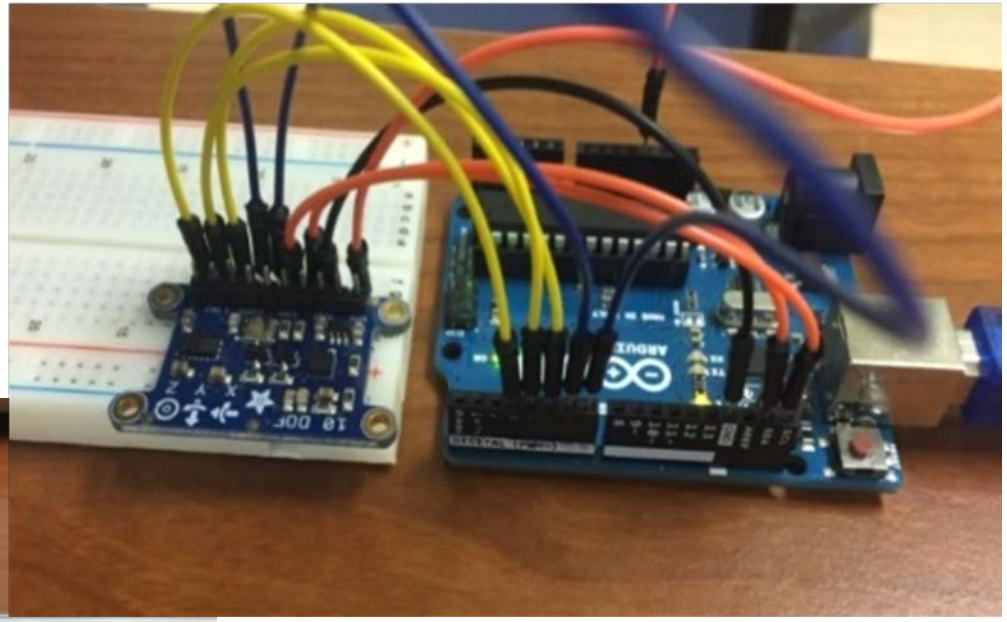
SU-SPACE Testing

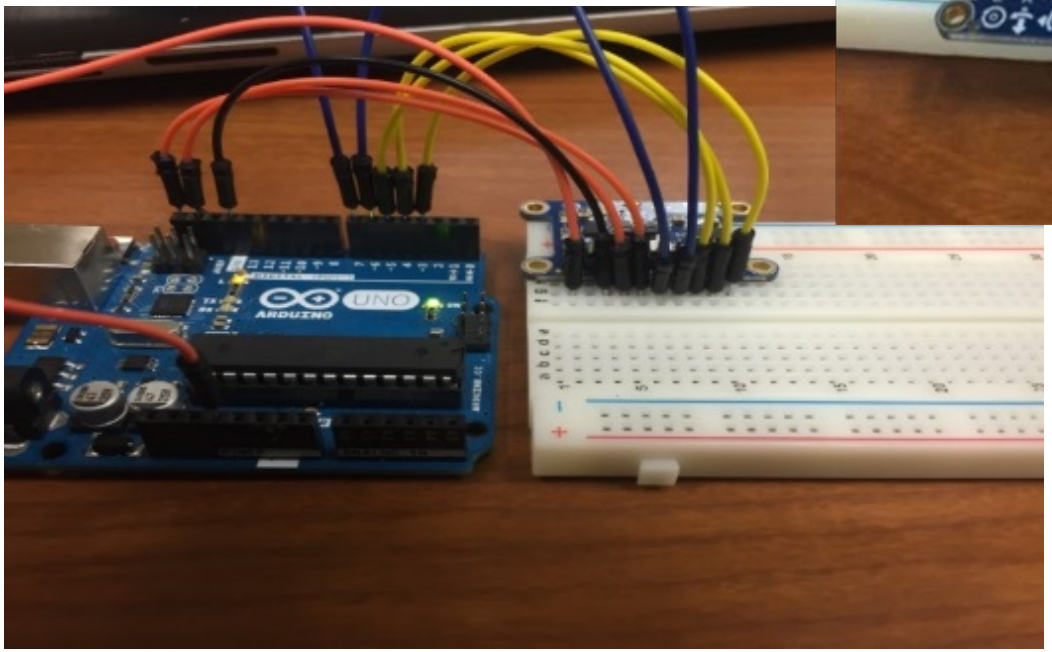
- Quick Status
  - Razor, Adafruit and Openlog have been tested
  - Still testing ADIS and tmp102

