HASP Payload Specification and Integration Plan

Payload Title: Student Payload Integrated First Flight (SPIFF)

Payload Class: [✓ Small] Large (circle one)

Payload ID: 2012-01

Institution: **Boston University / GA Tech / New Mexico Tech**

Contact Name: Nathan Darling

Contact Phone: 617 353 0285

Contact E-mail: nathandarling@gmail.com

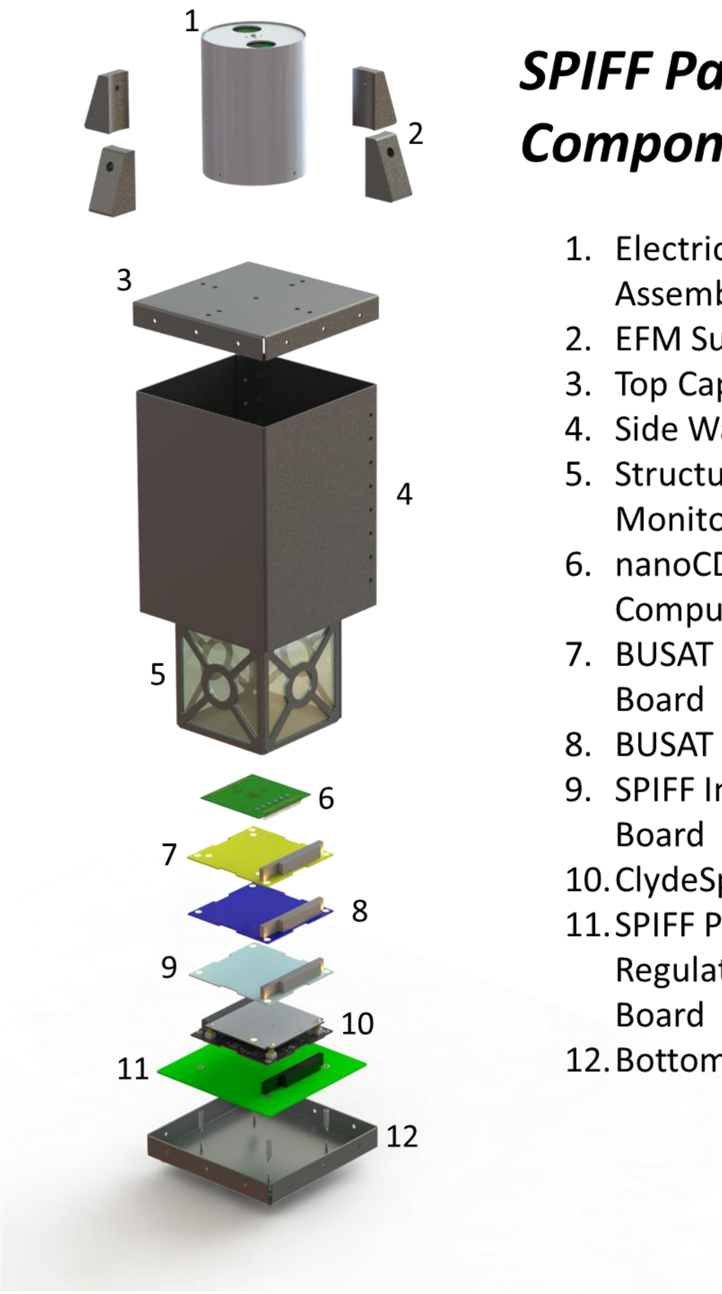
Submit Date: June 22, 2012

I. Mechanical Specifications:

A. Calculated weight of the payload (not including payload plate): **2.37 kg (2.64 kg with uncertainty)**

	Item	Measured	*Uncertainty*	Calculated	*Uncertainty*	Estimated	*Uncertainty*
STRUCTURES							
	Top Cap			115	25		
	Bottom Cap			115	25		
	Side Walls			398	25		
	Fasteners					50	30
	Standoffs					50	30
BUS / POWER							
	EPS	135	20				
	Batteries	260	20				
	C&DH			60	25		
PAYLOADS							
	Magnetometer			50	25		
	SHM			500	25		
	EFM			635	25		
TOTALS		***395***	***40***	***1873***	***175***	***100***	***60***
	Units: grams	***Total Mass:***	***2368***		***Total Mass with Uncertainty***	***2643***	

