WV Rocketeers

Preliminary Design Review

FAIRMONT STATE UNIVERSITY

WVU WVU-TECH FSC SU
MU WVWC JFFL NASA IV&V

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11/20/2014

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Mission Overview

Steven Hard

Mission Overview

- The objective of the WV RSC'15 mission will be to develop and test several science and engineering experiments for space operations
- Shall capture NIR Earth images from space, measure magnetic field of Earth, gather redundant flight dynamics data, & detect gaseous and ionized particles
  - Need access to optics port and atmospheric port
- Expect to validate the NOAA magnetic field model using data taken during the flight and to assess vegetation health with Earth images
- Benefits SmallSat community – COTS orientation estimation
- Elementary school systems – promote STEM careers

Top Level Requirements

Requirement	Verification Method	Description
Camera must be able to view earth's surface and configurable to take video at 60 fps	**Verification**	Software verification will determine if the frame rate is successfully reconfigured
Minimize distance between WVU-CAM NIR lens and optical port using linear translation	**Inspection**	The physical distance between the optical port and the NIR lens will be measured and determined if optimal
Need a data collection system to store the measurements (in-flight) @ 2 Hz	**Verification**	Software verification and analysis will verify this requirement
The system shall survive the vibration characteristics prescribed by the RockSat-C program.	**Test**	The system will be subjected to these vibration loads in June during testing week.

Theory and Concepts: Earth's Magnetic Field

- Background
  - Known that there are variations approximately (~0.2G) in the magnitude of Earth's surface magnetic field
- Purpose
  - Are there similar variations with altitude?
  - Based on NOAA's maps, have there been changes since last mapping?
    - What is the time scale for variations in earth's surface B-field?
    - Understanding complicated nature of Earth's B-field
    - Important for understanding the Earth's dynamo and how the Earth's B-field changes orientation over time

Theory and Concepts: NIR Vegetation Imaging

- Background
  - Pigment in plant leaves (chlorophyll) strongly absorbs visible light (from 0.4 to 0.7 μm) for use in photosynthesis.
  - Cell structure of the leaves strongly reflects near-infrared light (from 0.7 to 1.1 μm)
  - The more leaves a plant has, the more these wavelengths of light are affected
- Purpose
  - Assess the vegetation health along the east coast
  - Identify areas of sand or drier vegetation
  - Determine if science apparatus is feasible for orbital mission

Theory and Concepts: Cosmic Radiation

- Background
  - Ionization occurs when radiation enters the Geiger-Muller tube
  - This ionization causes electrons to split from their molecules and speed toward the positive end of the tube creating a pulse of electricity that can be read as a voltage
- Purpose
  - Detect cosmic radiation at high altitudes above the Karman line (100 km) and compare to low altitude readings
  - Study cosmic rays at and above the Karman line
  - Determine if science apparatus is feasible for orbital mission

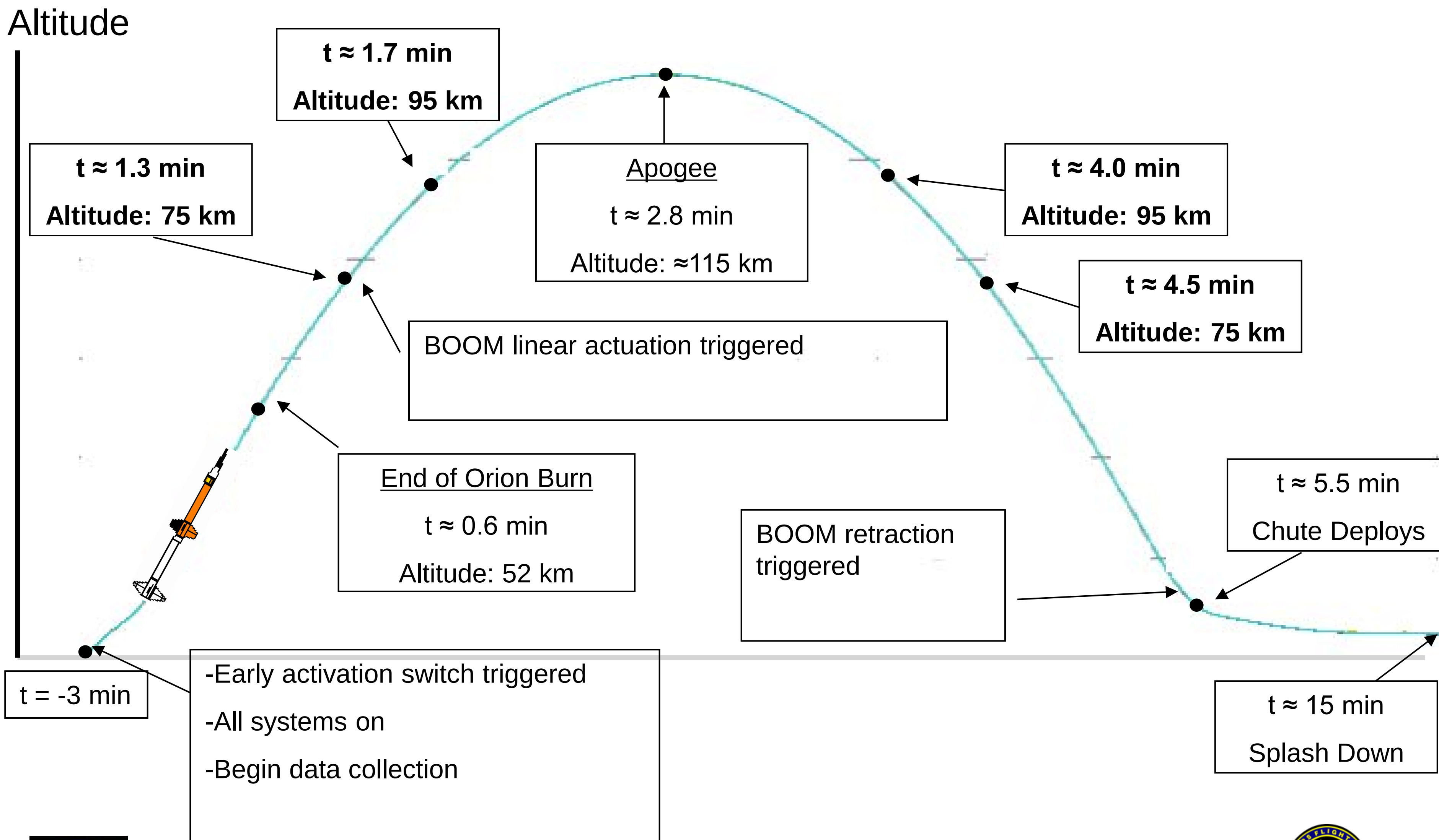
Expected Results: WVU-CAM

- Sequence of 60 second video clips throughout entire flight and payload recovery
- Extraction of “good” images from video data during flight
  - Good: visibly distinguishable land mass or NIR source
- Expect to create a Normalized Difference Vegetation Index (NDVI) of reflected NIR light intensities (from 0.7 to 1.1 µm) for each good image
  - Index of plant “greenness” or photosynthetic activity
- Visual telemetry showing evidence of any faults experienced during flight

Expected Results: SPACE (4x)

- Predict to detect slight deviations in the mapping of Earth’s magnetic field since NOAA’s previous mapping
  - Prove that the magnetic field is moving
- Also look to see fluctuations in magnitude of Earth’s magnetic field in relation to altitude
  - 2010 NOA WMM data indicates the total field at 38'N 75' W is just over 50,000 nT, while at 150 km elevation, this value is about 47,000 nT.
  - Expect to verify this data
- Comparison of COTS IMU performance with high resolution IMU
- Increased radiation levels with altitude
  - This radiation will be measured in terms of keV (kilo electron volts)
  - Expect that the radiation will be between .09-2.5 KeV in the E layer and 1-20 KeV in the D layer
- Detection of cosmic rays near apogee

Mission ConOps



Success Criteria

- Minimum Success Criteria:
  - Collect a single remotely captured NIR vegetation image for NDVI analysis and video telemetry data through entire flight
  - Collect IMU and B-field data between 75km and apogee
- Comprehensive Success Criteria:
  - Data from all experiments collected throughout entire flight
  - IMU and B-field data is in accordance (< ~10% variance) with the other subteam data and the NOAA model, respectively

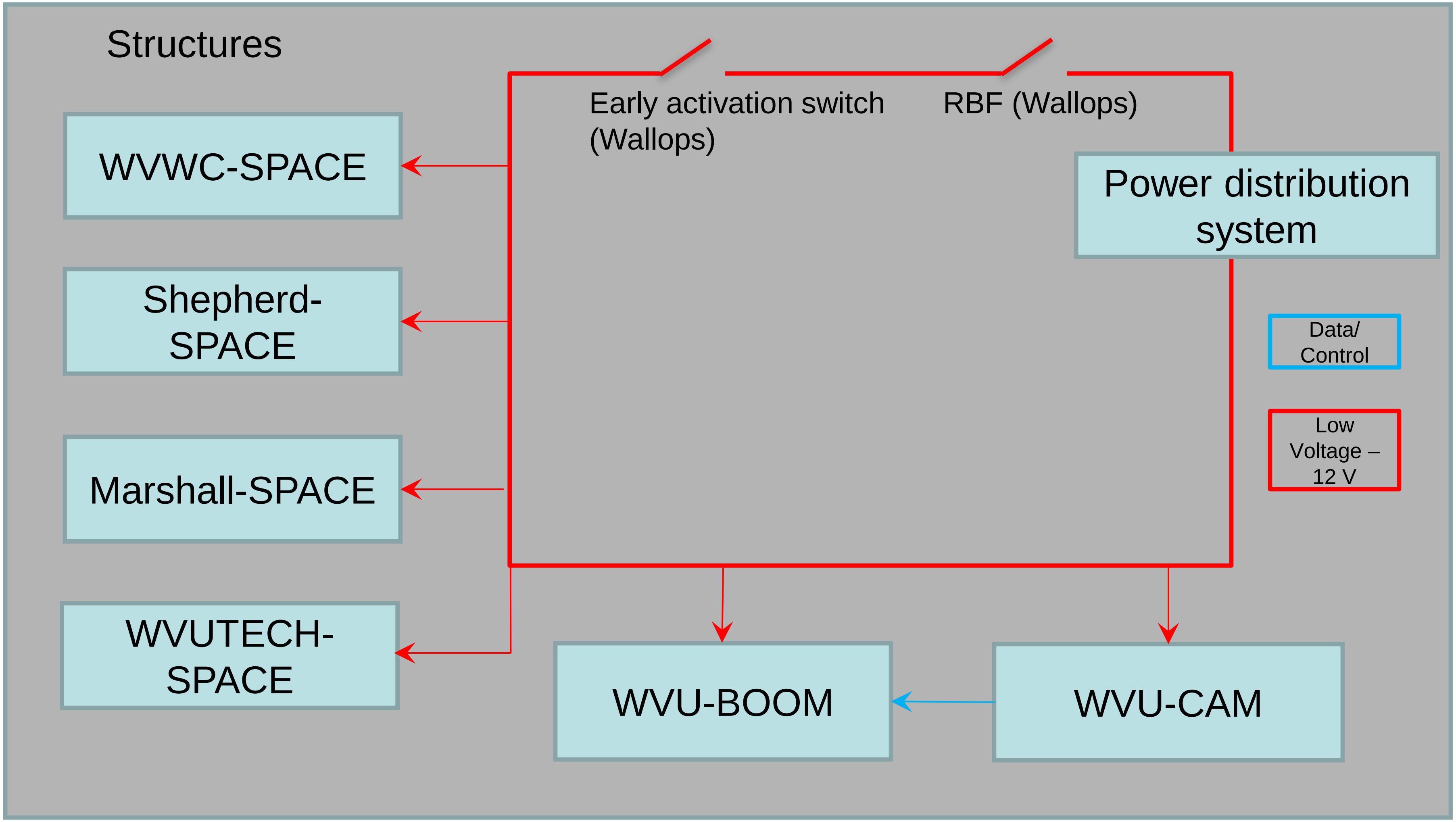
System Overview

Steven Hard

System Definitions

- WVU-CAM: West Virginia University Camera Imaging Experiment
- WVWC-SPACE: West Virginia Wesleyan College Student Partnership for Advancement of Cosmic Exploration Experiment
- Shepherd-SPACE: Shepherd University Student Partnership for Advancement of Cosmic Exploration Experiment
- Marshall-SPACE: Marshall University Partnership for Advancement of Cosmic Exploration Experiment
- WVUTech-SPACE: West Virginia University-Institute of Technology Student Partnership for Advancement of Cosmic Exploration Experiment
- PDS: Power Distribution System
- SIS: Structural Integration System