3.0f Subsystem Testing Results WVUT-SPACE

WVUT-SPACE Overview

- Subsystems
  - Flight Dynamics
  - Strain Gauge

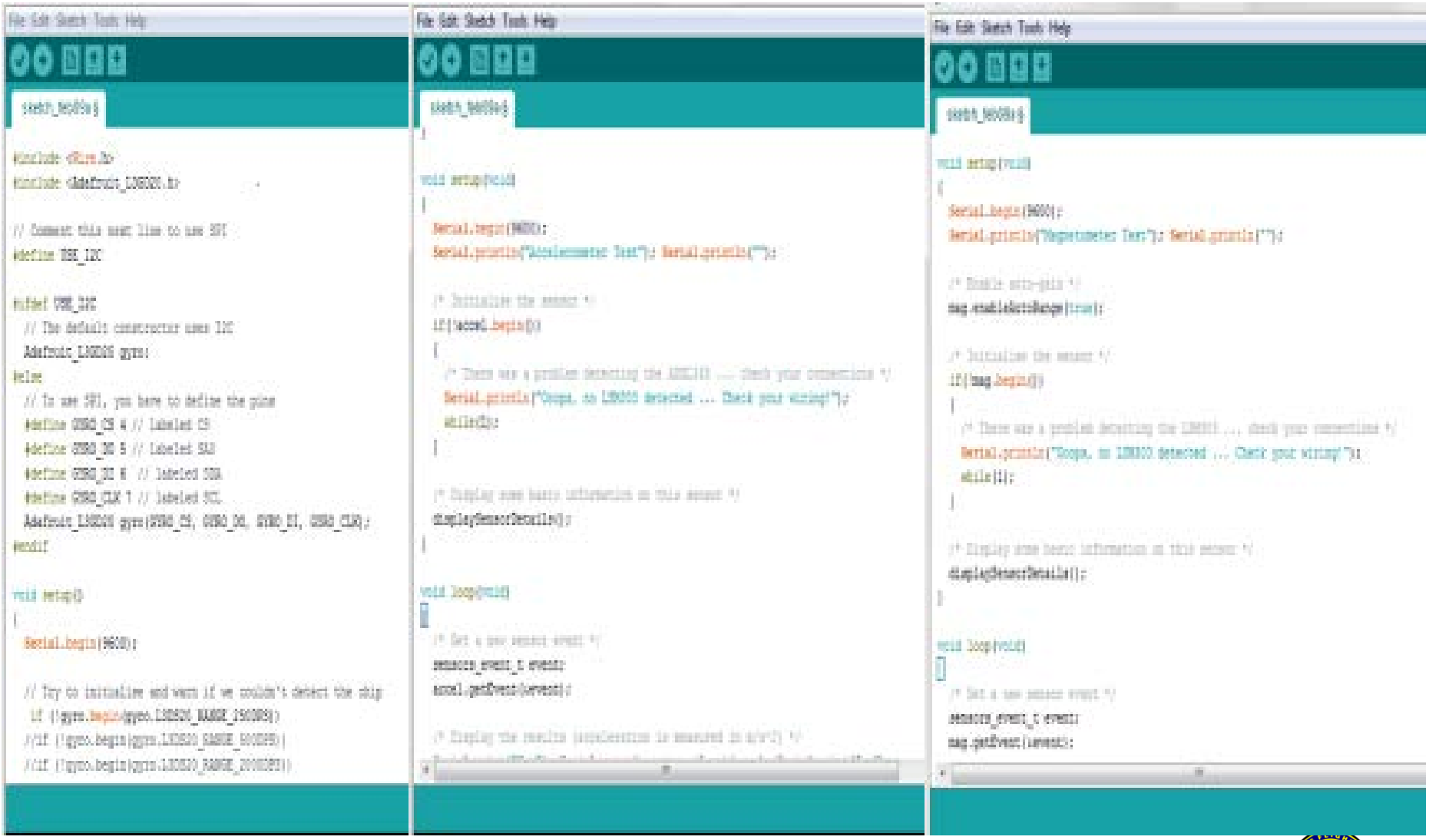




WVUT-SPACE Testing

- Quick Status
  - Flight Dynamics
    - Coding for Magnetometer, Accelerometer and Gyro have been completed but not yet successfully tested
    - Wiring for Arduino UNO board attempted but not yet verified
    - Coding for needs completed and tests need to be performed
  - Strain Gauge
    - Will integrate strain gauges with 3D printed parts of the SIS
    - PCB layout will include solid connection points
    - Coding needs completed and tests need to be performed