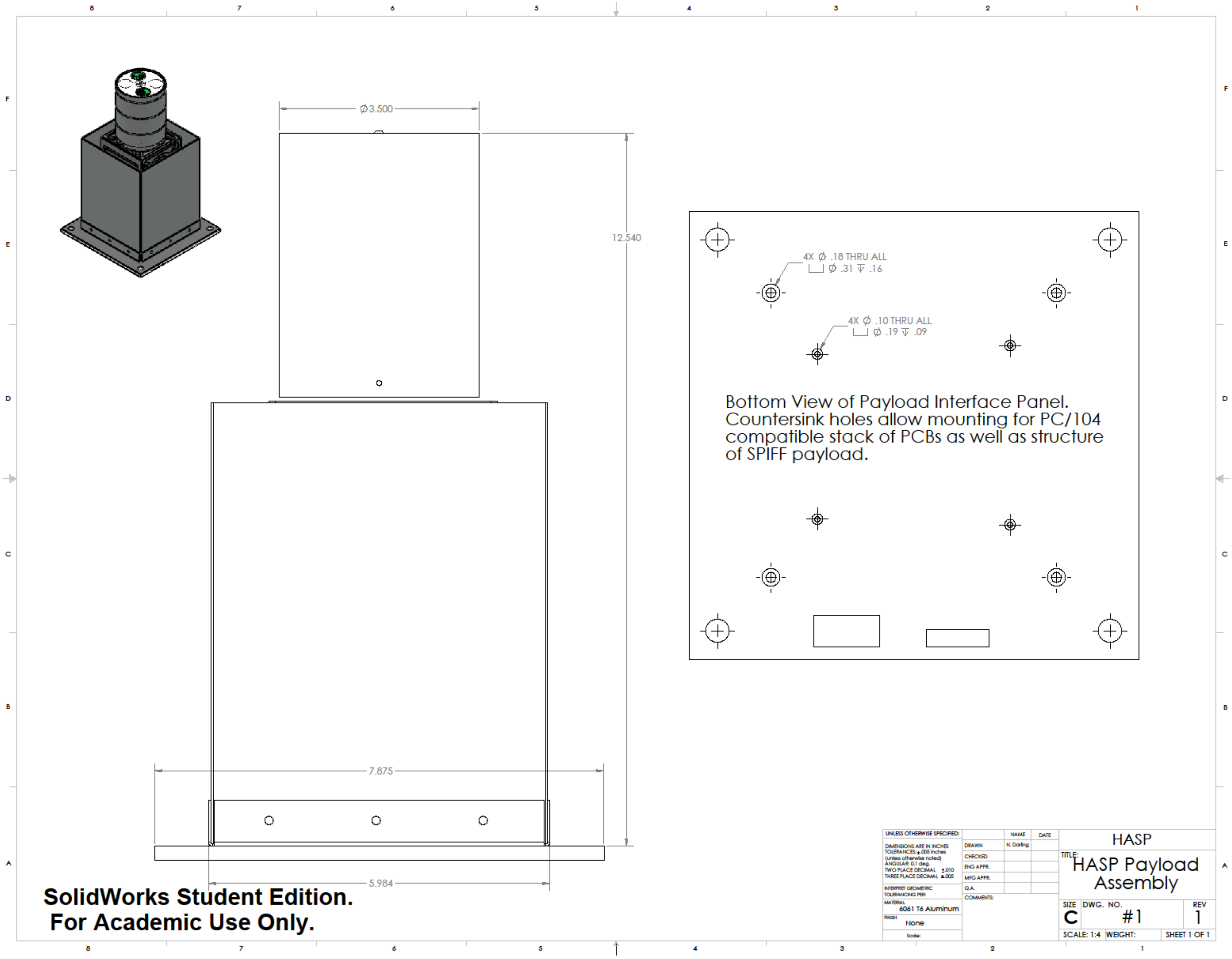
B. Mechanical drawings detailing the major components of SPIFF payload and mounting:



SPIFF Payload Components

1. Electric Field Mill Assembly (EFM)
2. EFM Supports
3. Top Cap
4. Side Walls
5. Structural Health Monitoring Assembly
6. nanoCDH Single Board Computer
7. BUSAT C&DH Circuit Board
8. BUSAT Magnetometer
9. SPIFF Interface Circuit Board
10. ClydeSpace EPS
11. SPIFF Power Regulation Circuit Board
12. Bottom Cap