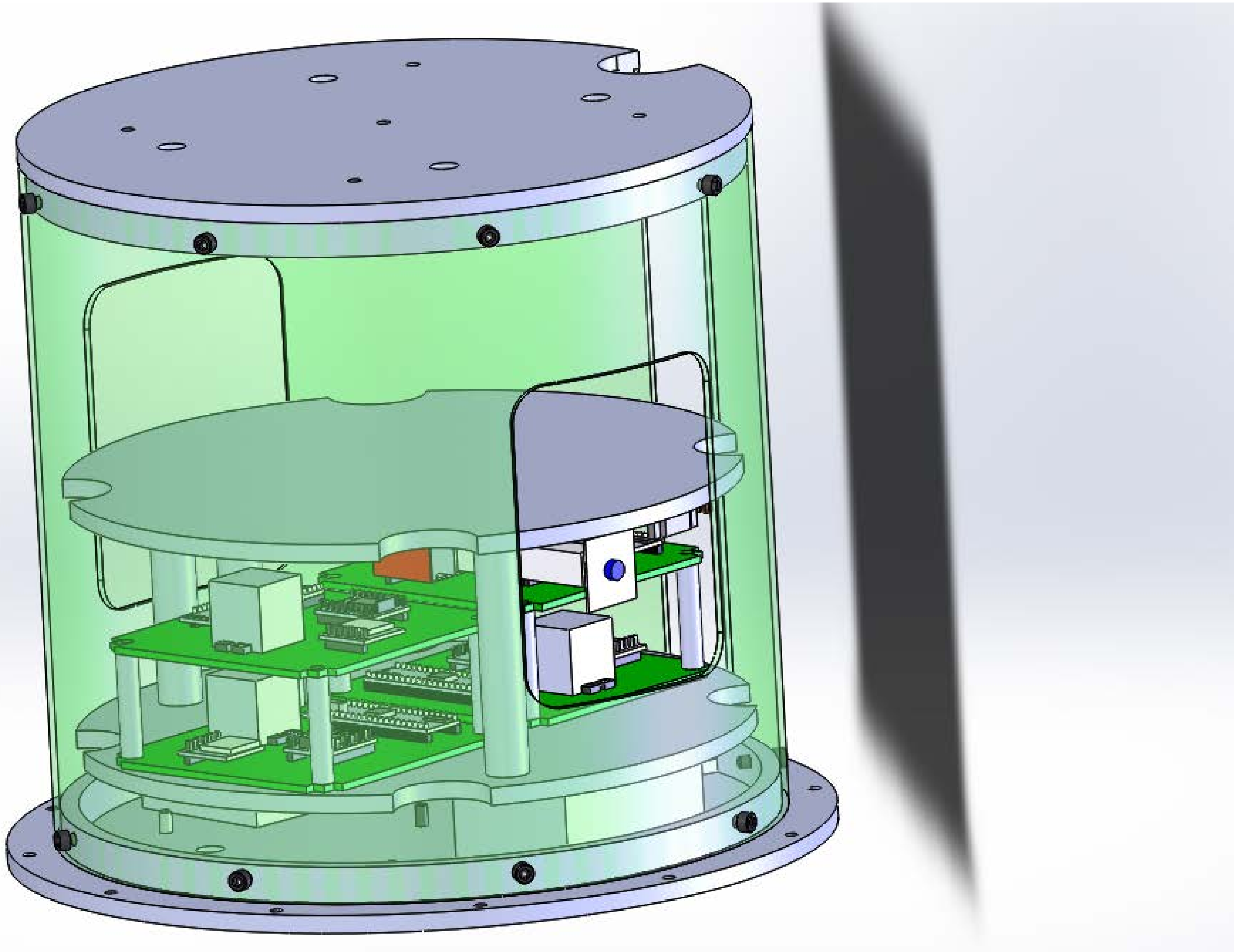
System Level Block Diagram



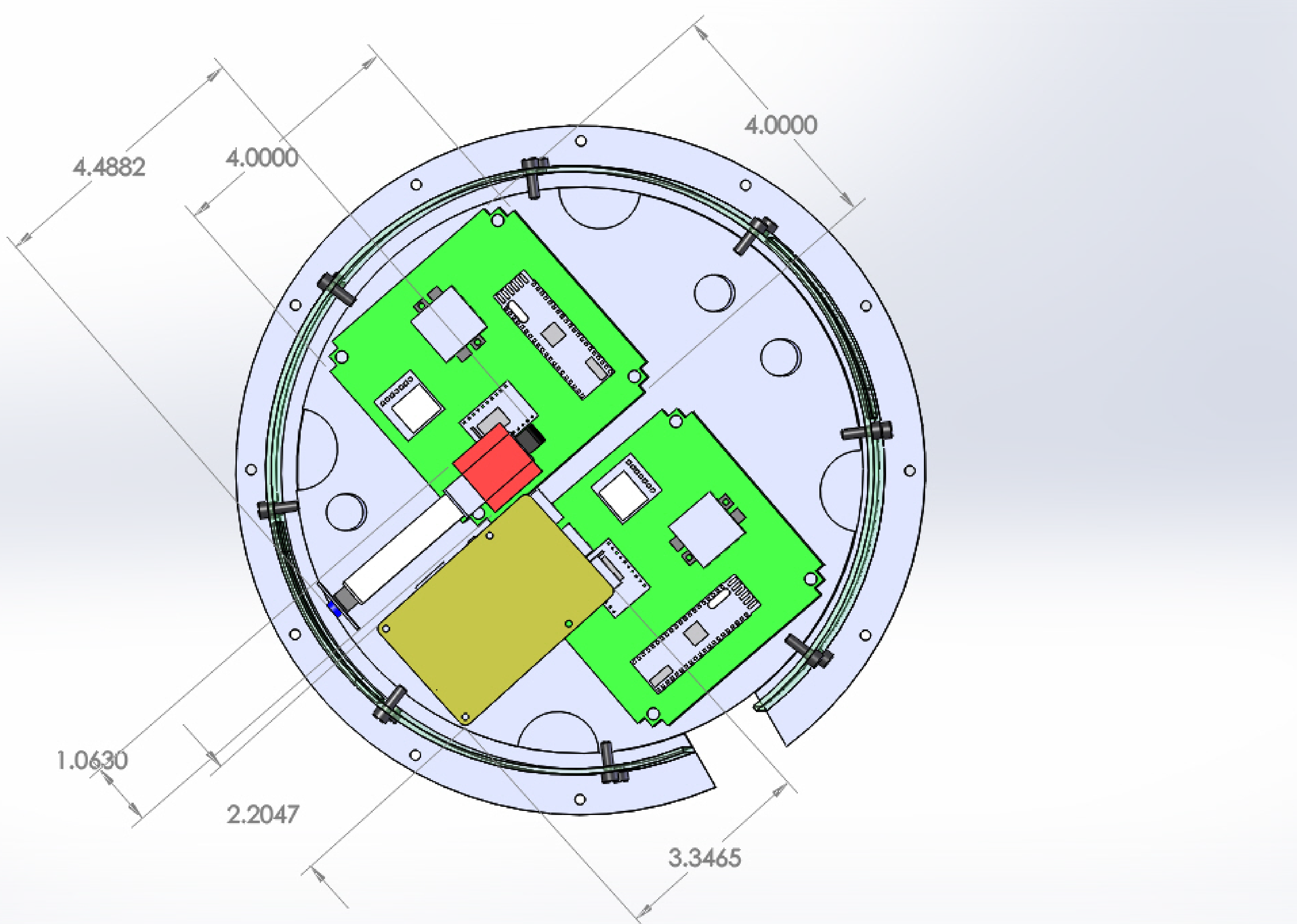
Critical Interfaces

Interface Name	Brief Description	Potential Solution
WVU-CAM	The WVU-CAM subsystem will need constant power throughout the flight from the power supply. Also a constant feed to the microprocessor to save all data.	WVU-CAM will need to be correctly wired into the PDS. Also the camera must utilize the proper communication protocol and connection to the microcontroller. Camera must be positioned viewing optical port
WVU-CAM	The NIR camera boom of the WVU-CAM subsystem will need constant power throughout the flight from the power supply to its servo motor. Also a control feed is needed to deploy/retract the boom after/before high-g events and current overload protection	NIR camera boom of the WVU-CAM will need to be correctly wired into the PDS. Also the microcontroller must utilize the proper communication protocol and connection to the servo motor for control signal.
SPACE (4x)	The SPACE (4x) subsystems will need constant power throughout the flight from the power supply. Also a constant feed to the microprocessor to save all data.	SPACE(4x) will need to be correctly wired into the PDS. Also the camera must utilize the proper communication protocol and connection to the microcontroller.

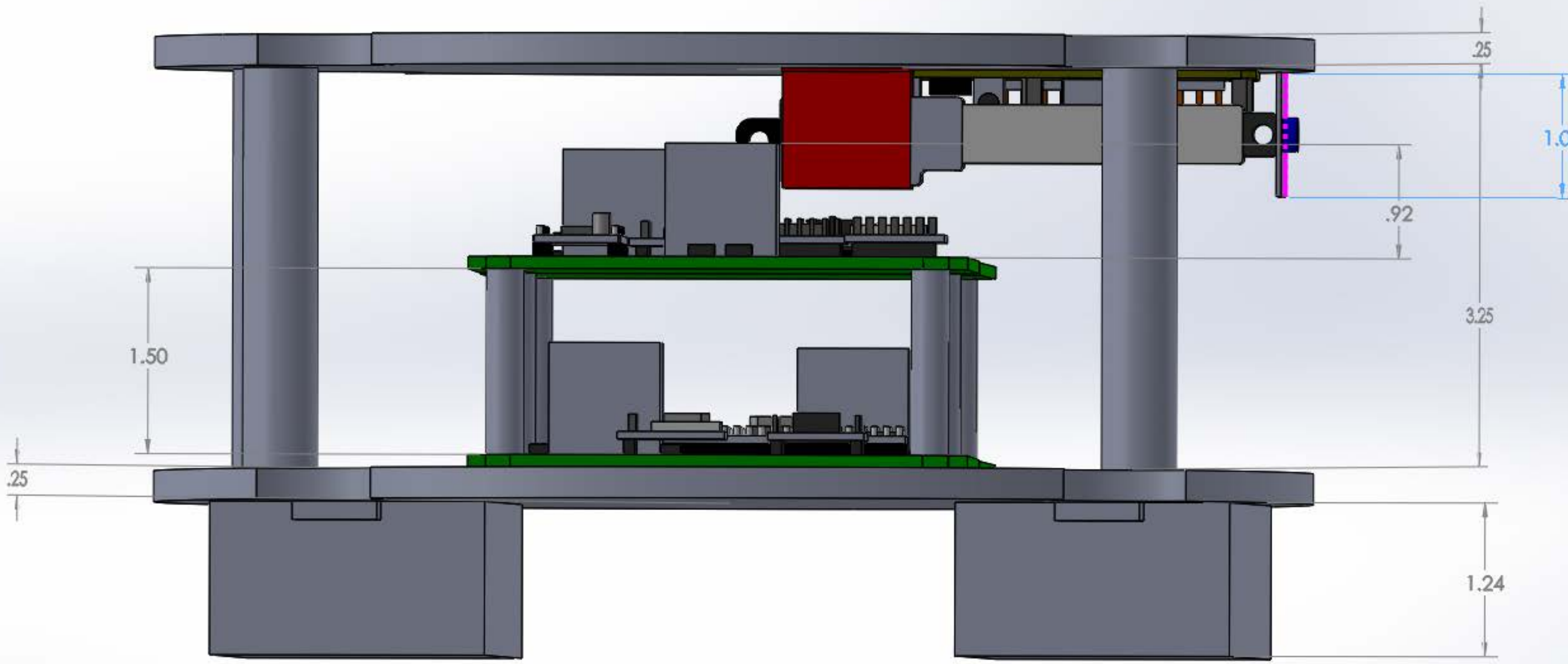
Design Assembly in Canister (Isometric View)



Top View Payload Dimensions

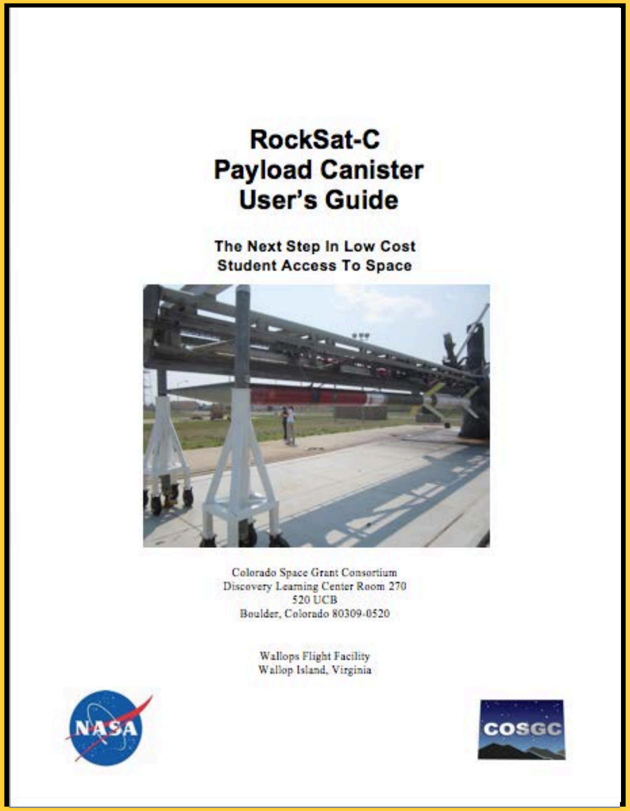


Side View Payload Dimensions



Design Overview: RockSat-C 2013 User's Guide Compliance

- User's Guide Requirements
  - Predicted mass: ~6 lb
    - Lead ballasts to make weight
  - Predicted volume: **Half can**
  - Activation type: Early activation
    - T-3mins
    - One activation only
  - Special requests: Ports
    - Optical – WVU
    - Atmospheric (Static) – WVWC


RockSat-C
Payload Canister
User's Guide

The Next Step In Low Cost
Student Access To Space

Colorado Space Grant Consortium
Discovery Learning Center Room 270
520 UCB
Boulder, Colorado 80309-0520