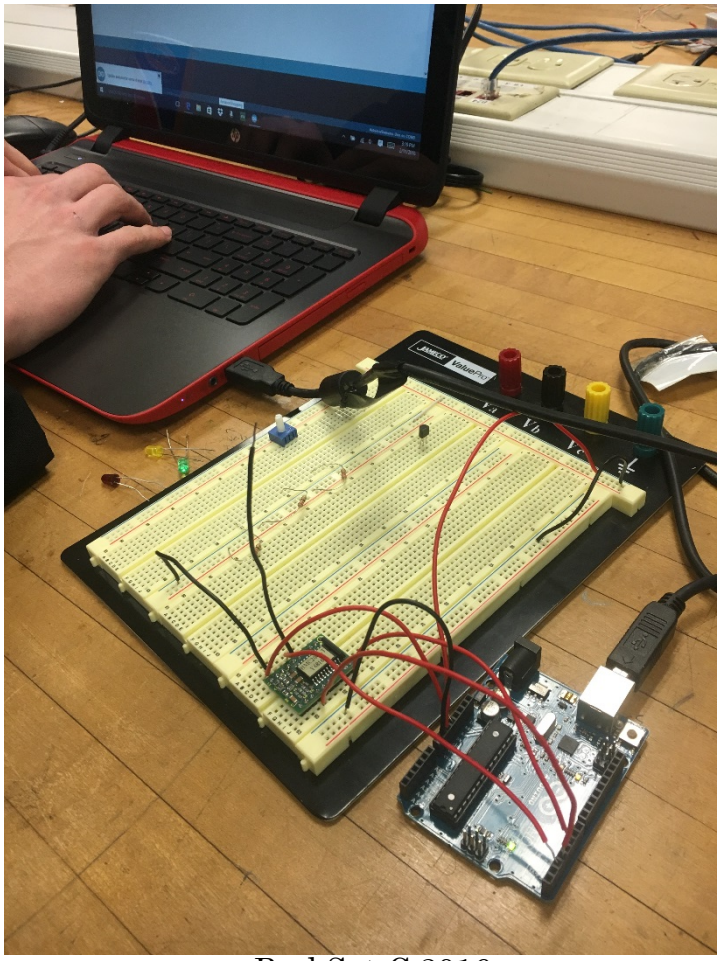
WVUT-SPACE Test Code



3.0g Subsystem Testing Results BVCTC-SPACE

BVCTC-SPACE Overview

- Main subsystem is Data Collection/Storage



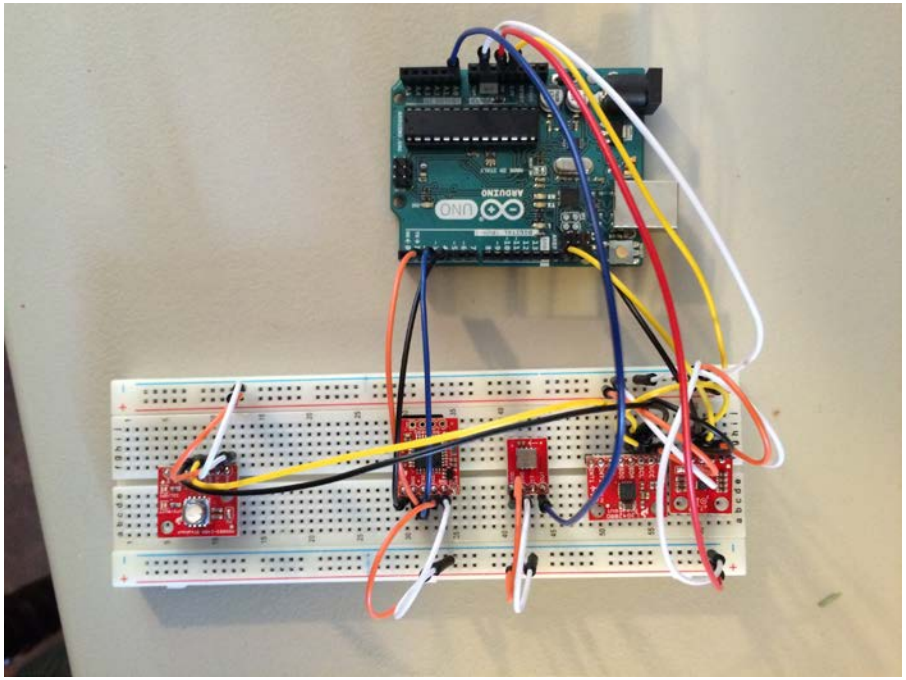
BVCTC-SPACE Testing

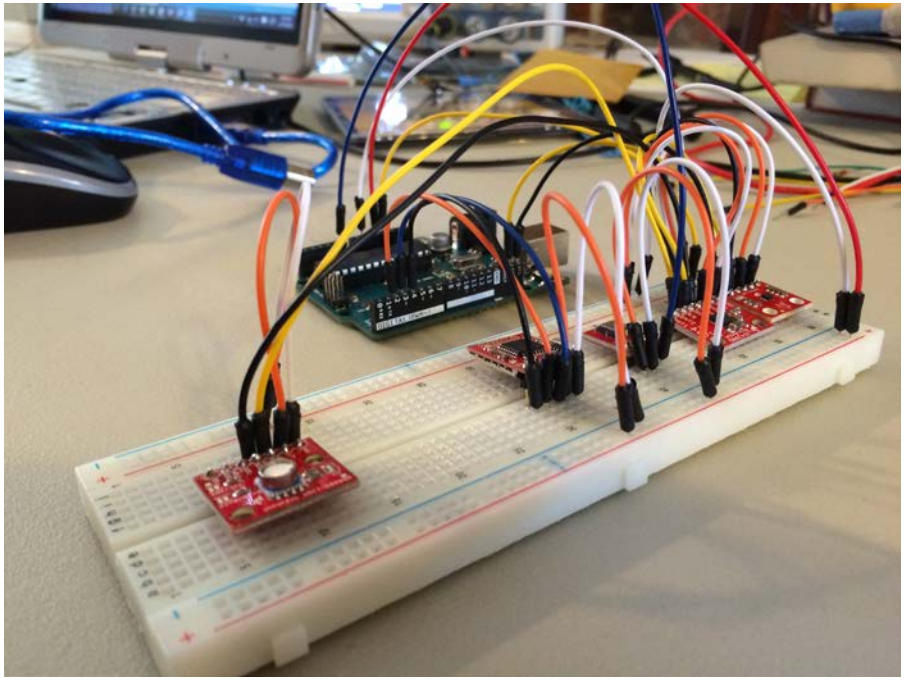
- Quick Status: Data Collection/Storage
  - Complete:
    - Function tests on individual sensors
    - Powering chips, confirming pin-outs, etc
  - Remaining tests:
    - Saving to SD card
    - ADIS16305 addressing (needs further work)
    - Comparison testing of printed housing prototypes
    - Select between shell prototypes: PLA/ABS/PC-Plus

3.0h Subsystem Testing Results BRCTC-SPACE

BRCTC-SPACE Overview

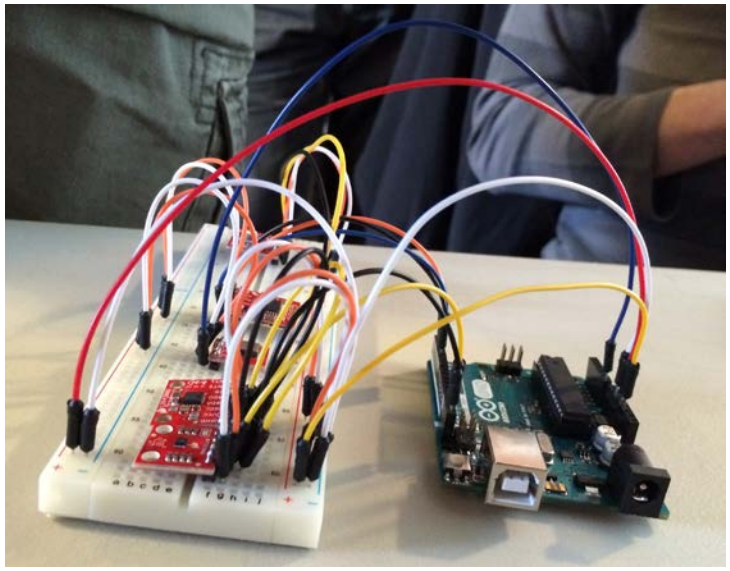
- Main subsystem:
  - Acceleration, gyroscope, barometric pressure, magnetometer





BRCTC-SPACE Accelerometer Testing

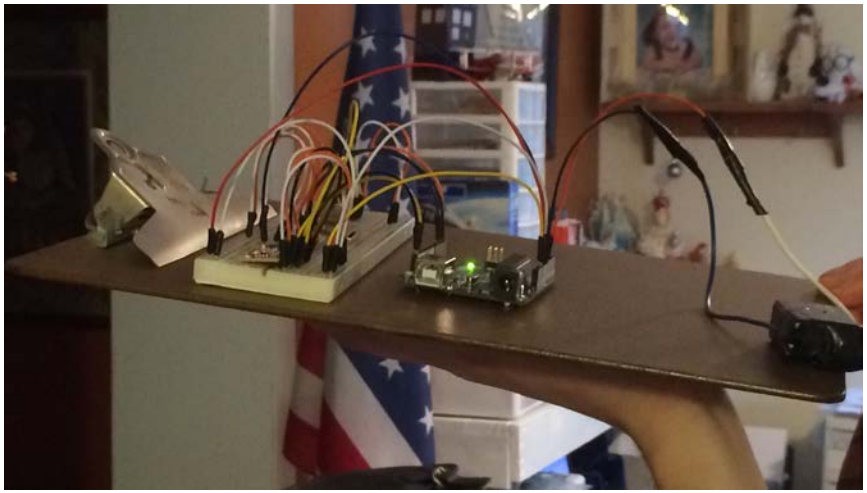
- Sensitivity and resolution tests conducted
- Accelerometer has been tested and data has been recorded
  - 8mV is equal to 1g
- Complete prototype testing still in progress