Figure 1: Payload Components



C. There are no potentially hazardous items on the SPIFF payload.

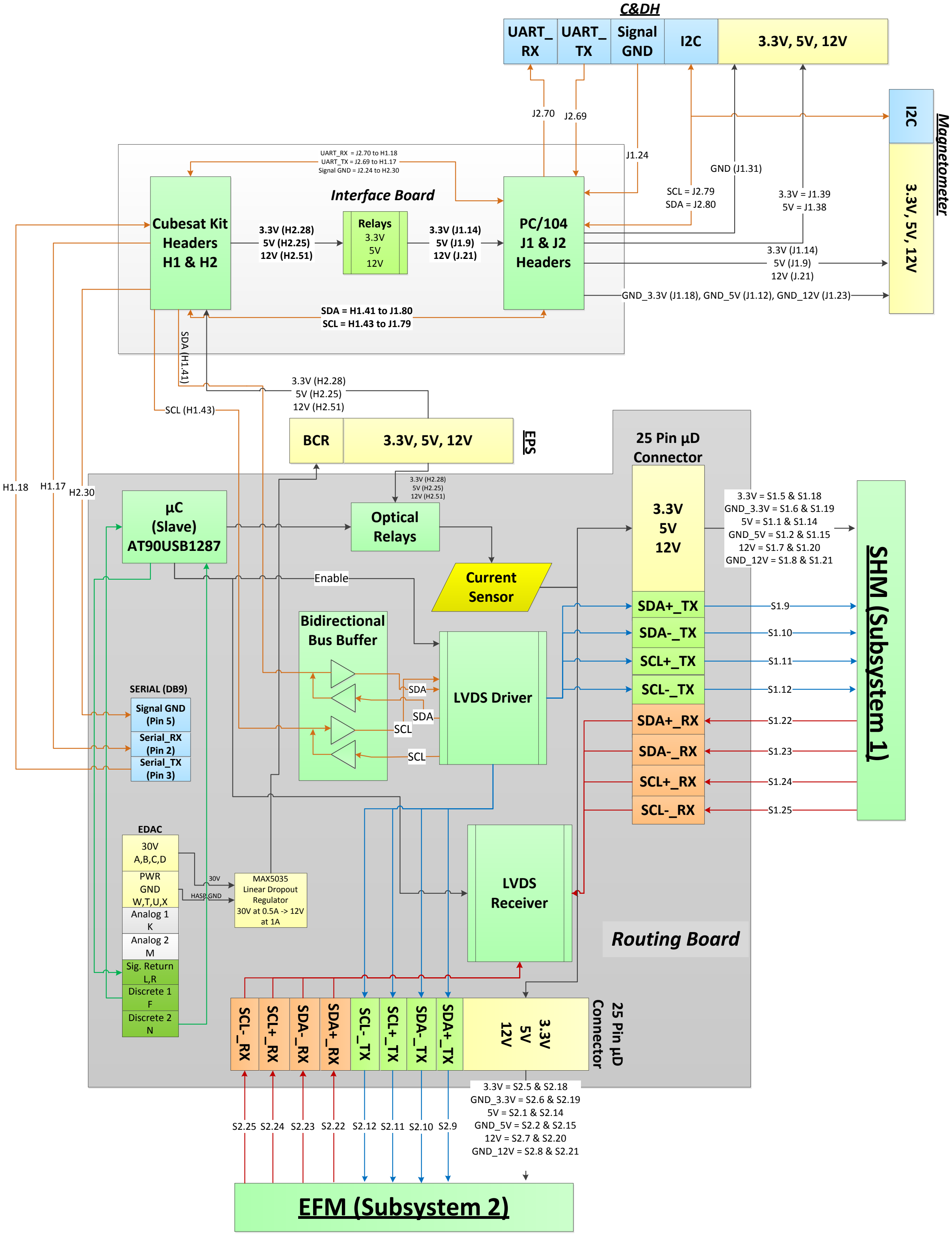
D. Other relevant mechanical information:

i. It should be noted that the electric field mill has a rotating part that could be damaged if stray wires or small components are dropped into the sensor. ***A red-tagged shroud will be provided to protect this component during integration and test.***

II. Power Specifications:

A. Measured current draw at 30 VDC: **0.33 A (estimated)**

B. Power System Wiring Diagram:



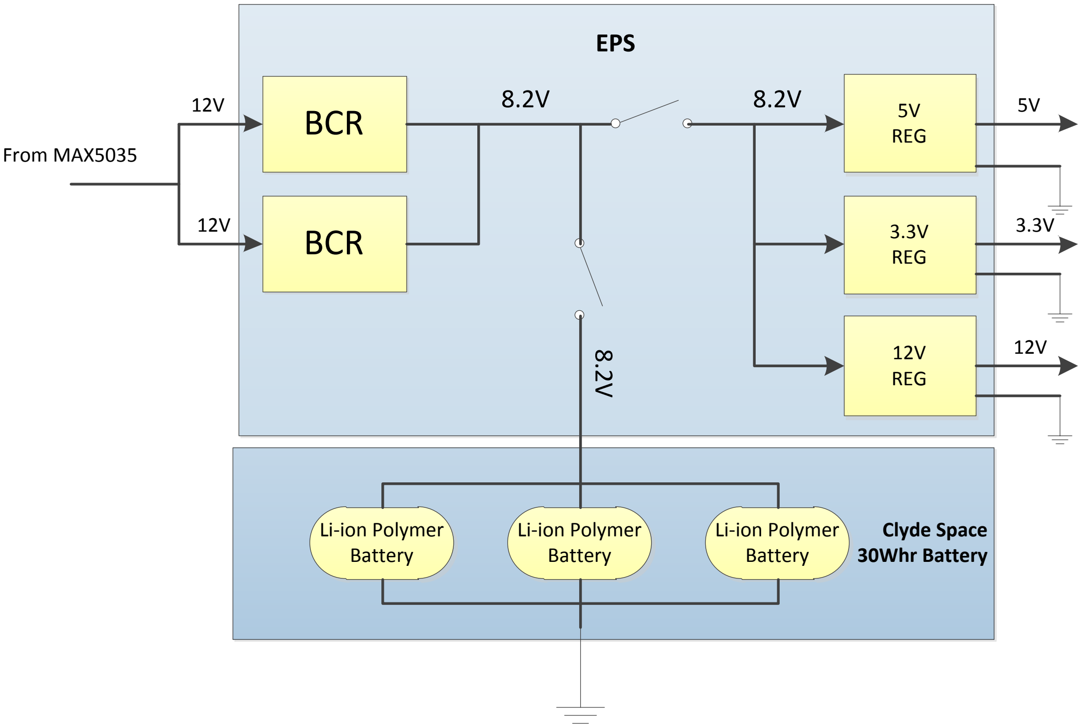
Key

C&DH = Command and Data Handling
MAG = Magnetometer
BCR = Battery Charge Regulator

S1 = Subsystem 1 (SHM- Structural Health Monitoring)
S2 = Subsystem 2 (EFM)
Cubesat Kit Headers = H1 and H2
PC/104 Headers = J1 and J2

Labeling Scheme = Designator.Pin Number
Example: Subsystem 2, SDA+_TX → S2.9

Clyde Space EPS (Electronic Power System C3D-USM-5023-EPS2) and Clyde Space 30Whr Battery (CS-SBAT2-30):



The Clyde Space EPS and 30Whr battery is the main power and regulation system onboard SPIFF.