Wallops Flight Facility
Wallop Island, Virginia

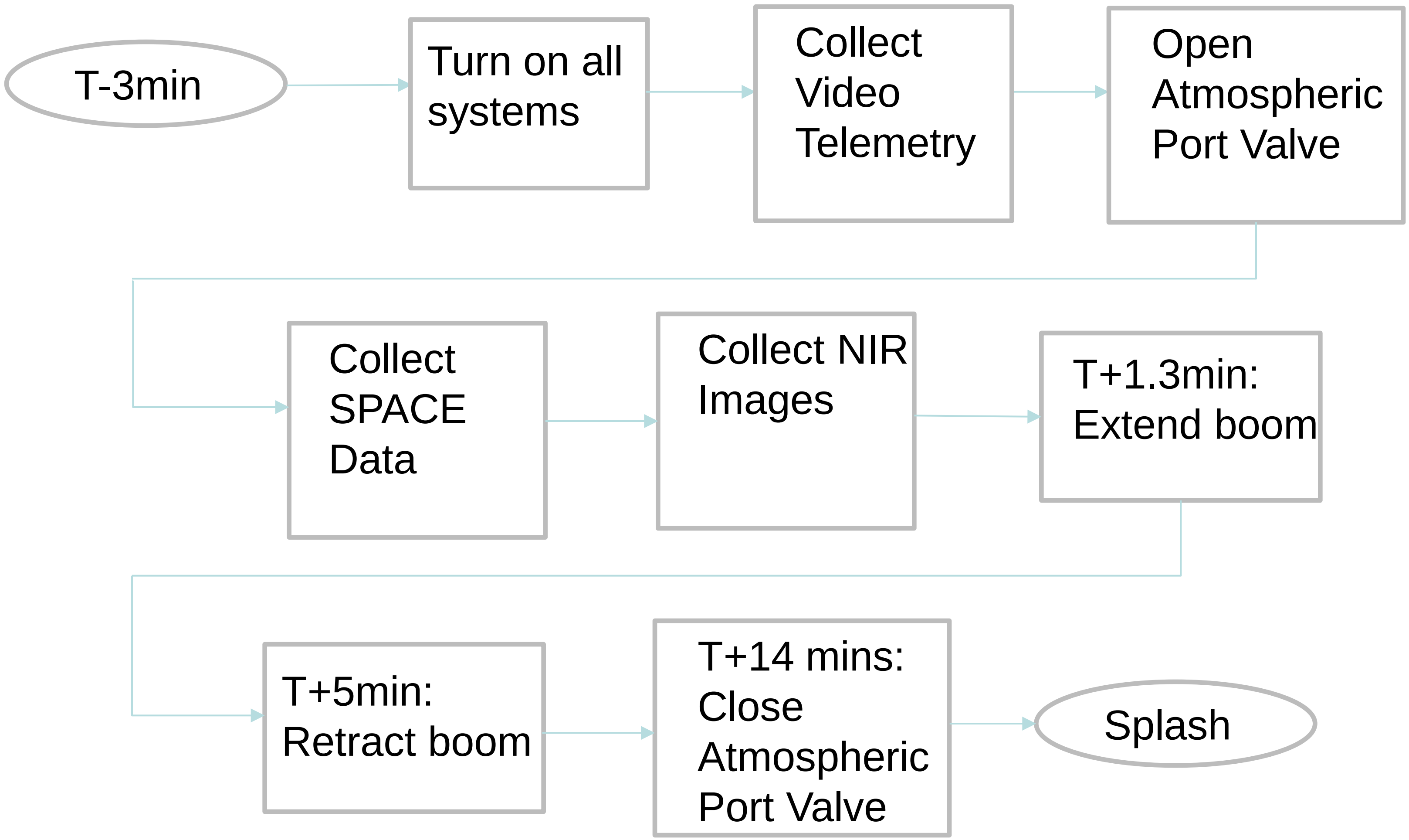
Design Overview: Shared Can Logistics

- Partners:
  - West Virginia University Team: WVU-CAM
  - NASA IV&V/Junior FIRST Lego League: WVU-CAM
  - West Virginia Wesleyan College: WVWC-SPACE
  - Shepherd University: Shepherd-SPACE
  - Marshall University: Marshall-SPACE
  - West Virginia University Institute of Technology: WVUTECH-SPACE
  - Fairmont State University: Canister Integration

Design Overview: Shared Can Logistics

- Plan for collaboration
  - Weekly/Monthly Telecon sessions
  - Share designs using Google drive
  - Will fit check before June
- Mounting to bottom plate
- Using a mid-mounting plate
- Ports:
  - Optical
  - Atmospheric: Static