-103.86	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-103.86	-104.47
-103.86	-104.47	-104.47	-104.47	-104.47	-104.47	-105.08	-104.47	-105.08	-104.47	-103.86
-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-103.86	-104.47	-104.47	-104.47
-103.86	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47
-104.47	-104.47	-103.86	-104.47	-104.47	-104.47	-104.47	-105.08	-104.47	-103.86	-103.86
-103.86	-104.47	-104.47	-104.47	-99.58	-104.47	-104.47	-104.47	-105.08	-104.47	-104.47
-104.47	-104.47	-104.47	-104.47	-103.86	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47
-104.47	-104.47	-104.47	-103.86	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47
-104.47	-105.08	-104.47	-104.47	-104.47	-97.75	-104.47	-104.47	-104.47	-104.47	-104.47
-103.86	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-105.08	-104.47	-104.47	-103.86
-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-104.47	-105.08	-103.86	-104.47	-104.47

BRCTC-SPACE Gyroscope Testing

- Rotational sensitivity testing was conducted
  - Rotated the device different directions at varying speeds
  - Fluctuations were recorded during each test and static noise was discovered



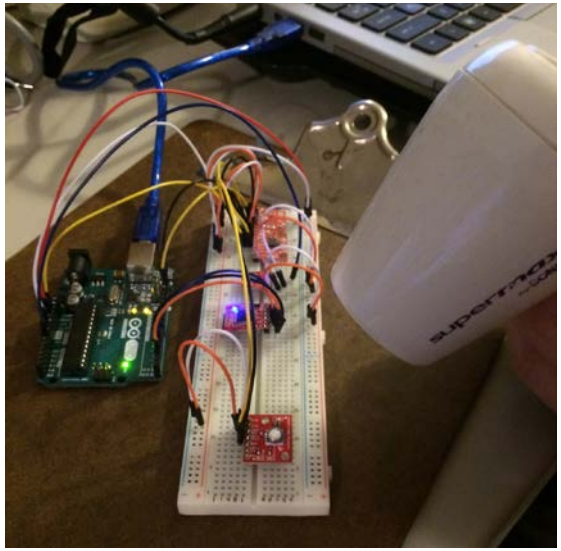
▯▯▯X:9 Y:-4 Z:10	▯▯▯X:8 Y:-7 Z:8	▯▯▯X:8 Y:-11 Z:12
▯▯▯X:5 Y:-8 Z:8	▯▯▯X:6 Y:-8 Z:10	▯▯▯X:9 Y:-8 Z:11
▯▯▯X:5 Y:-4 Z:7	▯▯▯X:5 Y:-6 Z:11	▯▯▯X:4 Y:-9 Z:8
▯▯▯X:5 Y:-8 Z:4	▯▯▯X:5 Y:-5 Z:10	▯▯▯X:3 Y:-9 Z:3
▯▯▯X:8 Y:-9 Z:8	▯▯▯X:2 Y:-7 Z:15	▯▯▯X:6 Y:-9 Z:11
▯▯▯X:4 Y:-4 Z:9	▯▯▯X:6 Y:-6 Z:11	▯▯▯X:10 Y:-11 Z:9
▯▯▯X:6 Y:-7 Z:14	▯▯▯X:9 Y:-6 Z:13	▯▯▯X:7 Y:-9 Z:10
▯▯▯X:8 Y:-7 Z:10	▯▯▯X:4 Y:-11 Z:10	▯▯▯X:10 Y:-6 Z:9
▯▯▯X:7 Y:-8 Z:5	▯▯▯X:4 Y:-8 Z:8	▯▯▯X:6 Y:-7 Z:8
▯▯▯X:8 Y:-6 Z:7	▯▯▯X:X:9 Y:-4 Z:7	▯▯▯X:4 Y:-3 Z:10
▯▯▯X:4 Y:-12 Z:9	▯▯▯X:2 Y:-9 Z:9	▯▯▯X:4 Y:-4 Z:11
▯▯▯X:3 Y:-9 Z:9	▯▯▯X:5 Y:-10 Z:10	▯▯▯X:4 Y:-3 Z:11
▯▯▯X:10 Y:-8 Z:5	▯▯▯X:7 Y:-6 Z:7	▯▯▯X:4 Y:-9 Z:7

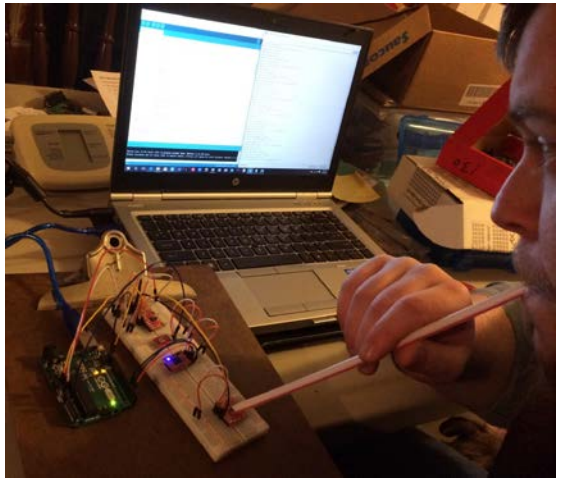
BRCTC-SPACE Barometer Testing

- The device has been tested and seems to be very accurate
  - Hair dryer used to test temperature
  - Straw used to test pressure

Pressure relative (mbar)	8211.52
Altitude change (m)	-0.13
▯▯▯Temperature C	-2273
Temperature F	-4059.4
Pressure abs (mbar)	6723.4
Pressure relative (mbar)	8211.52
Altitude change (m)	-0.13
▯▯▯Temperature C	-2273
Temperature F	-4059.4
Pressure abs (mbar)	6723.4
Pressure relative (mbar)	8211.52
Altitude change (m)	-0.13
Temperature C	22
Temperature F	71.6
Pressure abs (mbar)	1012.6