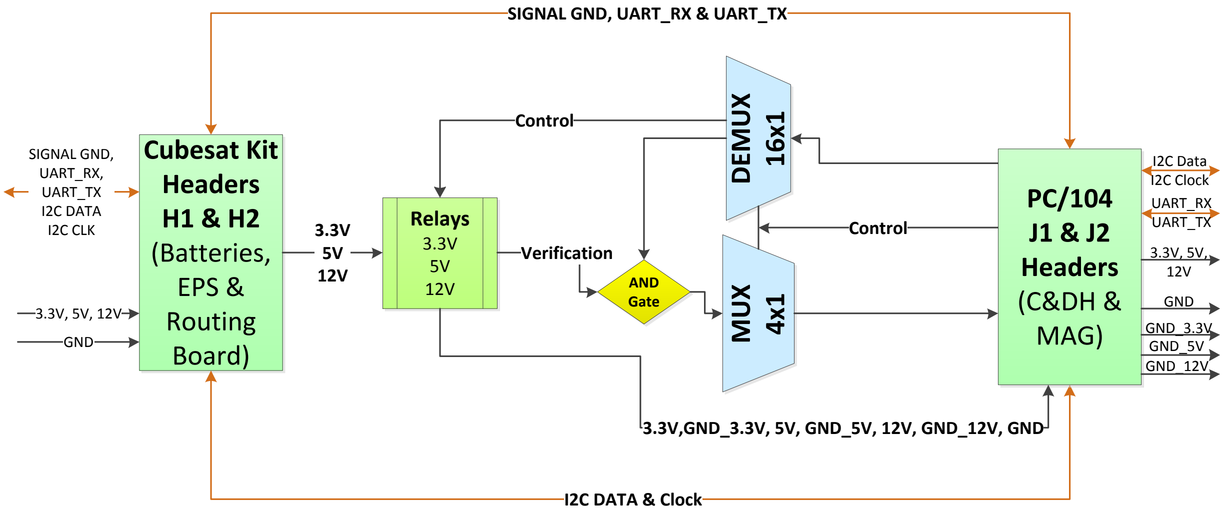
a) Inputs:
   a. Using the output of the Linear Dropout Regulator MAX5035 (12V at 1A), we will send the 12V power line to the BCRs (Battery Charge Regulator).
      i. The BCRs will step down the voltage to 8.2V which is the optimal level for the Lithium-ion Polymer batteries to charge.
      ii. There are two switches which isolate the batteries from the three regulators on the right. These switches are placed in their respective close positions during integration. The only way to isolate the batteries from the three voltage regulators is by manually disassembling the wires for the switches.
      iii. The EPS also uses the BCR output (8.2V) to regulate three different voltages (3.3V, 5V, and 12V). Below the EPS is the Clyde Space 30Whr Lithium-ion Polymer Battery which has a nominal voltage ranging from 6.2V to 8.2V. In the event of a power outage on HASP, the batteries will

become the source of power for SPIFF. It is important to note that all the grounds will converge to the battery ground and then ultimately to the HASP power ground.

b) Outputs:

    a. The EPS and battery will output 3.3V, 5V, and 12V with a common ground between the three voltages.

Interface Board:



The purpose of the Interface Board is to pass data and power from Cubesat Kit Headers to the PC/104 Headers.

a) Inputs for Power

    a. Inputs into the Interface Board are the three regulated power lines from the EPS: 3.3V, 5V, and 12V.

b) Inputs for Data

    a. The Serial_TX (from the the DB9 Connector) will be sent the Interface board and delivered over the UART_RX (Universal Asynchronous Receiver and Transceiver) line. This serial line is ultimately sent to C&DH.
    b. The UART_TX from C&DH is sent to the Interface Board and transferred to the Serial_RX line.
    c. The I2C Data and I2C Clock lines from the Routing Board to the Interface Board and ultimately sent to C&DH.

c) Outputs for Power

    a. This board will send 3.3V, 5V, and 12V through relays and then out to the PC/104 Headers which will ultimately head to the Command and Data Handling (C&DH) and Magnetometer (MAG) subsystems. By turning off the relays, the

Magnetometer subsystem will shut off, but C&DH will remain powered. These relays are controlled by C&DH via their microcontroller.

b. Isolated grounds will be sent to the Magnetometer subsystems: GND_3.3V, GND_5V and GND_12V.