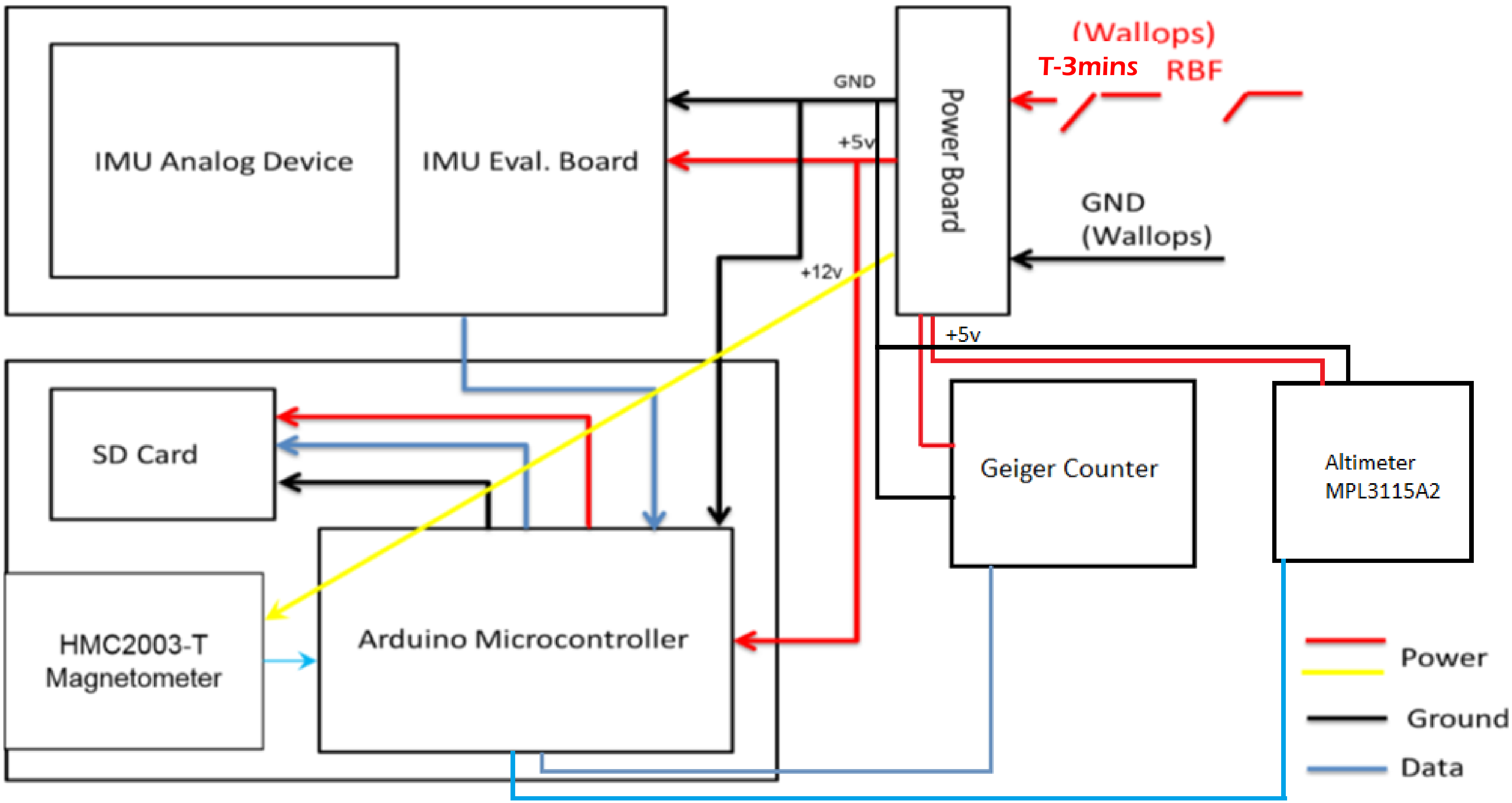
System Operations



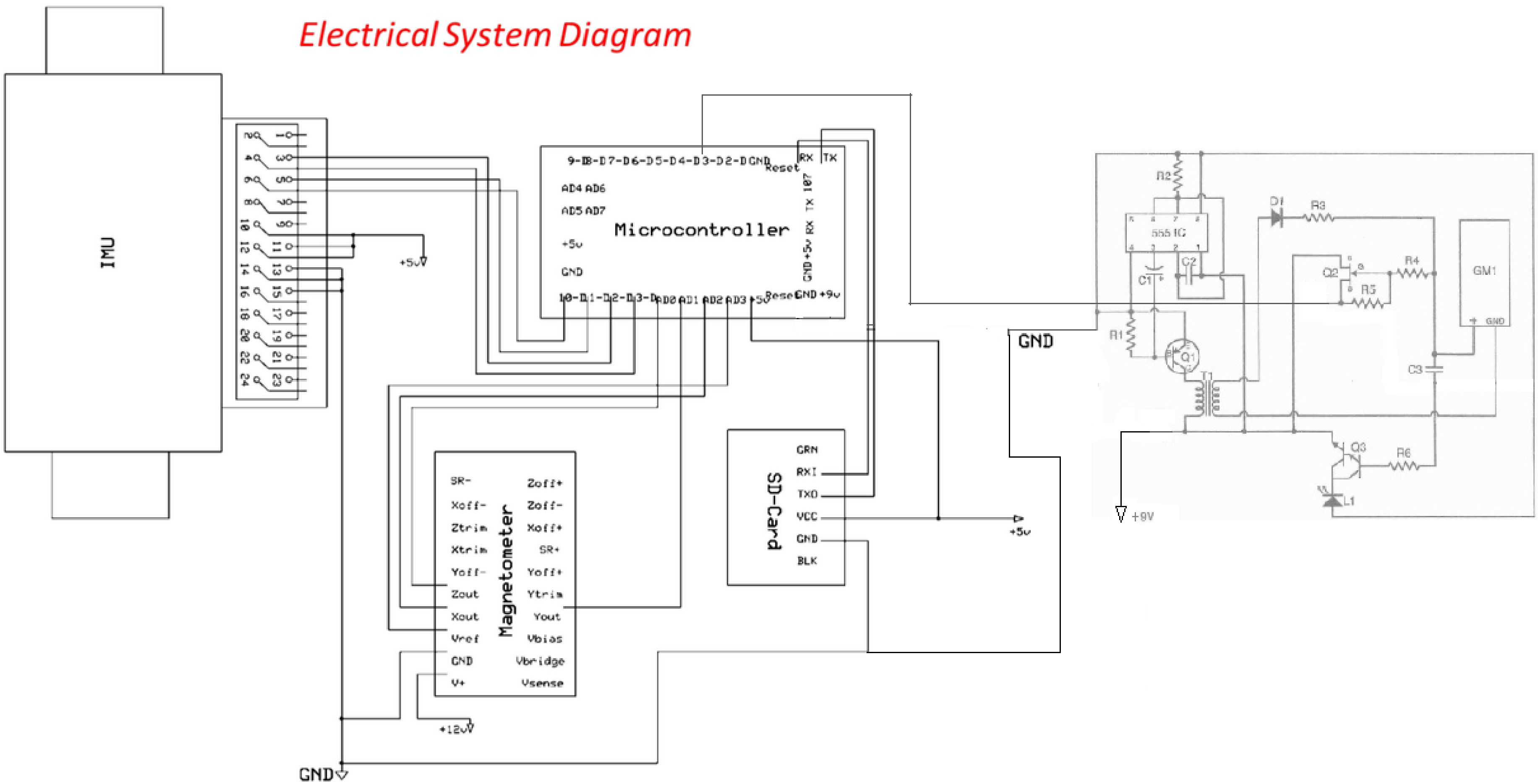
Subsystem Design
WVWC-SPACE

Andrew Tiffin

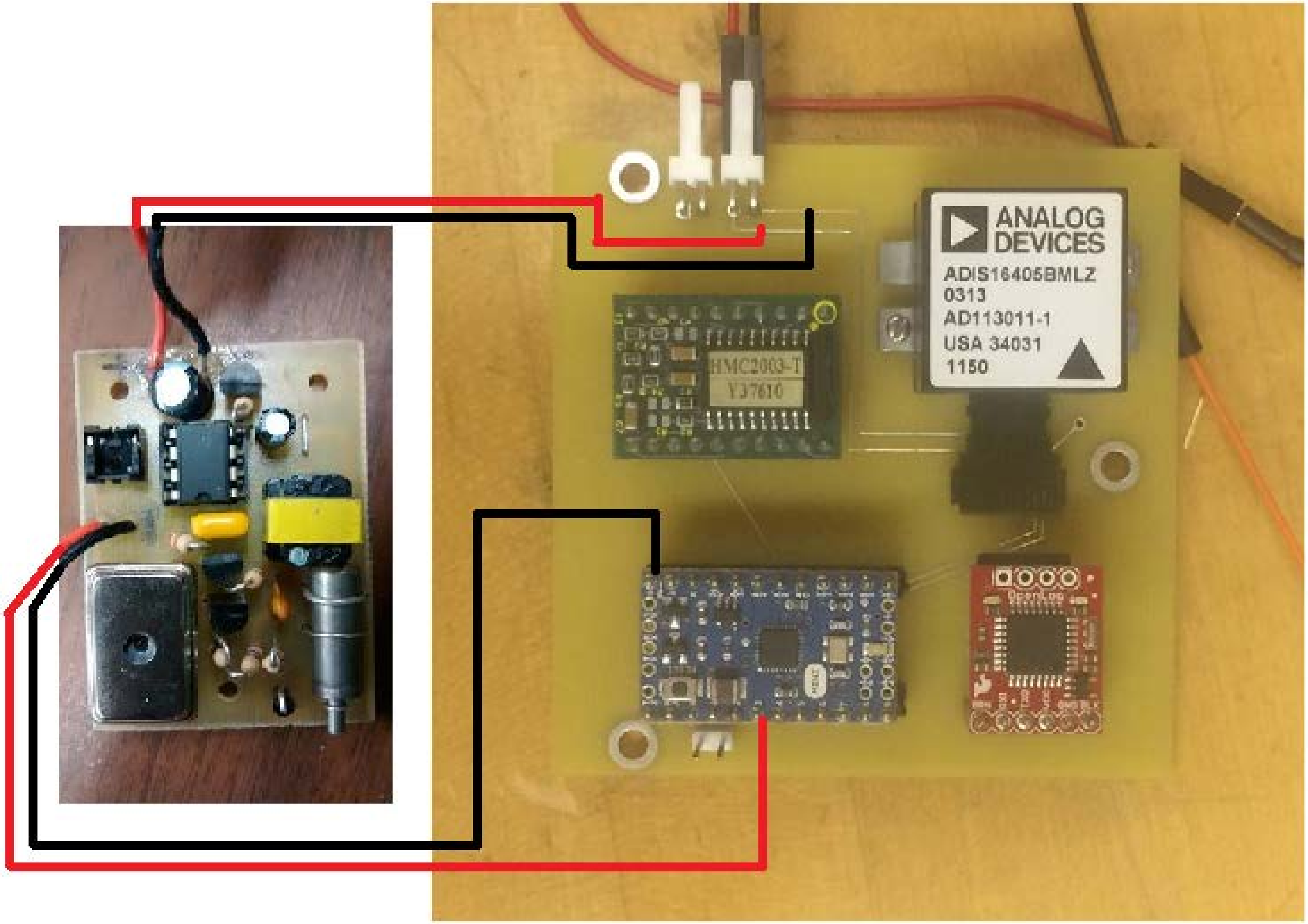
WVWC-SPACE: Electrical Diagram



WVWC-SPACE: Electrical Schematic

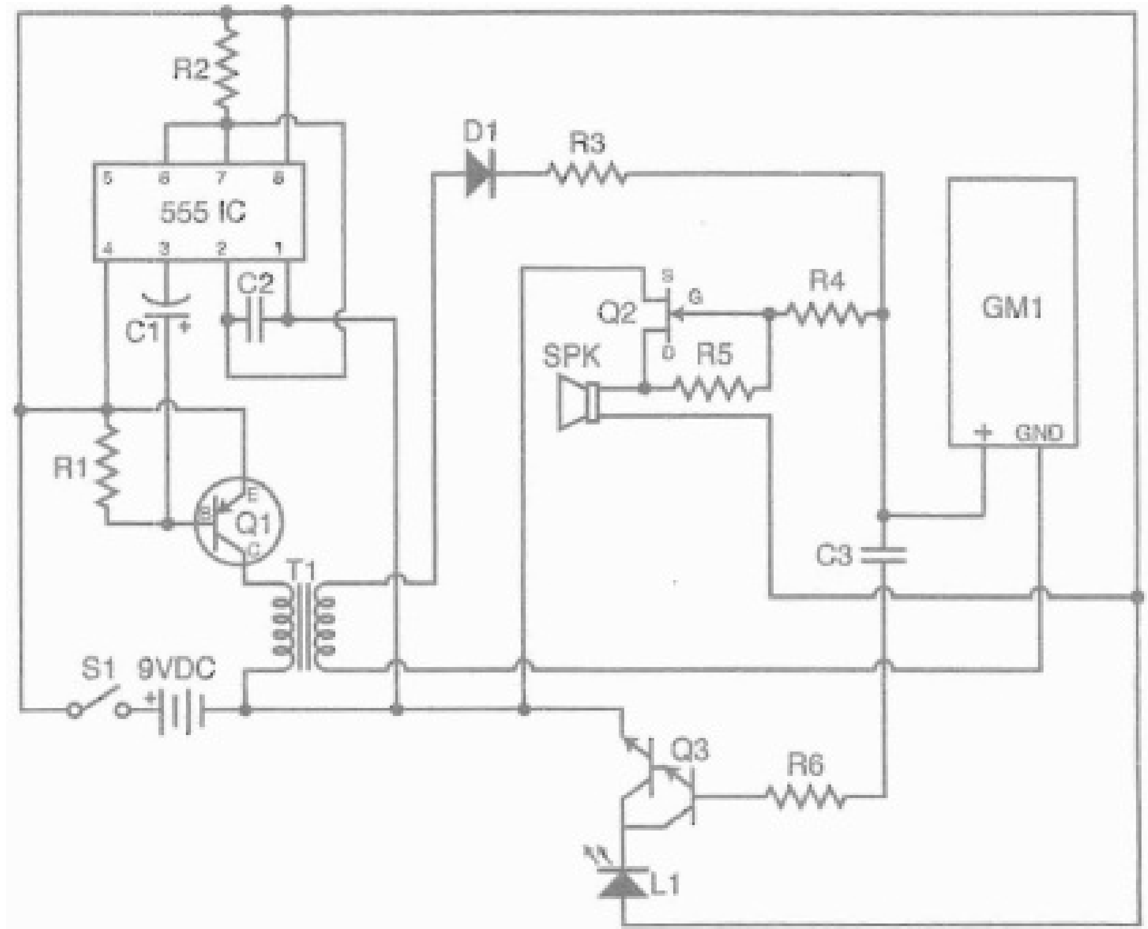


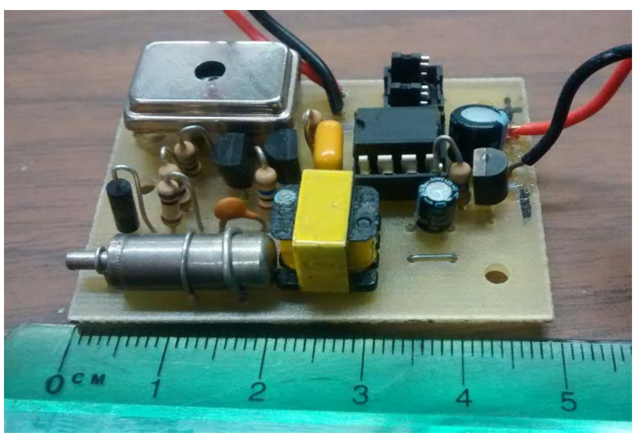
IMU and Magnetometer Payload



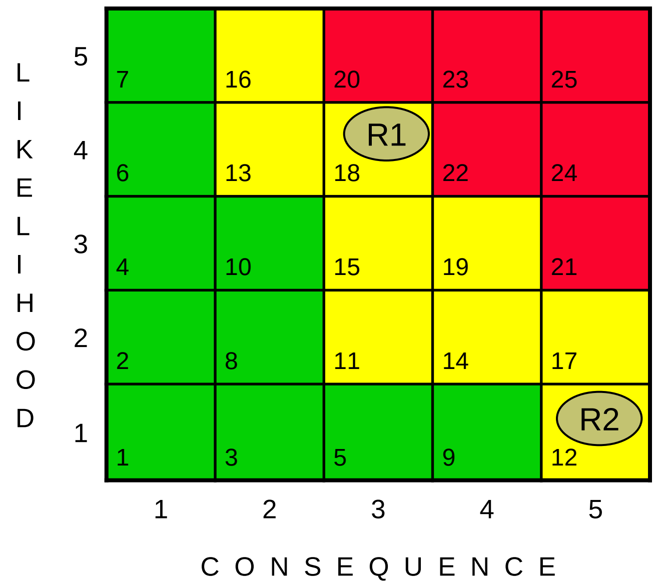
Geiger Counter Diagram

- 555 IC: 555 timer
- SPK: Speaker
- GM1: Geiger Tube





WVWC-SPACE: Risks



WVWC-SPACE.RSK.1: The high frequency spinning of the rocket will saturate the gyroscope

WVWC-SPACE.RSK.2: Mission objectives are not met IF micro controller fails in-flight

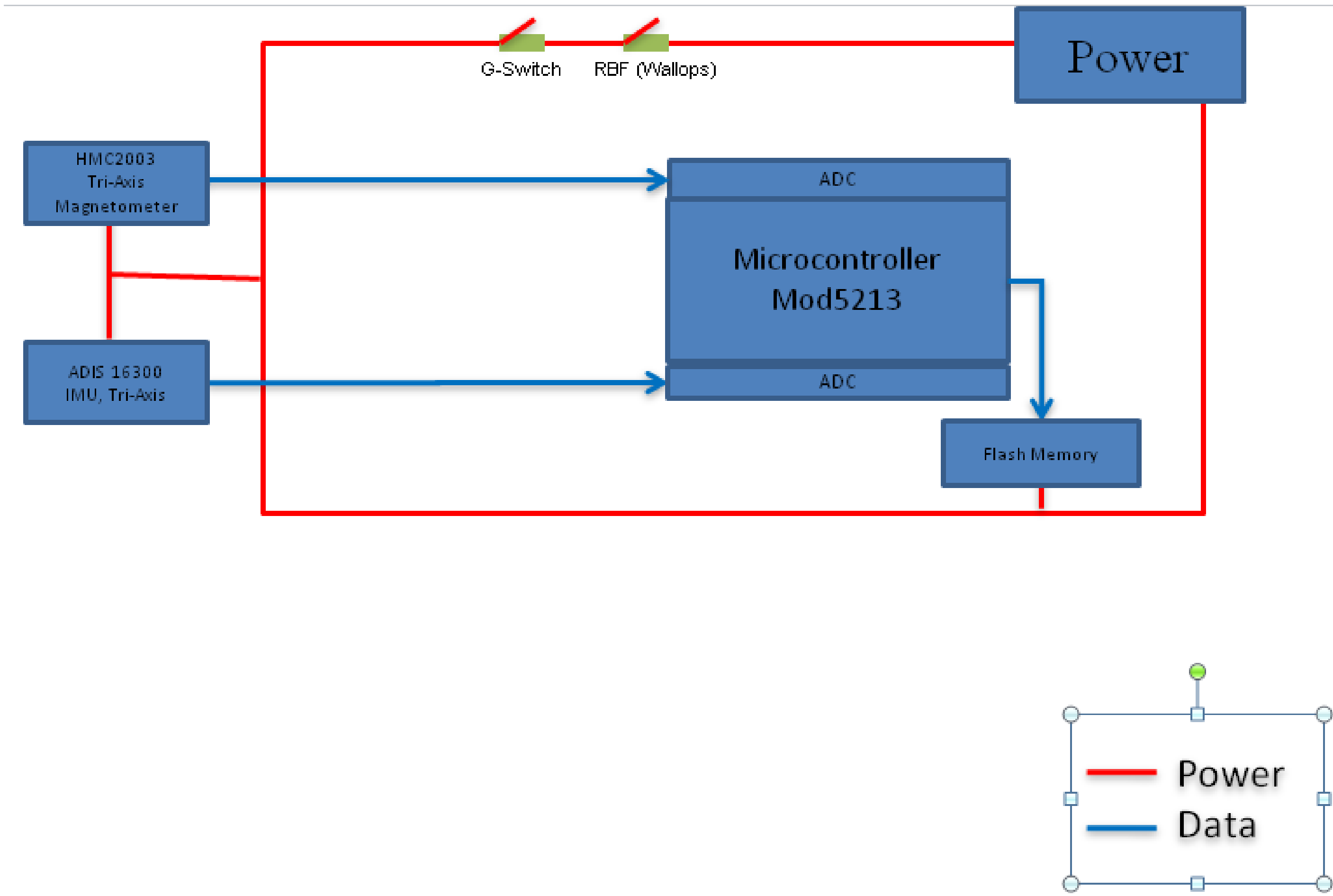
Subsystem Design
WVUTech-SPACE

Zack Dixon

WVUTech-SPACE Subsystem Design

- WVU Tech will incorporate the Netburner, Magnetometer, IMU, micro SD card onto a custom made PCB board.
- PCB Board will be the same overall dimensions as the other WV Rocketeer SPACE PCBs
- All components have been purchased and received
  - Currently being prototyped and tested.

WVUTech-SPACE: Electrical Diagram



Subsystem Design
Marshall-SPACE

Seth Baker

Marshall-SPACE System Overview

Subsystems:

Software and programming: Payload control programming will be done in the C++ variant used by Arduino. Off-board data analysis will be done using Java or Python.