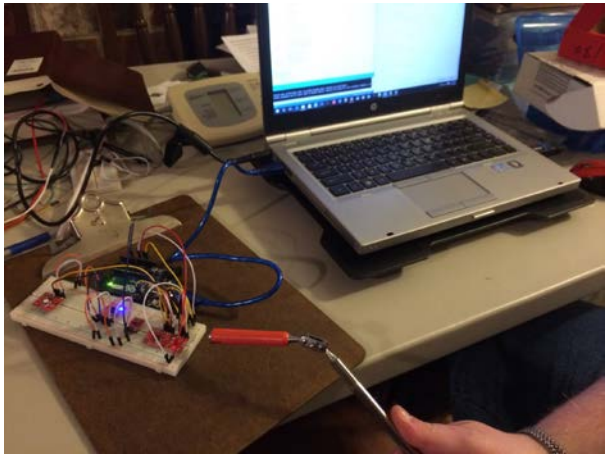
Pressure abs (mbar)	1012.7
Pressure relative (mbar)	1236.85
Altitude change (m)	0
▯▯▯Temperature C	22
Temperature F	71.6
Pressure abs (mbar)	1012.4
Pressure relative (mbar)	1236.48
Altitude change (m)	2.5
▯▯▯Temperature C	22
Temperature F	71.6
Pressure abs (mbar)	1012.7
Pressure relative (mbar)	1236.85





BRCTC-SPACE Magnetometer Testing

- Tested using a 2.5 mT (20.5 mG) bar magnet
  - Readings were tested on each axis
- Ran magnetometer alongside the barometer in simple data logging tests
  - Fluctuations in each test were observed while both sensors were attached



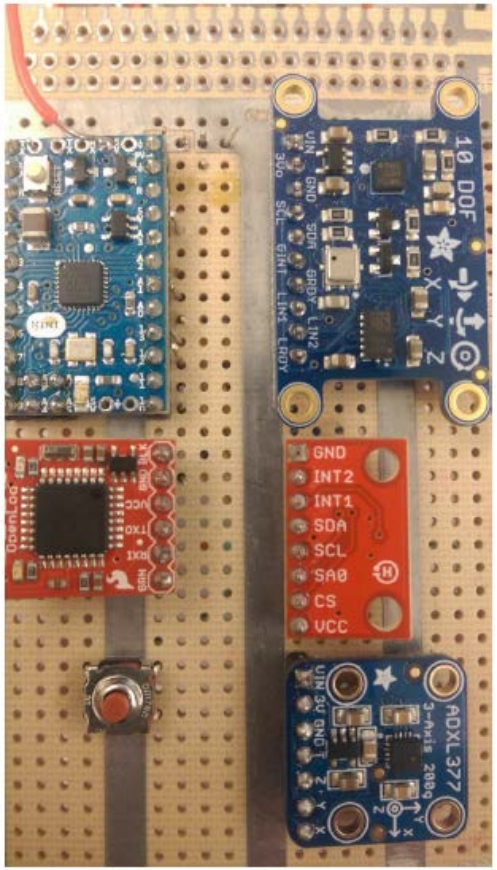
Pressure relative (mbar)= 1235.99
Altitude change (m) = 2.50
Magnetometer = x=-89,y=1827,z=-52
Temperature C = 22.00
Temperature F = 71.60
Pressure abs (mbar)= 1012.00
Pressure relative (mbar)= 1235.99
Altitude change (m) = 2.50
Magnetometer = x=-91,y=1828,z=-46
Temperature C = 22.00
Temperature F = 71.60
Pressure abs (mbar)= 1012.10

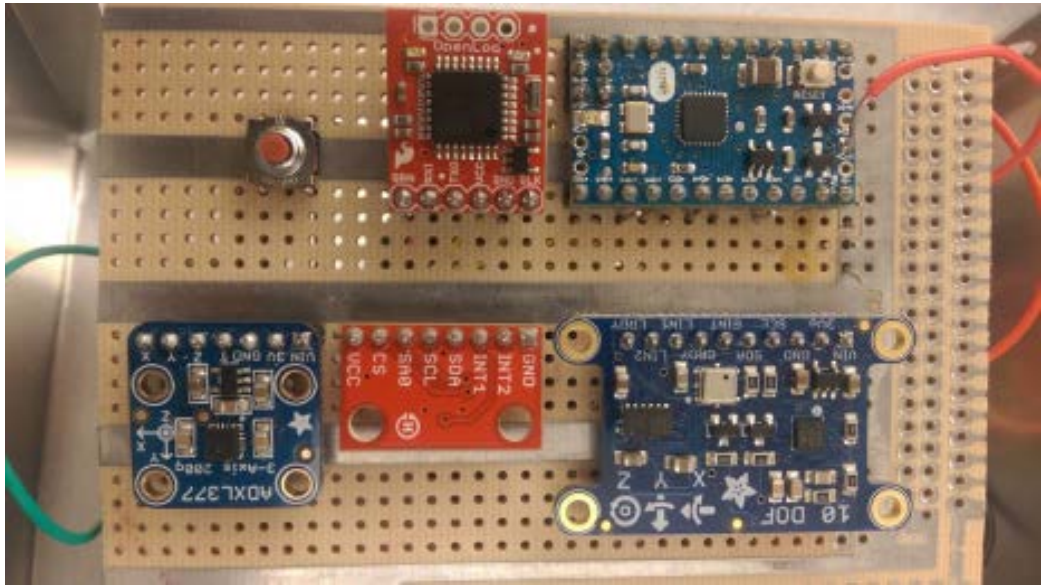
Pressure abs (mbar)= 1012.20
Pressure relative (mbar)= 1236.23
Altitude change (m) = 0.83
Magnetometer = x=-96,y=1822,z=-37
Temperature C = 22.00
Temperature F = 71.60
Pressure abs (mbar)= 1012.00
Pressure relative (mbar)= 1235.99
Altitude change (m) = 2.50
Magnetometer = x=-96,y=1831,z=-49
Temperature C = 22.00
Temperature F = 71.60