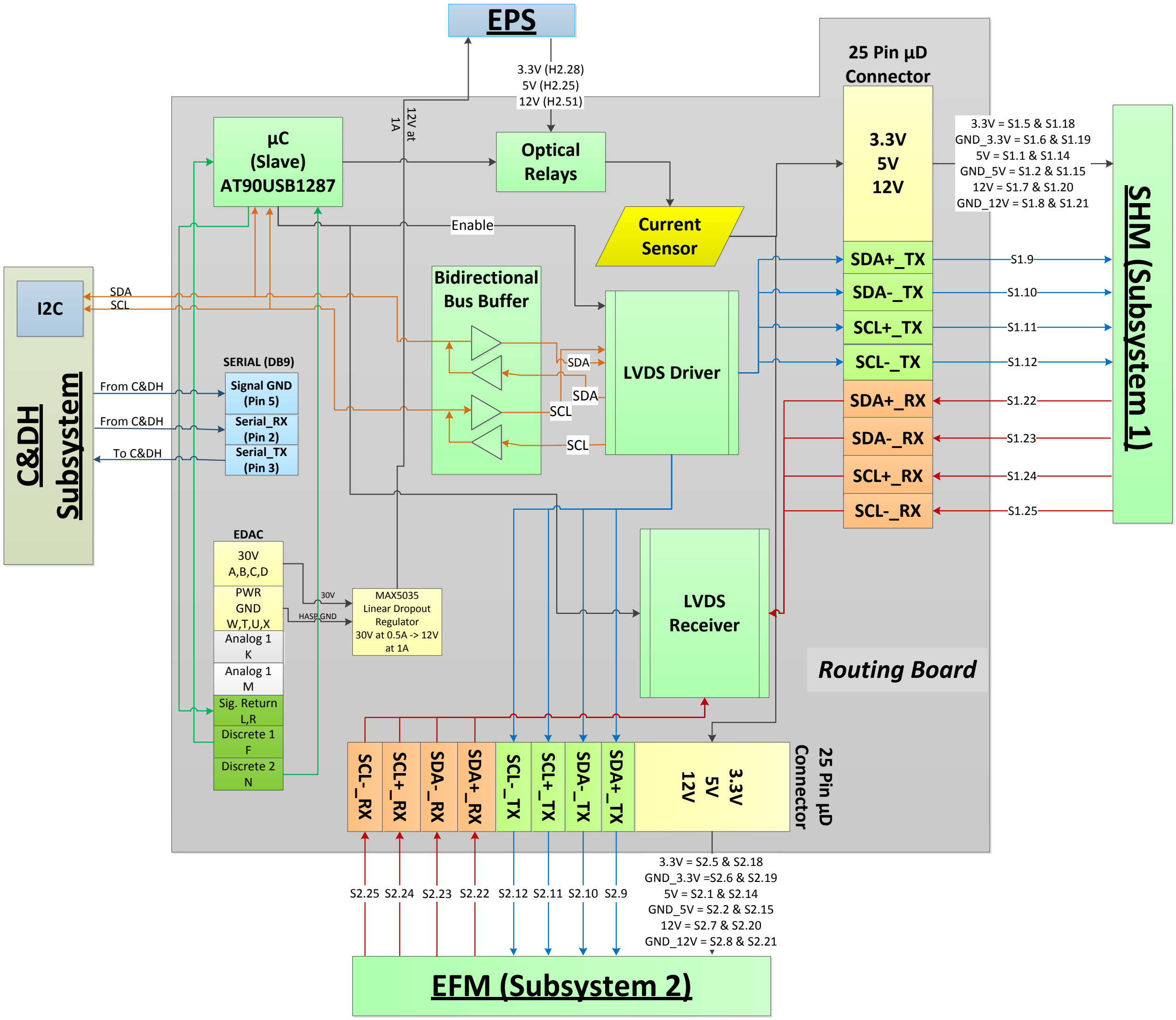
c. The EPS ground is sent to the C&DH Subsystem.

d) Outputs for Data

a. The Cubesat Kit Headers will pass the serial UART_TX to the Serial_RX on the DB9 connector (located on the Routing Board).

b. The I2C lines will also be originating from C&DH to the Routing Board for communication to the EFM, SHM, and the Routing Board.