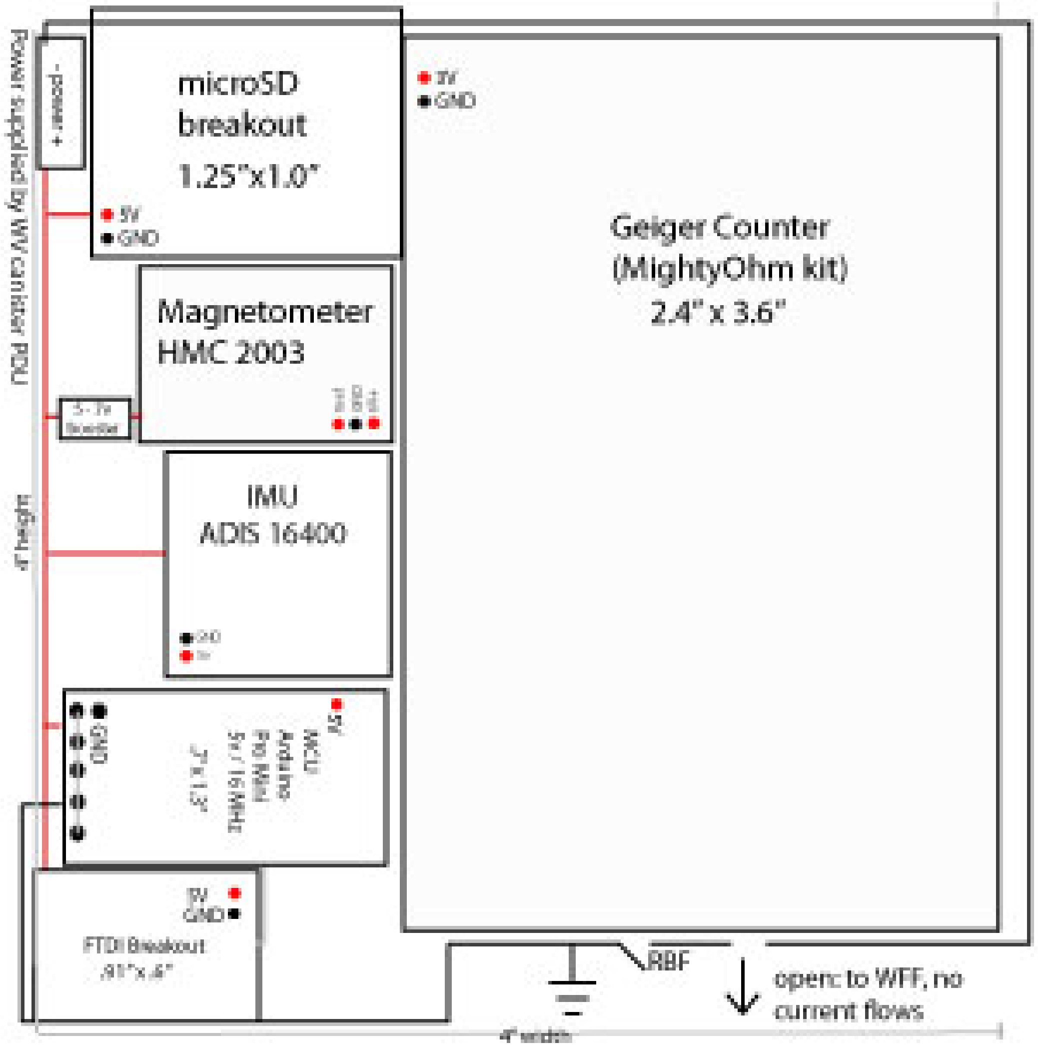
Mechanical Design: We will follow the examples of previous groups and mount our PCB board on a Lexan bracket.

Electrical Design: Payload will receive ~ 12V power from the rocket. Digital outputs on MCU will activate the various components. A voltage regulator will step down 12V input power to 5V, with exception of power to accelerometer, which will require a 5-3.3V regulator. Max current is expected to be < 500mA.

Marshall-SPACE Electrical Subsystem

- Discussion: Components were researched by individual team members. There were three primary requirements: physical dimensions, usability, and accuracy. The selected components include:
- Microcontroller: Arduino Mini Pro (5V, 16MHz)
- Stefan-Meyer Fluxgate Magnetometer FLC 100
- FTDI Breakout: required for programming the Arduino
- microSD Breakout: required for logging data to microSD card
- BMP 180 breakout: barometer and accelerometer
- MPU 6050 breakout: accelerometer and gyroscope
- MightyOhm Geiger Counter kit

Marshall-SPACE Electrical Diagram



- All units in inches
- Power supplied by rocket
- Power and data connections on PCB
- Total current < 500mA.
- FTDI breakout remains on final payload for on-going testing and improvements

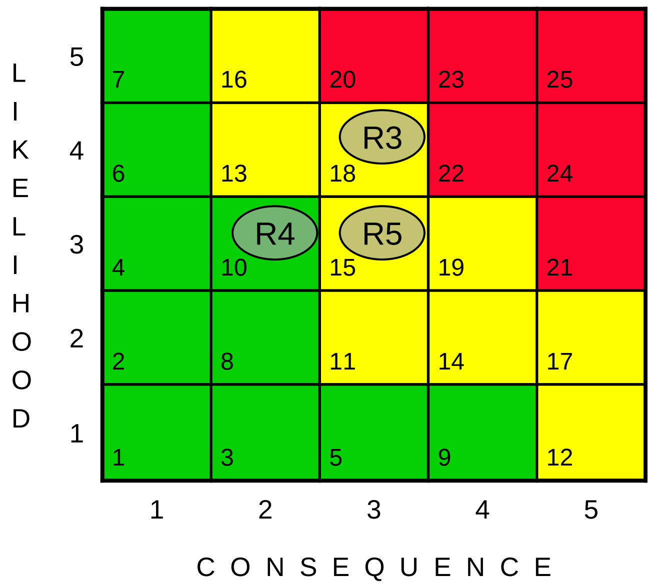
Marshall-SPACE: Risks

R3: Marshall-SPACE.RSK.1 - The MightyOhm Geiger kit has not been verified for aerospace applications. The risk is that the system will malfunction during flight. This risk can be mitigated by making flight readiness improvements during assembly

R4: Marshall-SPACE.RSK.2 - The Arduino Pro Mini's16Mhz processor may limit the amount of data collection during flight. This risk can be mitigated by utilizing test-driven development and writing software with the MCU's limitations in mind

R5: Marshall-SPACE.RSK.3 – Errors made during PCB development could cause delays and budget overruns. This can be mitigated by allowed for sufficient lead time and requests for assistance from contacts at Huntington's RCBI (Robert C. Byrd Institute for Advanced Manufacturing)

Marshall-SPACE: Risks



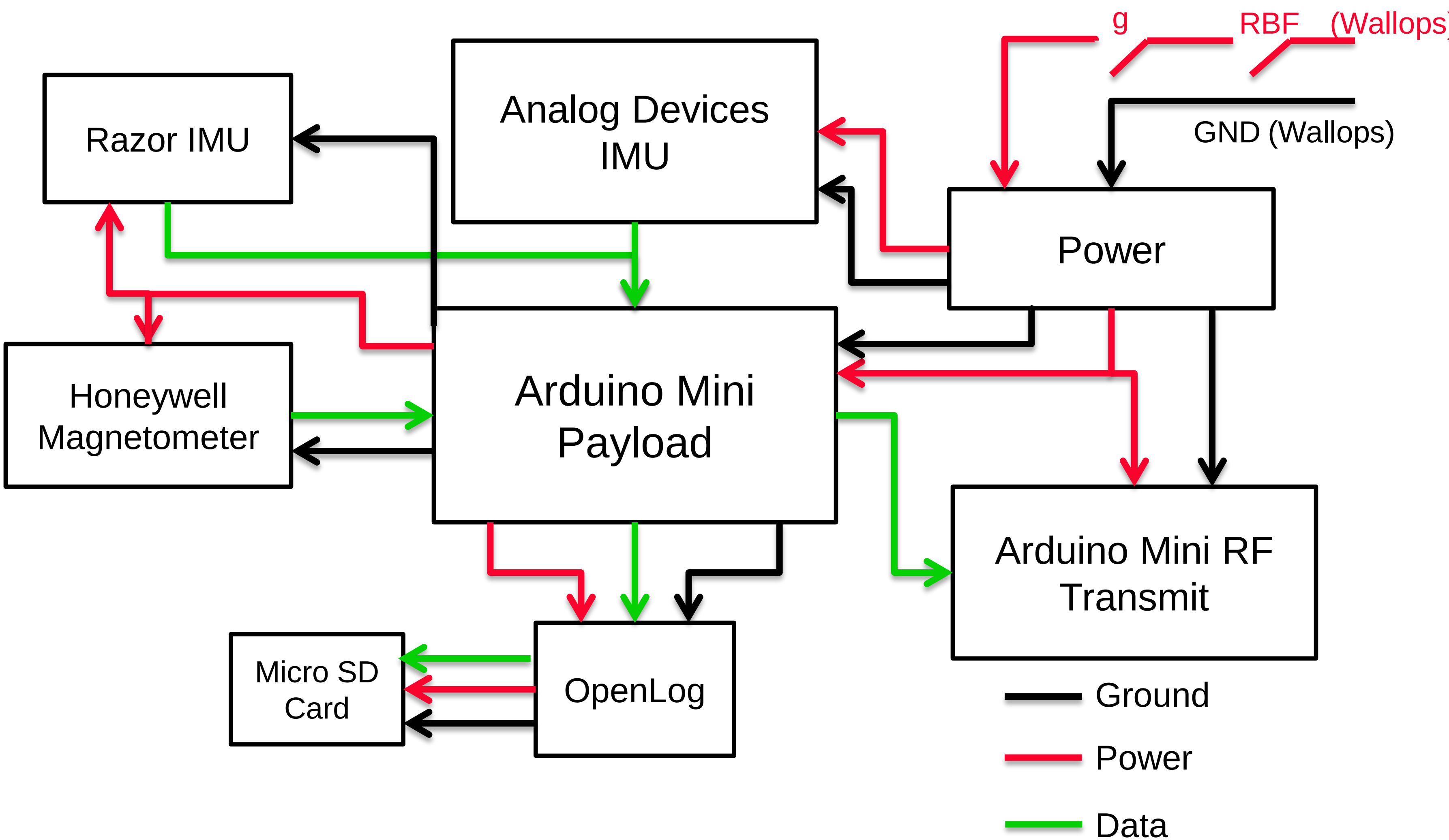
Subsystem Design
Shepherd-SPACE

Rachelle Huff

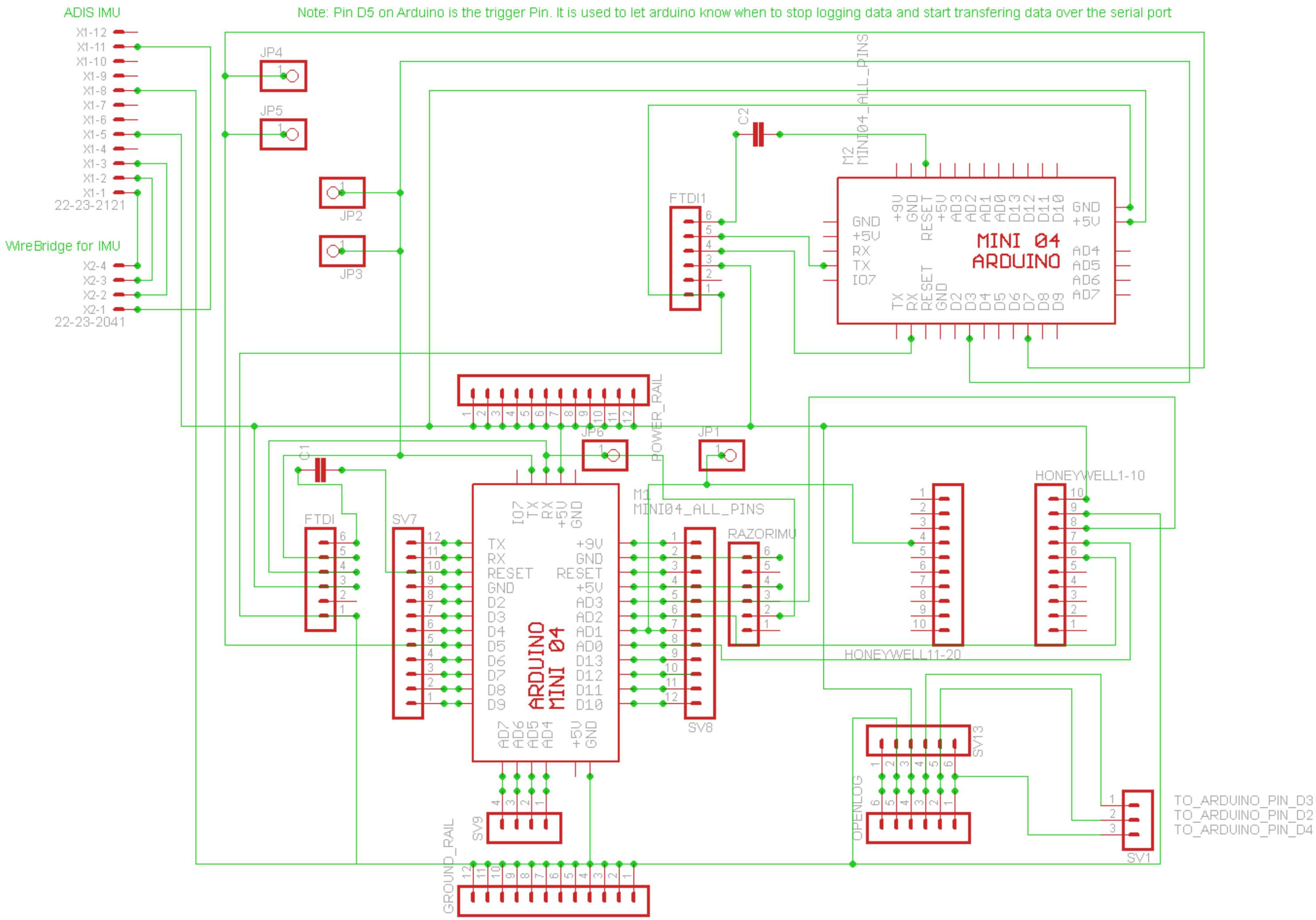
Shepherd-SPACE: Subsystem Design

- The main components Shepherd is to include in the design are:
  - Razor or COTS IMU and ADIS IMU
  - Honeywell Magnetometer
  - Micro SD card
  - Microcontroller: Arduino Mini-05
  - OpenLog
- All components will be put on a custom PCB, which will have the same dimensions as the other WV Rocketeer SPACE PCBs