3.0i Subsystem Testing Results FSU-SPACE

FSU-SPACE Overview

- Main subsystem:
  - Acceleration, gyroscope, barometric pressure, magnetometer





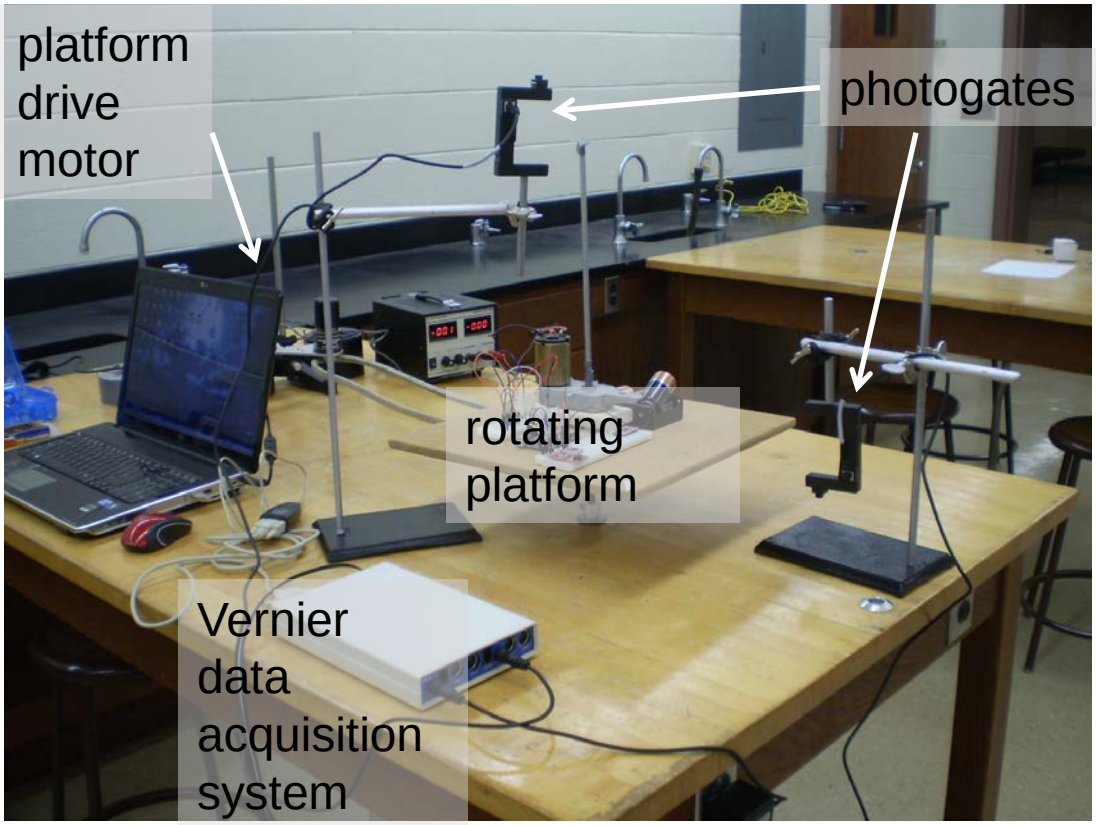
FSU-SPACE Testing

- Quick Status:
  - Complete:
    - Function tests on individual sensors
    - Powering chips, confirming pin-outs, etc
  - Remaining tests:
    - Verifying each sensor working and coded properly
    - Collect test data to verify sensor functionality
    - Complete prototype still in progress

3.0i Subsystem Testing Results WVWC-SPACE

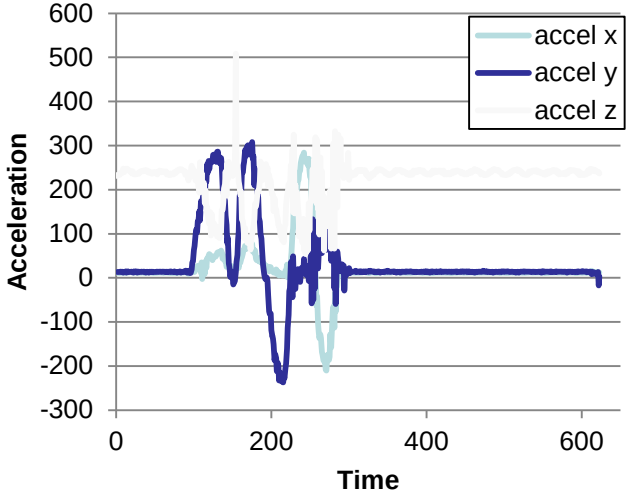
Subsystem Overview

- Subsystems:
  - Data Collection and Storage (flying on rocket
  - Motor (not flying on rocket)

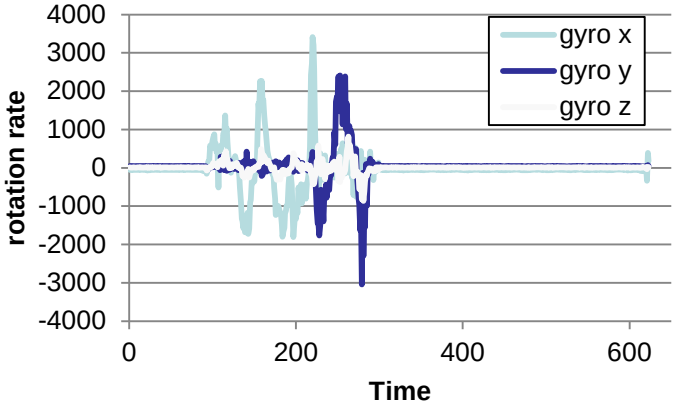


WVWC-SPACE Testing

- Quick Status: Data Collection & Storage
  - Microprocessor, OpenLog, and IMU all tested and working
  - Currently setting up software serial communication with serial devices