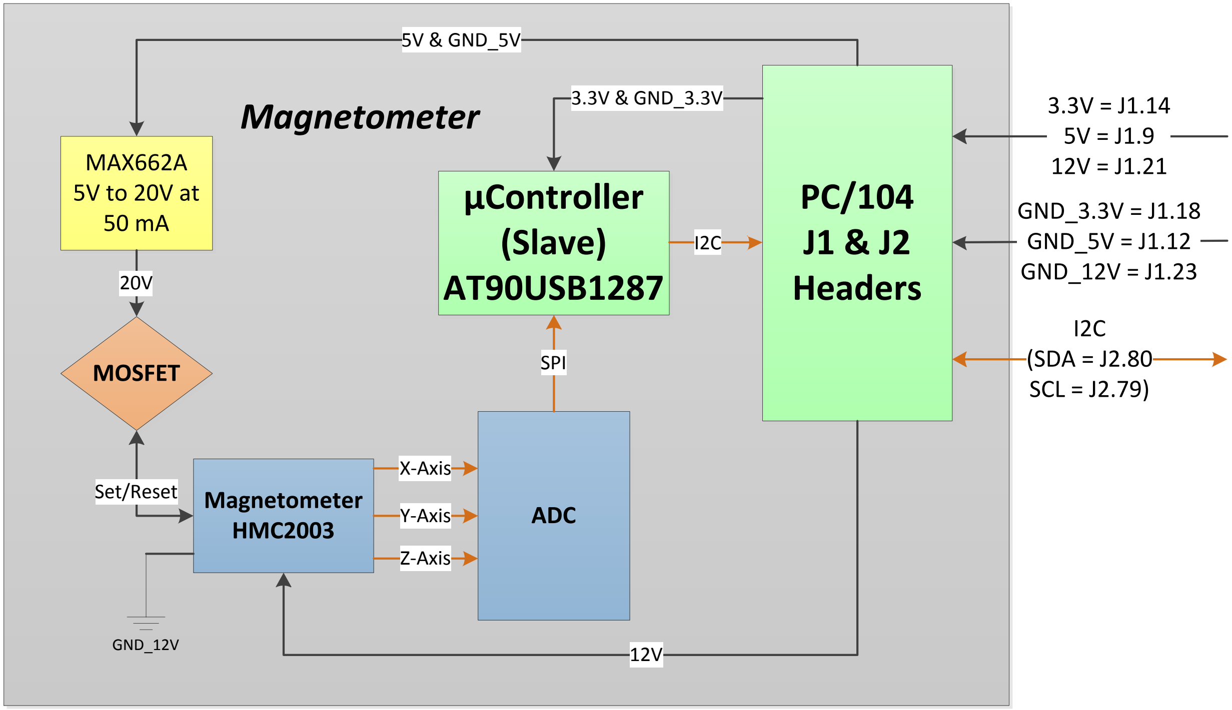
Routing Board:



The routing board is the central node for power and communication to the SHM and EFM. The provided interface plate with EDAC and DB9 connectors will attach to this board via directly soldered wires. This board will use these wires as inputs to facilitate the communication and power interface to the rest of the SPIFF.

a) Inputs for Power
    a. The Routing Board will take the 30V input and send this to a Linear Dropout Regulator which will drop the voltage down to 12V and send this to the EPS (BCR pins).
    b. This board will also receive 3.3V, 5V, and 12V from the EPS. These three power lines will be monitored for current data.
b) Inputs for Data
    a. This board will pass on the I2C data lines from Command and Data Handling (C&DH) to the EFM and the SHM. On this board we will convert the I2C lines to LVDS to the EFM and the SHM to prevent loss of data.
    b. The Routing Board will use the Discrete 1 line provided by HASP to turn off power to the EFM and SHM subsystems.
    c. The Routing Board will use the Discrete 2 line provided by HASP to turn on power to the EFM and SHM subsystems.
    d. SDA+_RX, SDA-_RX, SCL+_RX, and SCL-_RX are signals sent for the EFM or SHM that are relayed back over the I2C lines back to the C&DH.
c) Outputs for Power
    a. The Routing Board will output 3.3V, ground for the 3.3V line, 5V, ground for the 5V line, 12V, and ground for the 12V line.
        i. Each power line is monitored for power consumption.
d) Outputs for Data
    a. SDA+_TX, SDA-_TX, SCL+_TX, and SCL-_TX are data lines from the EFM and SHM toward the Routing Board which is then relayed to the C&DH Subsystem.

Magnetometer (MAG):

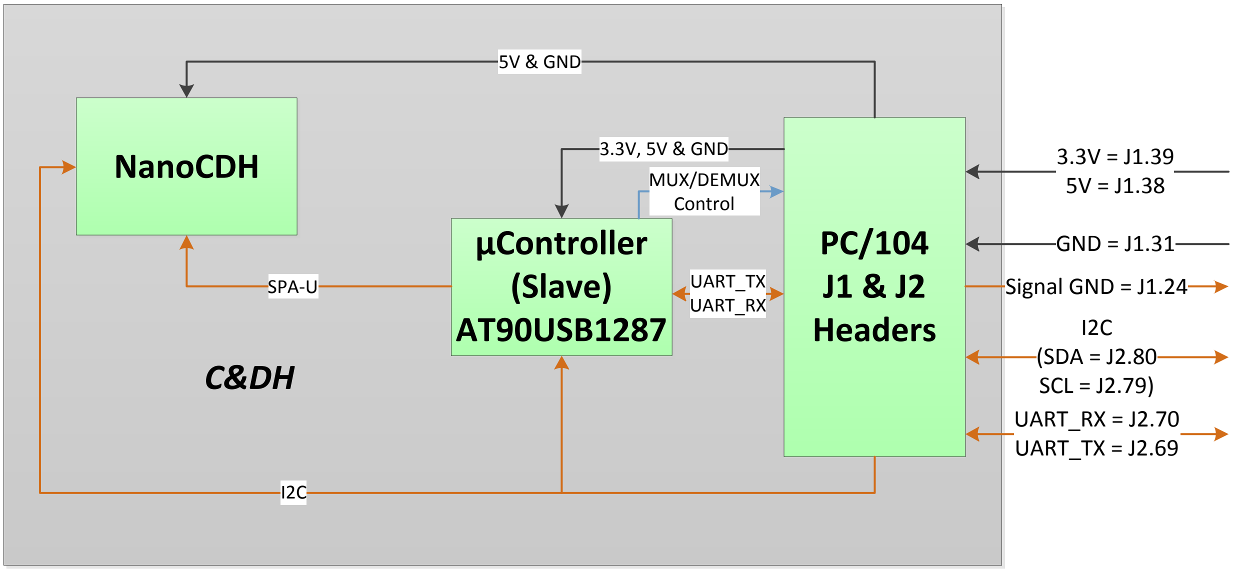


a) Inputs for Power
    a. The Magnetometer printed circuit board takes in the three voltages: 3.3V, 5V, and 12V.
    b. Three isolated grounds are used in this subsystem: GND_3.3V, GND_5V, GND_12V.