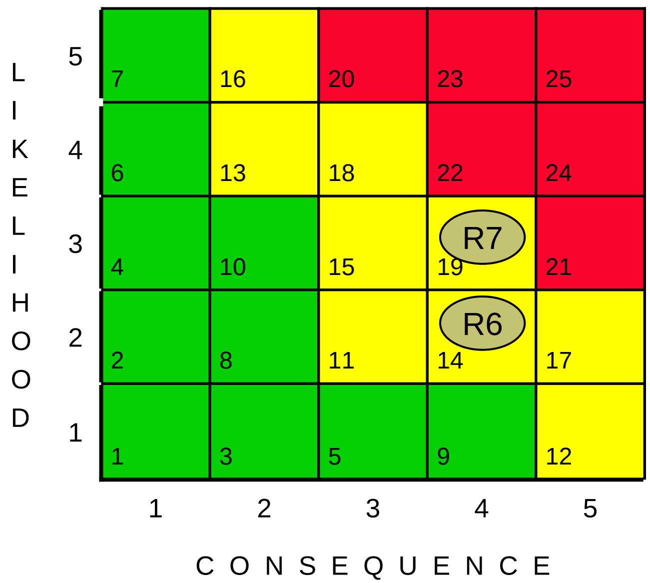
Shepherd-SPACE: Electrical Diagram



Shepherd-SPACE: Electrical Schematic



Shepherd-SPACE: Risks



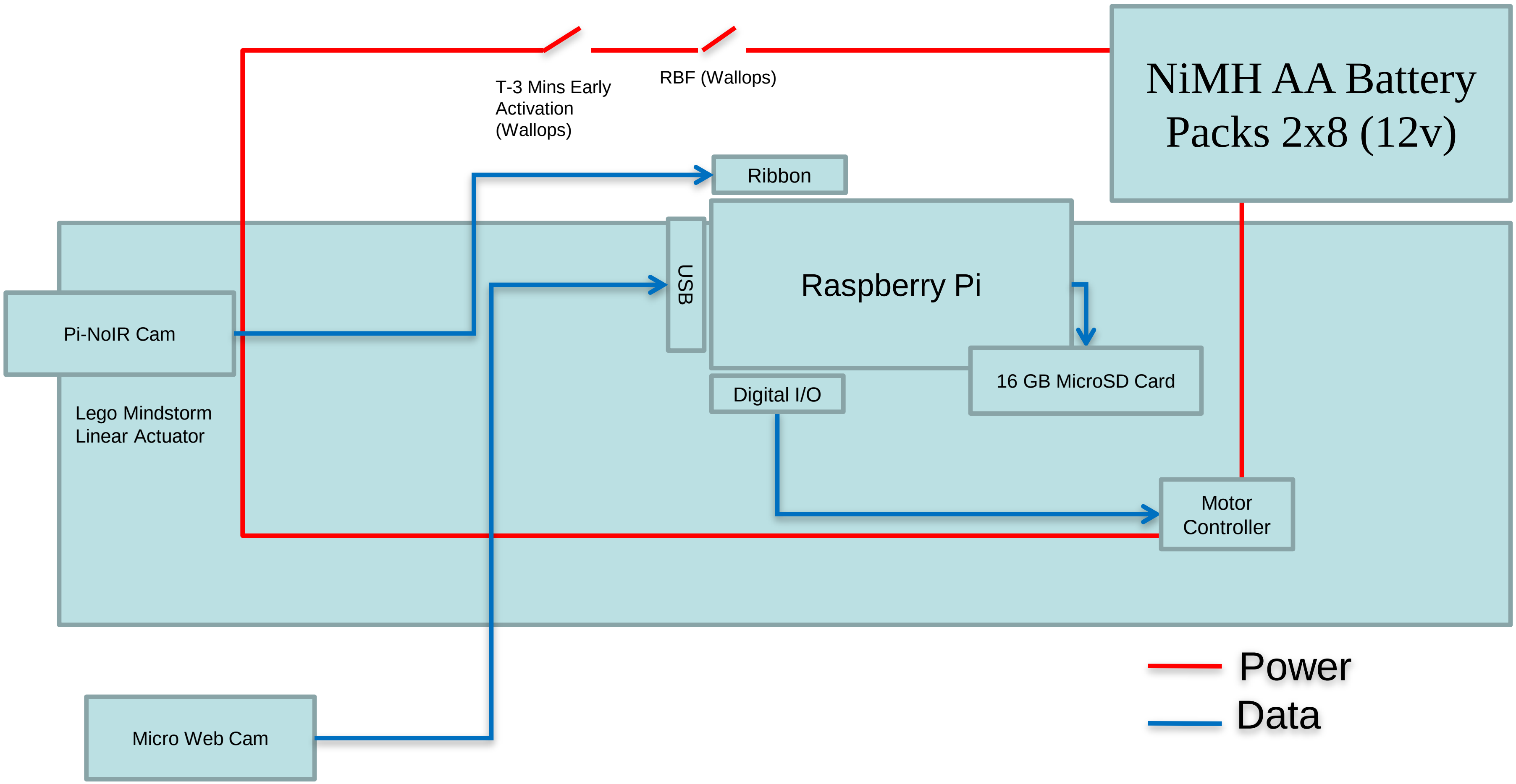
R6:Shepherd-SPACE.RSK.1: Mission objectives are not met IF the magnetometer fails to collect a sufficient amount of data to compare the B-field and WMM

R7:Shepherd-SPACE.RSK.2: Mission objectives are not met IF the Razor IMU malfunctions as it is not certain if it is flight worthy so we will no longer have redundancy in FD data when/if it dies

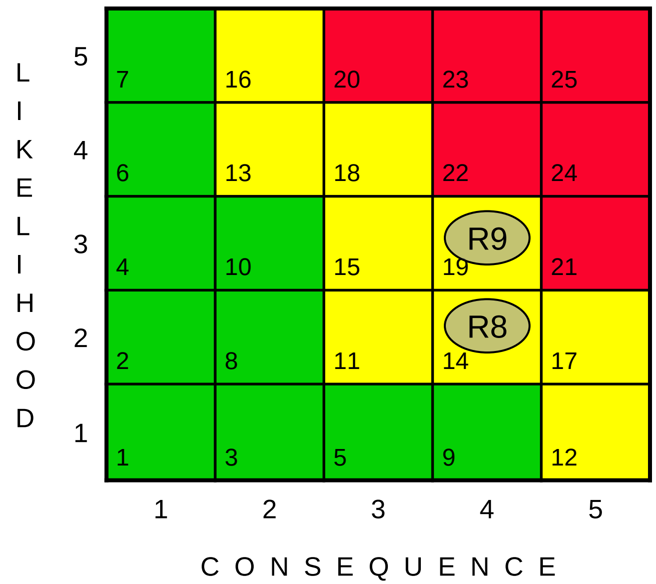
Subsystem Design
WVU-CAM

Steven Hard

WVU-CAM: Electrical Diagram



WVU-CAM: Risks

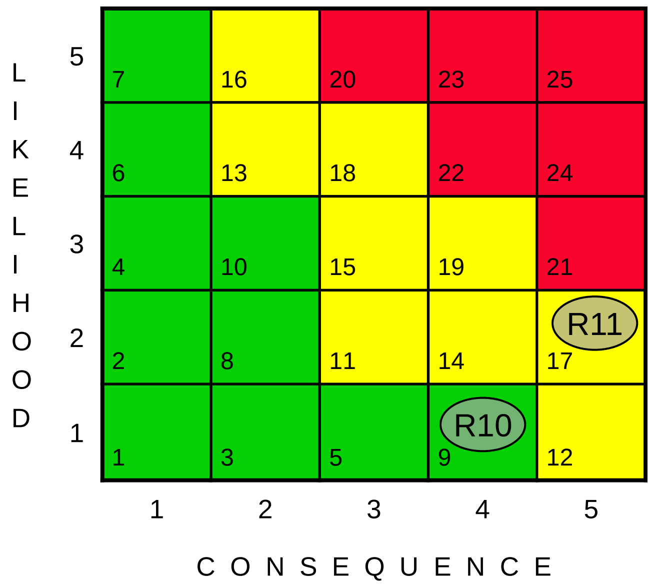


R8: WVU-CAM.RSK.1 - Mission objectives are not met IF the linear actuator boom causes damage to the NIR camera lens
R9: WVU-CAM.RSK.2 - Mission objectives are not met IF adequate lighting is not provided for Payload camera to detect all visual telemetry

Subsystem Design
Structural Support

Steven Hard

SSS: Risks



R10: STR.RSK.1 – Integration schedule and milestones will not be met IF a lead for Structures subsystem is not put in place

R11: STR.RSK.2 - Mission objectives are not met IF mounting bracket(s) fails in-flight

Subsystem Design
Power Distribution

Steven Hard

PDS: Risks

LIKELIHOOD		CONSEQUENCE 1	2	3	4	5
	5	7	16	20	23	25
	4	6	13	18	22	24
	3	4	10	15	19	21
	2	2	8	R12 11	14	17
	1	1	3	5	9	12

R12: PDS.RSK.1 – A strain will be placed on the power budget if the launch is significantly delayed <u>after the T-3min switch is activated</u>

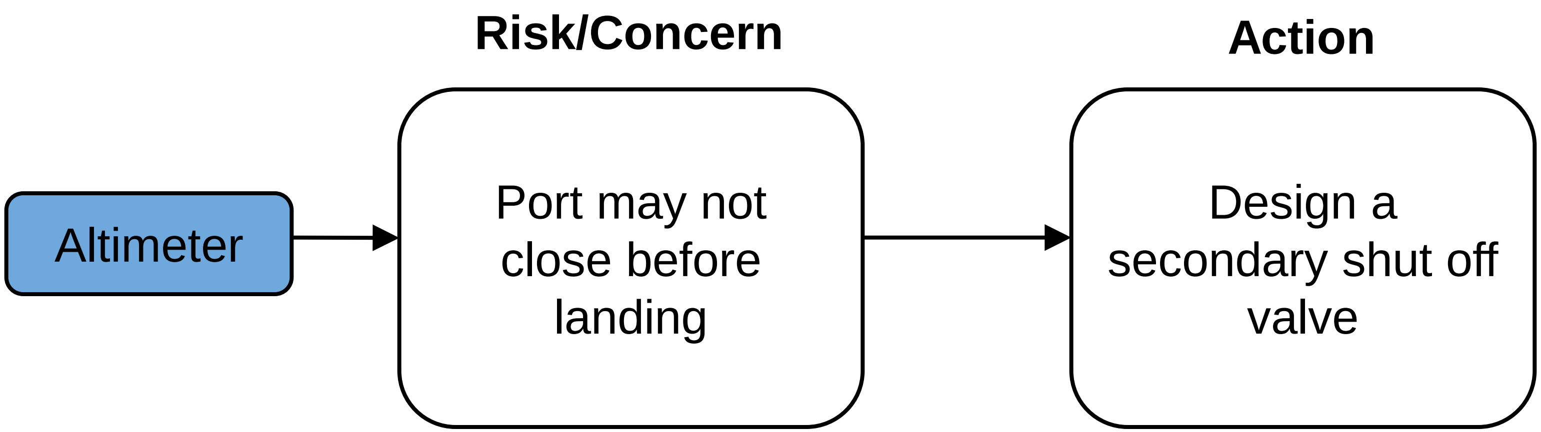
Test/Prototyping Plan

Team Leads

WVWC-SPACE Prototyping

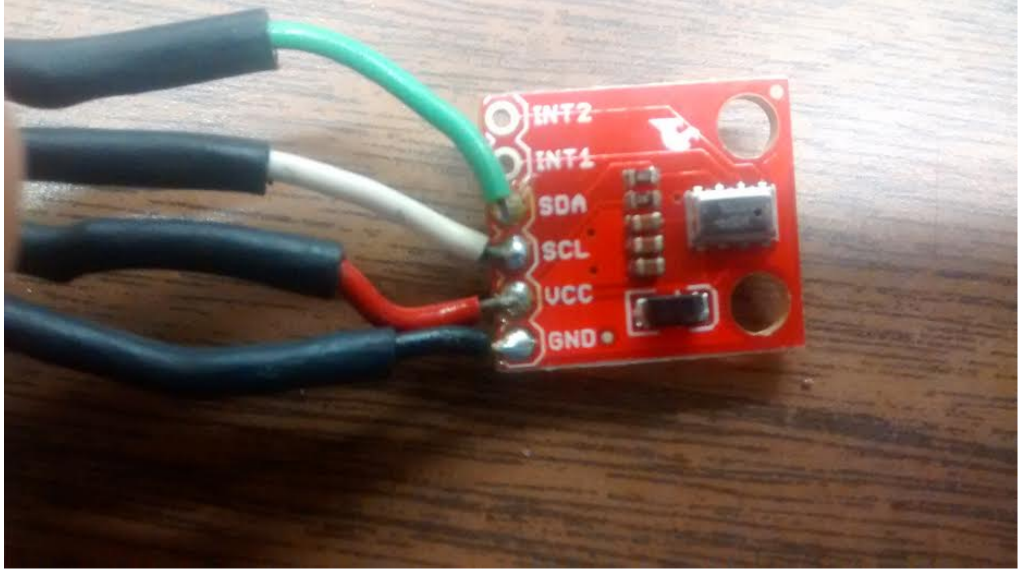
	Risk/Concern	Action
Geiger Counter	Determine if Geiger counter is functioning properly	Build and test device against a known radioactive source and compare with calibrated device
IMU	Spin rate of rocket could saturate gyro sensors of IMU	Build turntable for calibration and saturation testing