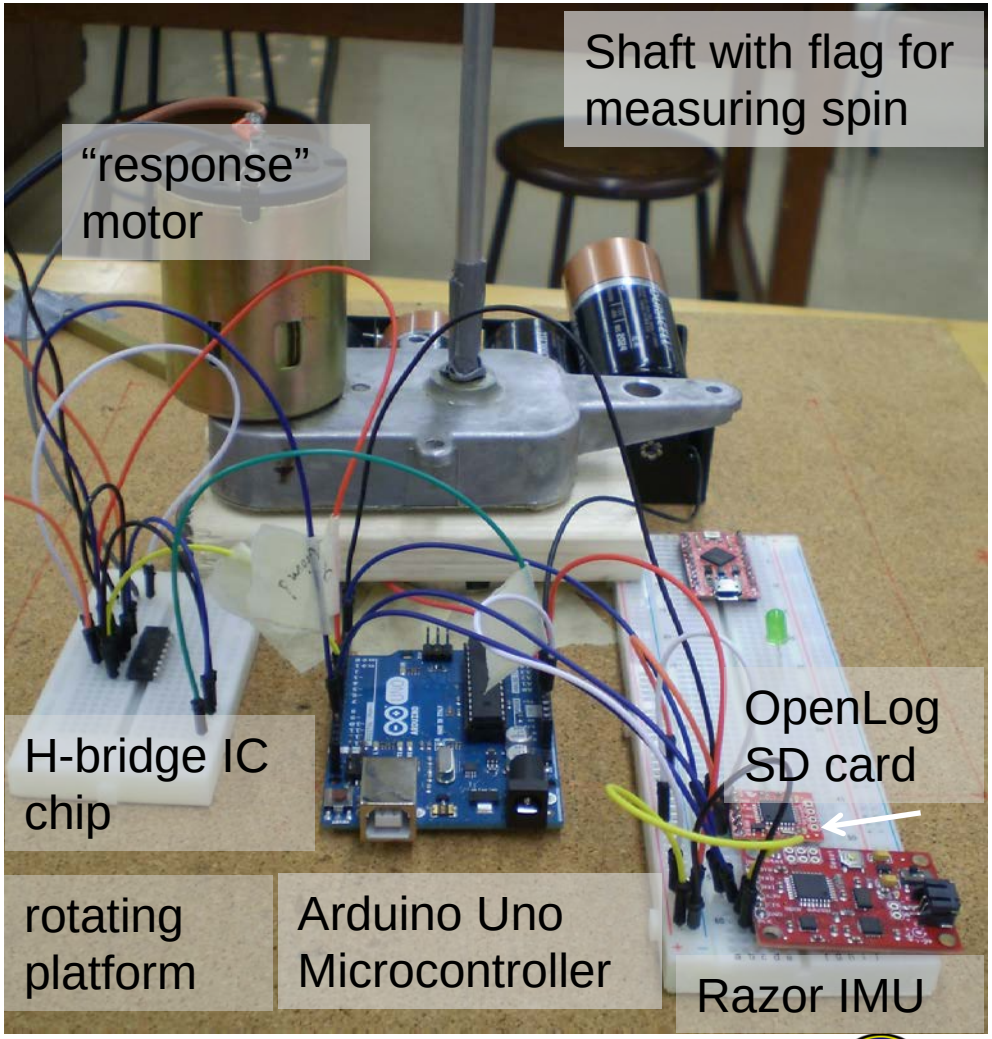
Razor IMU Accelerometer



Razor IMU Gyroscope

WVWC-SPACE Testing

- Quick Status: Motor
  - The acquired motor can spin with high torque at both low and high spin rates (>5 Hz)
  - Turntable apparatus has been built for testing ability of the payload to drive motor (reaction wheel) in response to rotation of platform
  - Currently testing motor with MOSFET transistor needed to control speed of motor
  - Experiencing an odd effect
    - Decreasing source current and voltage increases the speed of the motor



4.0 Plan for Full System Testing

Steven Hard

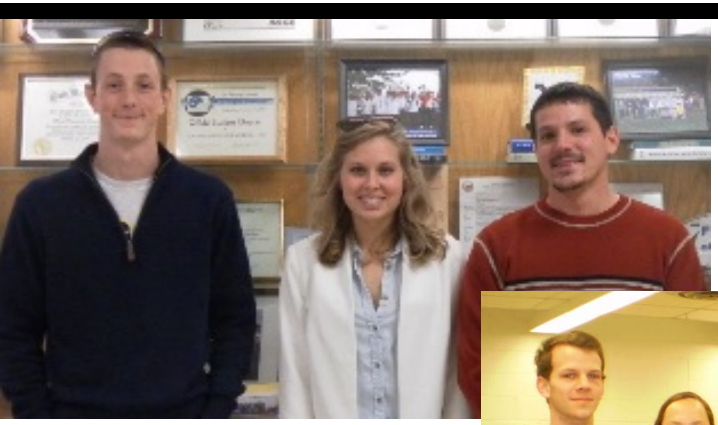
Plan for Subsystem Integration

- Mock-up canister will be used to fit test payload configuration
- Payload subsystems will be delivered to NASA IV&V for canister integration
- Major hurdles:
  - PCB design and fabrication
  - Manufacture polycarbonate plates
  - System integration and testing

5.0 Project Management Update

Steven Hard

Team Photos

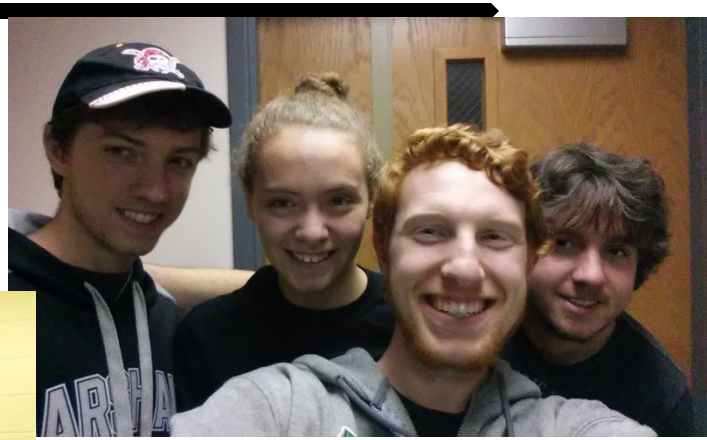


WVU

WVU-Tech (not shown)

Fairmont State (not shown)