b) Inputs for Data
    a. The Magnetometer subsystem uses the standard I2C lines as an input. The I2C lines consist of data (SDA) and clock (SCL).

c) Outputs for Data
    a. The Magnetometer subsystem outputs the two I2C lines which carry the X, Y, and Z axis measurements of the ambient magnetic field.

Command and Data Handling (C&DH):



a) Inputs for Power
   a. The C&DH subsystem utilizes the 3.3V and 5V directly from the EPS. Notice that there is difference between the Magnetometer power lines and that of the C&DH power lines. As long as the EPS is powered on, so will C&DH.
   b. The ground that C&DH receives is the EPS ground.

b) Inputs for Data
   a. The C&DH subsystem will receive the standard I2C data (SDA) and clock (SCL) lines from the Interface Board. This subsystem houses the starting point for the I2C lines.
   b. The UART_RX comes from the DB9 serial connector provided by HASP. This UART line is transmitted through the Interface Board to C&DH.

c) Outputs for Data
   a. The C&DH subsystem will also transmit the I2C lines out to all of the SPIFF instruments.
   b. UART_TX will be transmitted through the Interface Board and sent to the serial connector on the Routing Board. Signal Ground will also be transmitted to the serial connector provided by HASP.

C. Other relevant power information:

   i. The ClydeSpace FlexUEPS (off-the-shelf) will provide power management for the SPIFF mission. For more details, please see the accompanying Clyde Space documentation.

Downlink Telemetry Specifications:

A. Serial data downlink format: Stream [✓ Packetized] (circle one)

B. Approximate serial downlink rate (in bits per second): **24.1 bps**

   a. **Serial Downlink Rate =**
   Nominal Telemetry Rate (bytes/min)*(min./60 sec)*(8 bits / byte)

C. Specify your serial data record including record length and information contained in each record byte:

Mode	Rate
Nominal telemetry rate (N = 5 packets)	181 bytes/min

Description	Length
DOWNLINK PACKET	
Starting word	1 byte
System time	4 bytes
Packet ID	2 bytes
Number of payload	2 bytes
System status	2 bytes
Number of payload packets	2 bytes
Payload packets per downlink packet	N packets x [(1 + 1 + 4 + 2 + M_1 + M_2 + M_3) bytes/packet]
Checksum	8 bytes
PAYLOAD PACKET	
Instrument code	1 byte
Instrument status	1 byte
Time of packet arrival	4 bytes
Packet length	2 bytes
Data	M bytes
HUB DATA (incl. mag.)	
Subsystem data	M_1 = 8 bytes
EFM DATA	
Subsystem data	M_2 = 8 bytes
SPH DATA	
Subsystem data	M_3= 8 bytes

D. Number of analog channels being used: **None**

E. If analog channels are being used, what are they being used for: N/A

F. Number of discrete lines being used: **None**

G. If discrete lines are being used what are they being used for: **N/A**

H. Are there any on-board transmitters? If so, list the frequencies being used and the transmitted power: **N/A**

I. Other relevant downlink telemetry information: **N/A**

III. Uplink Commanding Specifications:

A. Command uplink capability required: [✓ Yes] No (circle one)

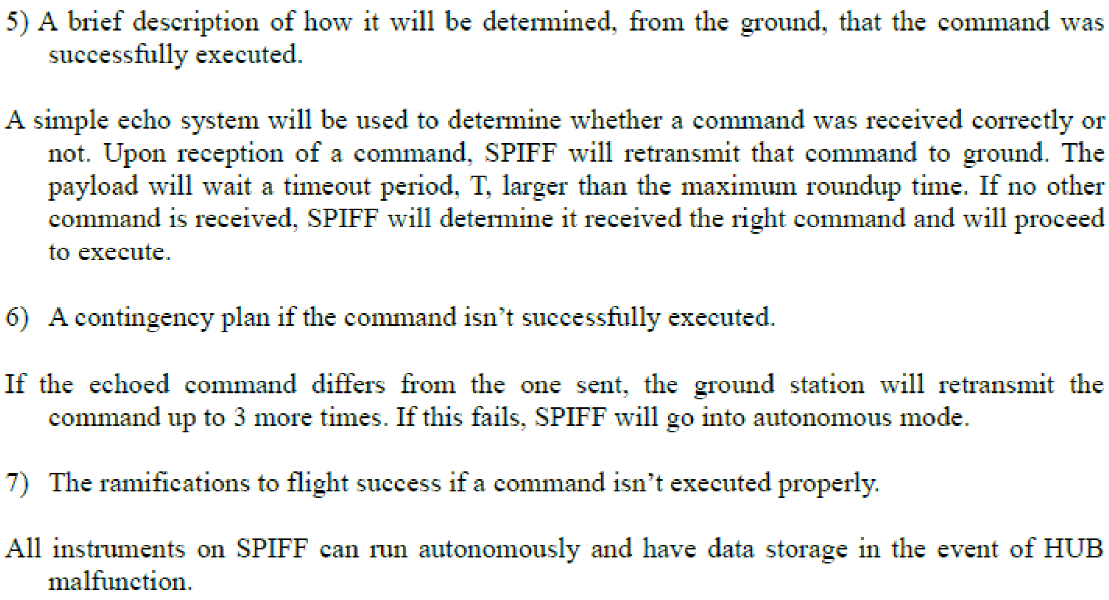
B. If so, will commands be uplinked in regular intervals: [✓ Yes] No (circle one)