WVWC-SPACE Prototyping



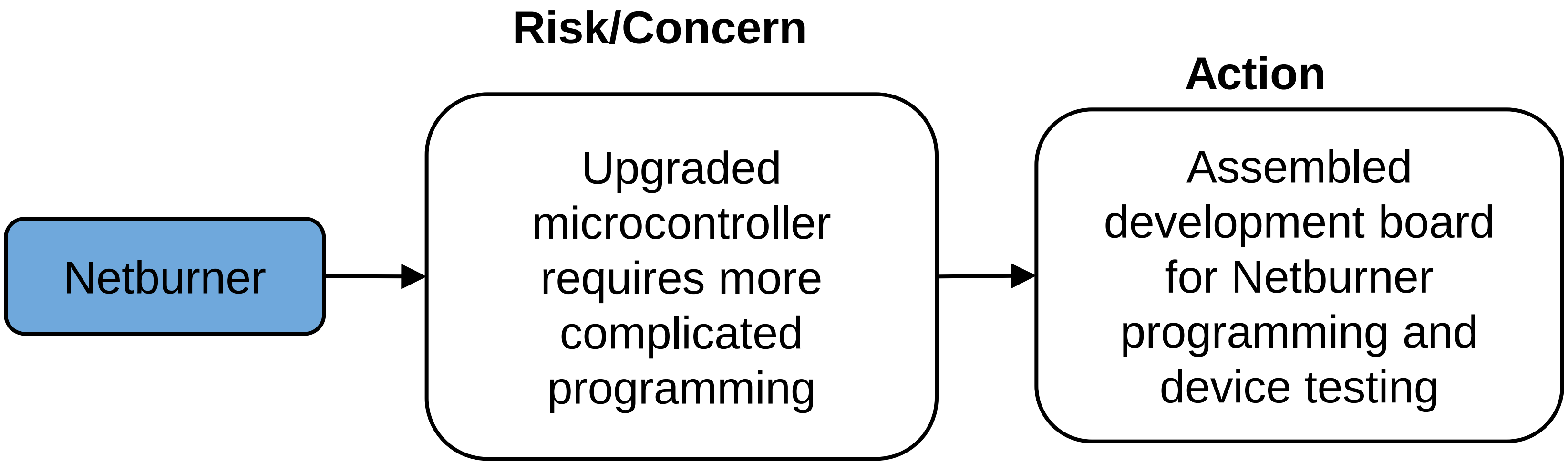
- All components have been prototyped on breakout boards and/or preliminary payload PCBs
- Current prototyping plan involves continued development of electrical schematics and custom PCB designs

WVWC-SPACE Prototyping (MPL3115A2)



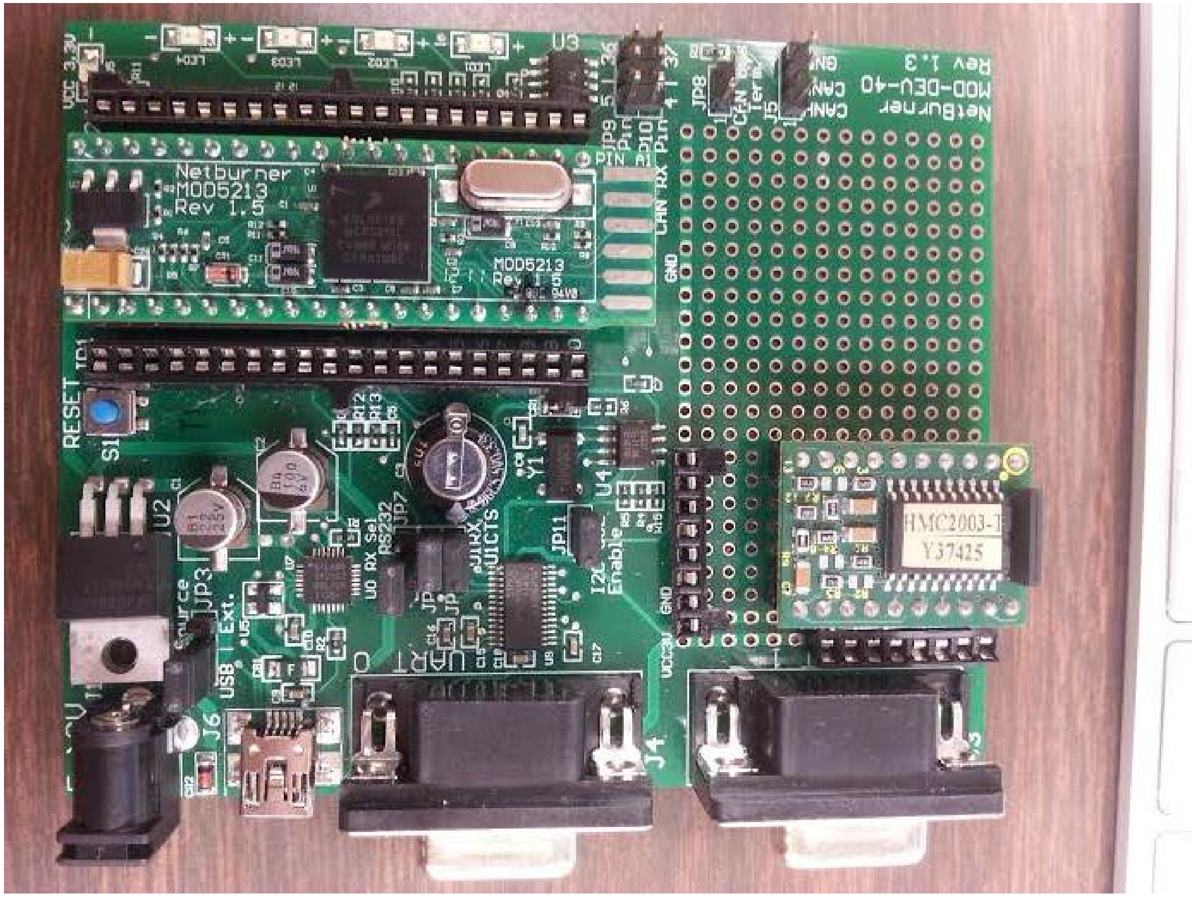
- Altimeter sensor has been extensively tested, but still needs to be integrated into circuit

WVUTech-SPACE Prototyping



- All Components need to be programmed and tested with Netburner controller.
- MOD-DEV-40 board from Netburner is being used as a testing station for components.
- Coding and testing will be done before the design and purchase of the payload PCB in the Spring
- Goal is to eventually test the PCB design as it will be flown

WVUTech-SPACE Prototyping (MOD-DEV-40)



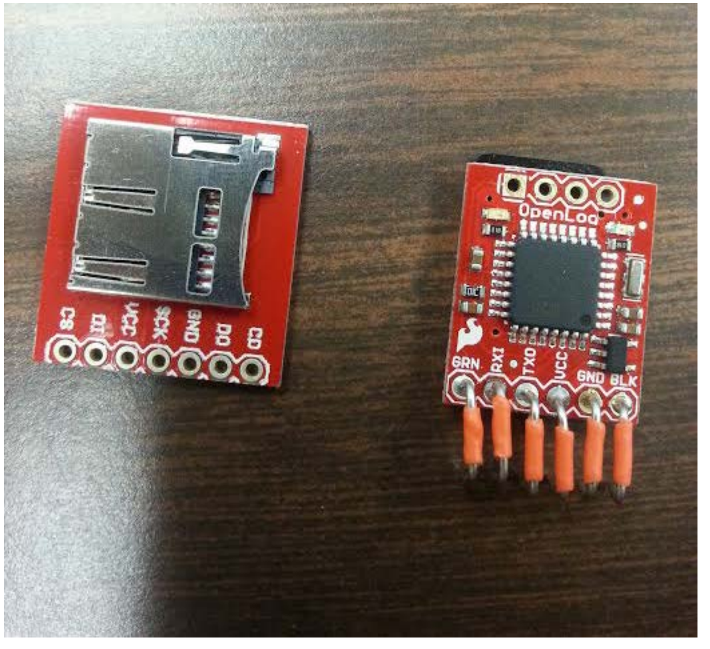
Netburner micro controller connected to the MOD-DEV-40 development board along with HMC2003 Magnetometer

WVUTech-SPACE Prototyping (IMU)

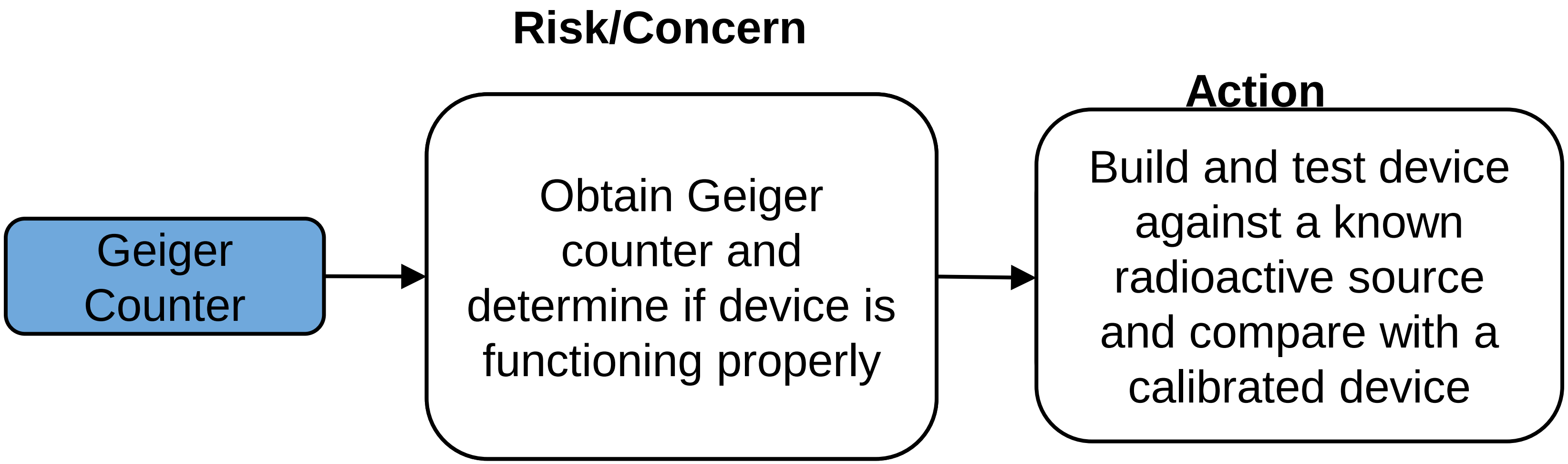
- Analog Devices ADIS 2300 IMU, iSensor pin board, and connector ribbon
- iSensor pin board allows for ease of adaptation during testing.
- Will allow for programming and micro controller adaptation.

WVUTech-SPACE Prototyping (Memory)

- Micro SD card readers
- Will be added to MOD-DEV-40 to allow all components to collect data and store it.



Marshall-SPACE Prototyping



- With the exception of the Geiger counter, all components are pre-assembled on breakout boards
- Current prototyping plan involves assembling the components on a breadboard for testing
- Assuming all components pass unit and integration testing, Eagle schematics will be developed and a custom PCB ordered
    - PCB will primarily handle data, power, and mechanical connections between the various breakout boards.

Shepherd-SPACE Prototyping

Risk/Concern

Action

Magnetometer → Determine if the magnetometer is working properly and returning good data → Test device using a fairly strong magnet while having removed all other metal items within a radius of a few feet

- All components already assembled on breadboard, ready to be tested/in process of being tested
- Coding will be adjusted accordingly until satisfying results have been gathered
- When components work sufficiently, Eagle CAD will be used to create a custom PCB Design for the payload
  - This PCB will be printed for the final payload to be assembled, then more tests will be done

WVU-CAM Prototyping

Risk/Concern

Action

NIR Camera Boom → The actuation of the boom could potentially run NIR lens into optics port window if not designed properly → Building and testing boom configuration to physically limit boom actuation

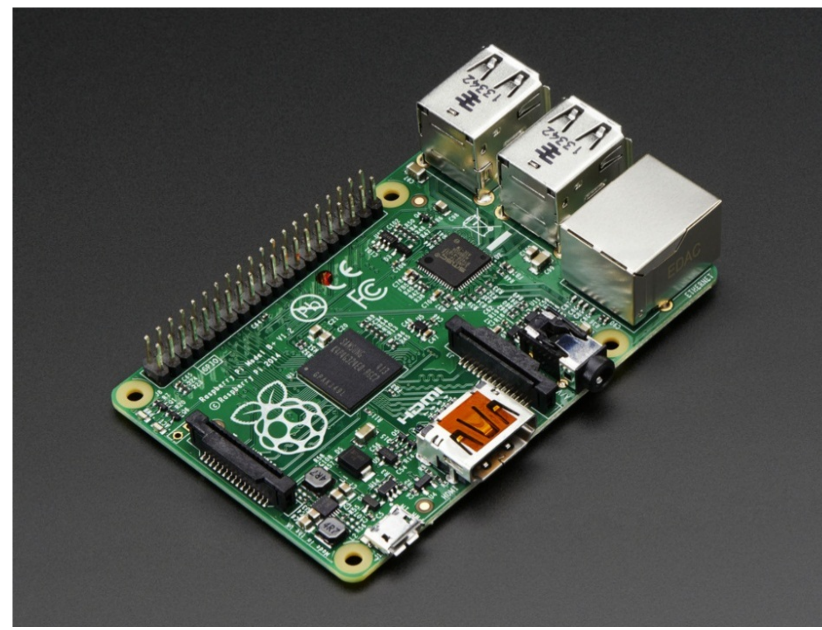
STR → Mechanical structures lead identified later than anticipated which could potentially cause delays in integration → Work closely with ME to prototype complete payload canister layout

WVU-CAM Prototyping (Linear Actuator)

- Firgelli Technologies L12 Actuator 30mm 210:1 12V PLC/RC Control
  - 210:1 12V Position Controller
  - Peak Power Point: 45 N @ 2.5 mm/s
  - Max Speed (no load): 5 mm/s
  - Input Voltage: 12V
  - Stall Current: 450 mA at 5 V & 6 V, 200 mA at 12 V
  - Stroke: 30mm