Wesleyan



Marshall

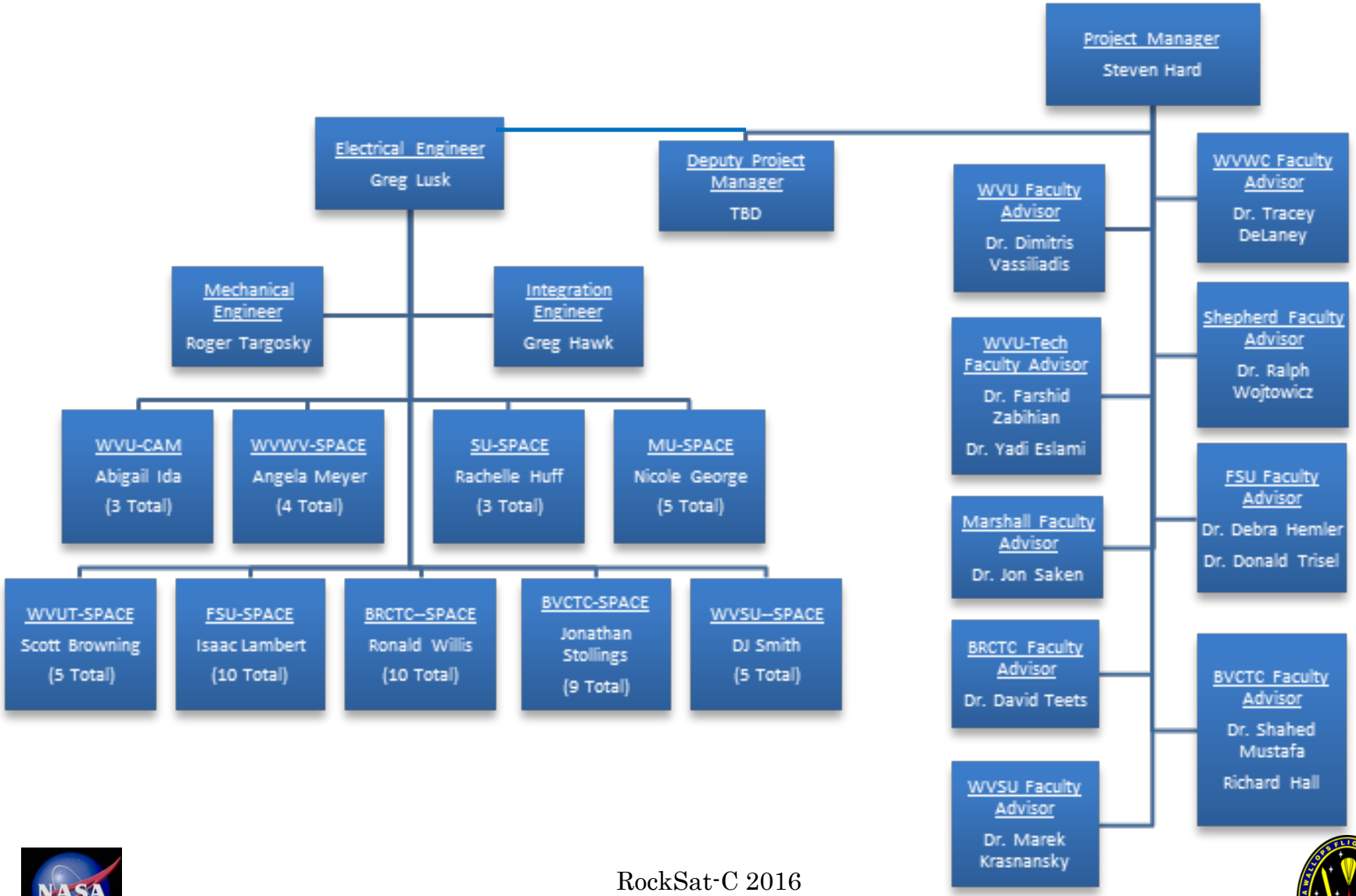
Blue Ridge (not shown)

Bridge Valley (not shown)

Shepherd

WV State

Organizational Chart



Schedule

- Major Milestones
  - CDR (12/8/2015)
  - Prototype high risk items (12/20/2015)
  - Flight award announcement (1/16/2016)
  - Procure remaining components (1/18/2016)
  - Design PCBs (Week of 2/1/2016)
  - STR (Week of 2/22/2016)
  - ISTR (Week of 3/28/2016)
  - Assemble PCBs (Week of 4/4/2016)
  - Receive canister (Week of 4/11/2016)
  - FMSR (Week of 5/2/2016)
  - Vibration & atmospheric chamber testing (Week of 5/23/2016)
  - Deliver preliminary check-in document (Week before 6/6/2016)
  - LRR (Week of 6/6/2016)
  - Travel to Wallops (6/16/2016)
  - Launch (6/23/16)*
  - * Tentative, no guarantee – small chance launch could get cancelled due to weather or other unforeseen delays

6.0 User Guide Compliance

Steven Hard

User Guide Compliance

Requirement	*Status/Reason (if needed)*
Center of gravity in 1" mid-can?	With 1’
Contained in can	
Connected to can by 4/5 bulkheads on top and bottom only	
Mass at 20±0.2lbs (full can)	Currently 20 lbs with ballast for 0.2lb tolerance
Shared canister clearance	N/A
No voltage on the can	No opportunity to check yet
Activation wires at least 4 ft	
Activation wire at least 24 gauge	22 gauge
Early Activation: current < 1 A	No opportunity to check fully integrated current draw yet
T-0 Activation: current < .1 A	Not using
Battery Type	Li-Po (will not charge at Wallops)

Design Overview: Shared Can Logistics

- Partners (NASA IV&V Sponsored):
  - West Virginia University Team: WVU-CAM
  - West Virginia Wesleyan College: WVWC-SPACE
  - Shepherd University: SU-SPACE
  - Marshall University: MU-SPACE
  - West Virginia University Institute of Technology: WVUTech-SPACE
  - Fairmont State University: FSU-SPACE
  - Bridge Valley Community Technical College: BVCTC-SPACE
  - Blue Bridge Community Technical College: BRCTC-SPACE
  - West Virginia State University: WVSU-SPACE

Design Overview: Shared Can Logistics

- Plan for collaboration
  - Weekly/Monthly Telecon sessions
  - Share designs using Google drive
  - Will fit check before June
- Mounting to both bottom and top bulkheads of canister.
- Structural interfacing:
  - Aluminum standoffs
- **Not** using a mid-mounting plate
- Ports:
  - Optical (WVU & MU)
  - Multipurpose (FSU & BRCTC)

Budget

Margin:	0.25	Budget:	$17,000.00	Last Update:	11/11/2015 19:28
WV RSC'16 Payload					
Item	**Supplier**	**Estimated, Specific Cost**	**Number Required**	**Toal Cost**	**Notes**
Devices	Various	$980.00	9	$8,820.00	9 experiments kept under $1k each
PCBs	Advanced Circuits	$270.00	9	$2,430.00	9 subsystems require custom PCBs, expect 2 revisions each
Electronic Components	Digi-Key	$150.00	9	$1,350.00	1 set of components per 9 PCBs
Structural Supplies	McMaster-Carr	$300.00	1	$300.00	Only need 1 set of mechanical parts
Lab Supplies	Various	$70.00	9	$630.00	Allowance for lab supplies for each team
Total (no margin):					$13,530.00
Total (w/ margin):					$16,912.50

Worries and Concerns

- Biggest concerns:
  - Not all SPACE experiments have demonstrated working prototypes
  - Behind schedule on PCB designs
- Mitigation plans:
  - Face-to-face meetings with teams needed technical assistance
  - Utilize knowledge/expertise of teams that are proficient in PCB design software and other expert sources

Conclusions

- Continued software testing with prototype designs
  - Integrated payload configurations causing some software debugging issues
- Finalized electrical schematics and PCB designs
  - Ran into some snags with Gerber file conversions for submission to PCB vendor