C. How many commands do you expect to uplink during the flight (can be an absolute number or a rate, i.e. *n commands per hour*): Depending upon circumstances, approximately **5 – 10 commands in total** are projected.

D. Provide a table of all of the commands that you will be uplinking to your payload:

Name	**Code**	**Description**	**Critical**
Instrument On	0xA5	Turns payload on	Yes
Instrument Off	0x81	Turns payload off	Yes
Downlink (Send Data Packets)	0x3C	Returns collected data from instruments	Yes
Diagnostic	0xD6	Performs diagnostic check on instrument following SPA protocols	No
Pause (Stop Taking Data)	0x1F	All instruments in idle state	Yes
Reset	0x48	SPA in start-up condition	Yes
Resume	0x95	Returns instrument to state prior to Pause command	Yes

Per HASP Flight Operation Plan:



5) A brief description of how it will be determined, from the ground, that the command was successfully executed.

A simple echo system will be used to determine whether a command was received correctly or not. Upon reception of a command, SPIFF will retransmit that command to ground. The payload will wait a timeout period, T, larger than the maximum roundup time. If no other command is received, SPIFF will determine it received the right command and will proceed to execute.

6) A contingency plan if the command isn't successfully executed.

If the echoed command differs from the one sent, the ground station will retransmit the command up to 3 more times. If this fails, SPIFF will go into autonomous mode.

7) The ramifications to flight success if a command isn't executed properly.

All instruments on SPIFF can run autonomously and have data storage in the event of HUB malfunction.

E. Are there any on-board receivers? **No.** If so, list the frequencies being used: **N/A**

F. Other relevant uplink commanding information: **N/A**

IV. Integration and Logistics

A. Date and Time of your arrival for integration: July 30, 2012. Time pending flight purchase.

B. Approximate amount of time required for integration: 3 hours

C. Name of the integration team leader: Christopher Hoffman

D. Email address of the integration team leader: cman2790@bu.edu

E. List **ALL** integration participants (first and last names) who will be present for integration with their email addresses:

Name	Email
Nathan Darling	nathandarling@gmail.com
Christopher Hoffman	cman2790@bu.edu
Joshua Mendez	ub313@gatech.edu
Jordan Klepper	jaklepper@gmail.com
Matthew Landavazo	matthewlandavazo@gmail.com

F. Define a successful integration of your payload (Including “Day in the life” test):

i. Payload unpacked from shipping container

ii. Payload connected to laptop computer via serial connection. Laptop emulates HASP uplink / downlink

iii. Power supplied to SPIFF payload. C&DH, Routing Board, EPS and Battery all receive power. Verified by personnel with direct access to EPS and Battery.

iv. “Diagnostic” command “uplinked” via emulator. This diagnostic is meant only for the C&DH system (payloads are off still). Diagnostic command returns ACK/NACK as per command echo described in III.D. If ACK, proceed. If NACK, power down payload and troubleshoot.

v. “Instrument On” uplinked via emulator. Verify that instruments are receiving power with direct access to EPS and Battery as well as instruments themselves.

vi. Send “Diagnostic”. This command returns ACK/NACK for C&DH as well as payloads. If ACK, proceed. If NACK, power down instruments (“Instruments off”) and troubleshoot.

vii. Send “Downlink” command. Verify data downlinked.

viii. Send “Pause” command. Verify pause.

ix. Send “Resume” command. Verify data downlinkd.

x. Send “Pause” command. Verify Pause.

xi. Send “Reset” command, followed by “Diagnostic”.

This test sequence is meant to be repeated after mechanical interface to gondola is completed (V.G.i) as “Day in the life” tests.

G. List all expected integration steps:

   i. Thermal testing will be performed at Boston University prior to integration.

   ii. Mechanical interface (structural and electrical) via mounting plate completed

   iii. “Day in the life” test

   iv. De-bug and re-run if necessary

H. List all checks that will determine a successful integration:

   i. Data from “day in the life” test within expected parameters.

   ii. Analog downlink data within expected parameters.

I. List any additional LSU personnel support needed for a successful integration other than directly related to the HASP integration (i.e. lifting, moving equipment, hotel information/arrangements, any special delivery needs…):

   i. Hotel, rental car, public transportation and meals information would be greatly appreciated

   ii. No lifting or delivery needs.

J. List any LSU supplied equipment that may be needed for a successful integration:

   i. Soldering Station (soldering iron, ESD protection, soldering supplies for simple repairs of circuitry and wire harness.

   ii. Multimeter

   iii. Oscilloscope

   iv. Power Supply