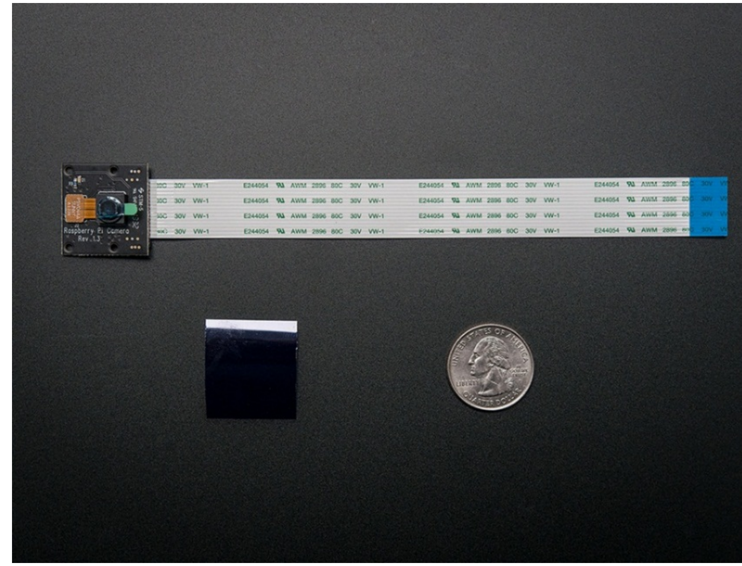
WVU-CAM Prototyping (Camera CPU Board)

- Raspberry Pi Model B+
  - 5V supply has polarity protection (2A fuse and hot-swap protection so you can plug/unplug USB without resetting the board)
  - 4 USB ports
  - 40 GPIO
  - Composite (NTSC/PAL) video integrated into 4-pole 3.5mm 'headphone' jack
  - MicroSD card socket
  - Four mounting holes in rectangular layout
  - Size: 85mm x 56mm
  - Broadcom SoC running at 700MHz processor (can be overclocked)
  - 512MB RAM



WVU-CAM Prototyping (Cameras)

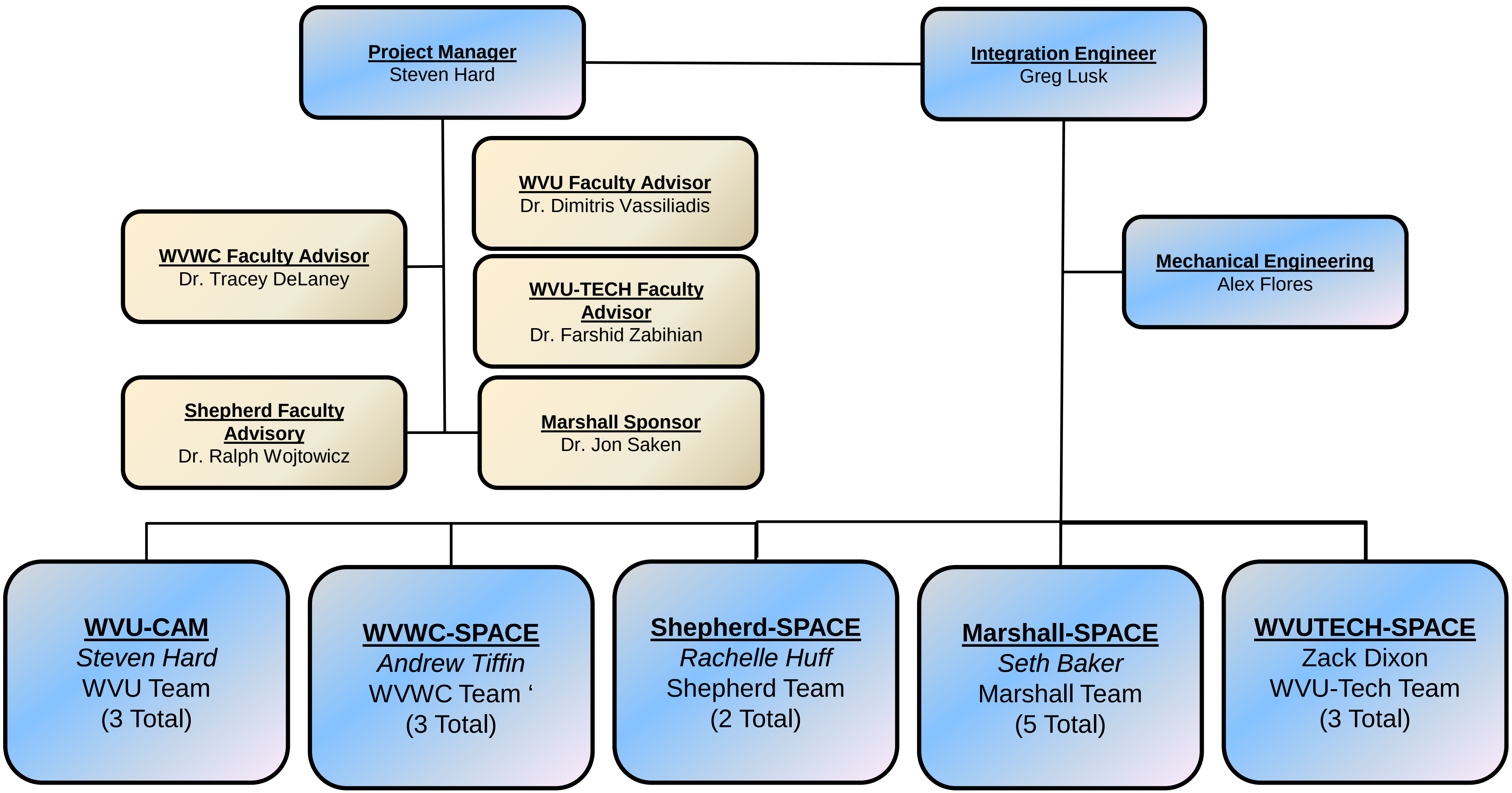
- Raspberry Pi NoIR Camera Board - Infrared-sensitive Camera
  - Board size: 25mm x 20mm x 9mm
  - 5MP (2592 × 1944 pixels) Omnivision 5647 sensor in a fixed focus module
  - Support 1080p30, 720p60 and 640x480p60/90 video resolution
- Mini Webcam for Robot Video Real Time Video Stream
  - Weight: 0.20 lbs
  - Max Resolution: 1024 x 768
  - 3' (914.4mm) Retractable USB-A Cable



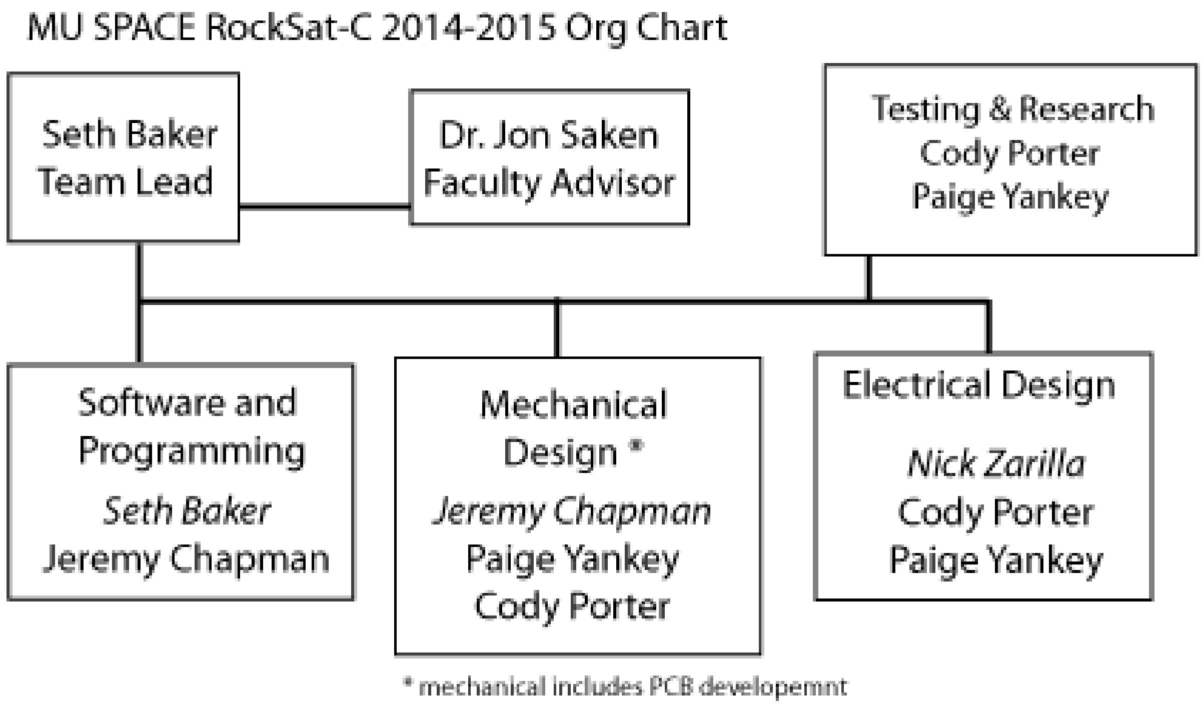
Project Management Plan

Steven Hard

Organizational Chart



Marshall Project Management



Schedule

- Major Milestones
  - CDR (12/4/14)
  - Prototype high risk items (11/28/15)
  - Flight award announcement (1/16/2015)
  - Procure remaining components (1/17/2015)
  - Design PCBs (Week of 2/16/15)
  - STR (Week of 3/23/15)
  - ISTR (Week of 4/6/15)
  - Receive canister (Week of 4/20/15)
  - FMSR (Week of 5/20/15)
  - Deliver preliminary check-in document (Week of 6/4/15)
  - LRR (6/17/15)
  - Travel to Wallops (6/18/15)
  - Launch (6/25/15)*

  * Tentative, no guarantee – small chance launch could get cancelled due to weather or other unforeseen delays

Budget

- Most of experimental components have been procured/delivered
  - Lead time not anticipated to be a factor

Margin:	0.25	Budget:	$3,000.00	Last Update:	11/17/2014 11:15
Item	**Supplier**	**Estimated, Specific Cost**	**Number Required**	**Toal Cost**	**Notes**
Motor Controller	DigiKey	$150.00	2	$300.00	1 for testing
Linear Actuator	Firgelli	$120.00	1	$120.00	1 mini tracked linear actuator
Raspberry Pi	DigiKey	$35.00	2	$70.00	1 for testing
Pi NoIR Cam	Adafruit	$25.00	2	$50.00	1 for testing
Mini WebCam	Amazon	$90.00	2	$180.00	1 for testing
Magnetometer	Honeywell	$220.00	1	$220.00	Marshall Payload
Inertial Measurement Unit (s)	Analog Devices Sparkfun	$150.00	2	$300.00	Marshall Payload
Microcontroller	DigiKey	$25.00	1	$25.00	Marshall Payload
Printed Circuit Boards	Advanced Circuits	$33.00	4	$132.00	1 board/SPACE
Misc. Electronics (R,L,C)	DigiKey	$50.00	4	$200.00	4 misc/SPACE
Testing Materials	Various	$75.00	4	$300.00	Testing equipment for each team
Total (no margin):					$1,897.00
Total (w/ margin):					$2,371.25

Team Organization

Team Member	Email Address	Phone Number	US Person? (Y/N)
Steven Hard (NASA IV&V - Team Lead)	Steven.L.Hard@nasa.gov	304-367-8287	Y
Dimitris Vassiliadis (WVU - Advisor)	Dimitris.Vassiliadis@mail.wvu.edu	304-293-4920	Y
Josh Waggoner (WVU)	jdwaggoner@mix.wvu.edu		Y
Greg Lusk (Fairmont State)	grglusk@gmail.com		Y
Farshid Zabihian (WVU-Tech- Advisor)	Farshid.Zabihian@mail.wvu.edu	304-442-3280	Y
Thy Dinh (WVU-Tech - Student Lead)	tdinh@mix.wvu.edu		Y
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Cody Porter (Marshall U)	porter214@marshall.edu		Y
Paige Yankey (Marshall U)	yankey@marshall.edu		Y
Tracey Delaney (WVWC - Advisor)	delaney_t@wvwc.edu	304-473-8330	Y
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Eric Kramer (WVWC)	kramer_et@wvwc.edu		Y
Paul Mallory (WVWC)	mallory_dp@wvwc.edu		Y
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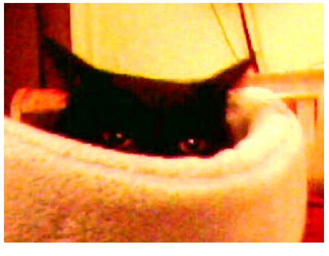
Rachelle Huff (Shepherd U - Student Lead)	rhuff02@rams.shepherd.edu		Y
Andy Shtanko (Shepherd U)	iqvasya@gmail.com		Y

Availability Matrix

Team Name/School Here: WV Rocketeers					
Fall 2014 RS-C Team Availability Matrix					
		PLEASE USE MOUNTAIN TIME ZONE TIMES			
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
7:00 AM	No	yes	yes	yes	No
8:00 AM	No	yes	yes	yes	yes
9:00 AM	No	yes	No	yes	No
10:00 AM	No	Yes	No	No	No
11:00 AM	No	Yes	No	yes	Yes
12:00 PM	No	Yes	No	yes	Yes
1:00 PM	yes	Yes	No	yes	Yes
2:00 PM	yes	Yes	No	No	Yes
3:00 PM	yes	No	No	No	No
4:00 PM	No	No	No	No	No

Management

- Preliminary schedule for the semester
  - Weekly/monthly telecons in preparation for PDR
  - Rotate by team/experiment
- Monetary budget – covered
- Team mentors (industry, faculty)
  - NASA IV&V Facility



Don't let the schedule sneak up on you!

Conclusion

- Begin prototyping critical interfaces and risk items
- Finalize design layout
- Issues, concerns, any questions