HASP Payload Specification and Integration Plan

Payload Title: StratoPigeon

Payload Class: Small Large (circle one)

Payload ID: 5

Institution: **University of Maryland**

Contact Name: Connie Ciarleglio

Contact Phone: 202-441-0103

Contact E-mail: connie@nearspace.net

Submit Date: 6/1/2010

I. Mechanical Specifications:

A. Measured weight of the payload (not including payload plate)

	Theoretical Mass (g)	Quantity	Measured Mass (g)	Max. Mass (g)	Margin of Error
servo	80	1	56	57	1%
CPU + SATA	90	1	175	177	1%
power board	50	1		60	20%
comms board	20	1		24	20%
HDD boards	30	2		72	20%
batteries	375	1		394	5%
HDDs	60	2	90	182	1%
peg/pin attachment	50	1	181.44	183	1%
enclosure	575.2	1	1024	1034	1%
motor board	50	1	43	43	5%
xtend	18	1		19	5%
SRB X146	20	1		24	20%
gps	3.5	1		4	5%
cabling	150	1	114	137	20%
margin	200			200	
Total	1771.7		Total Max. Mass	2610	

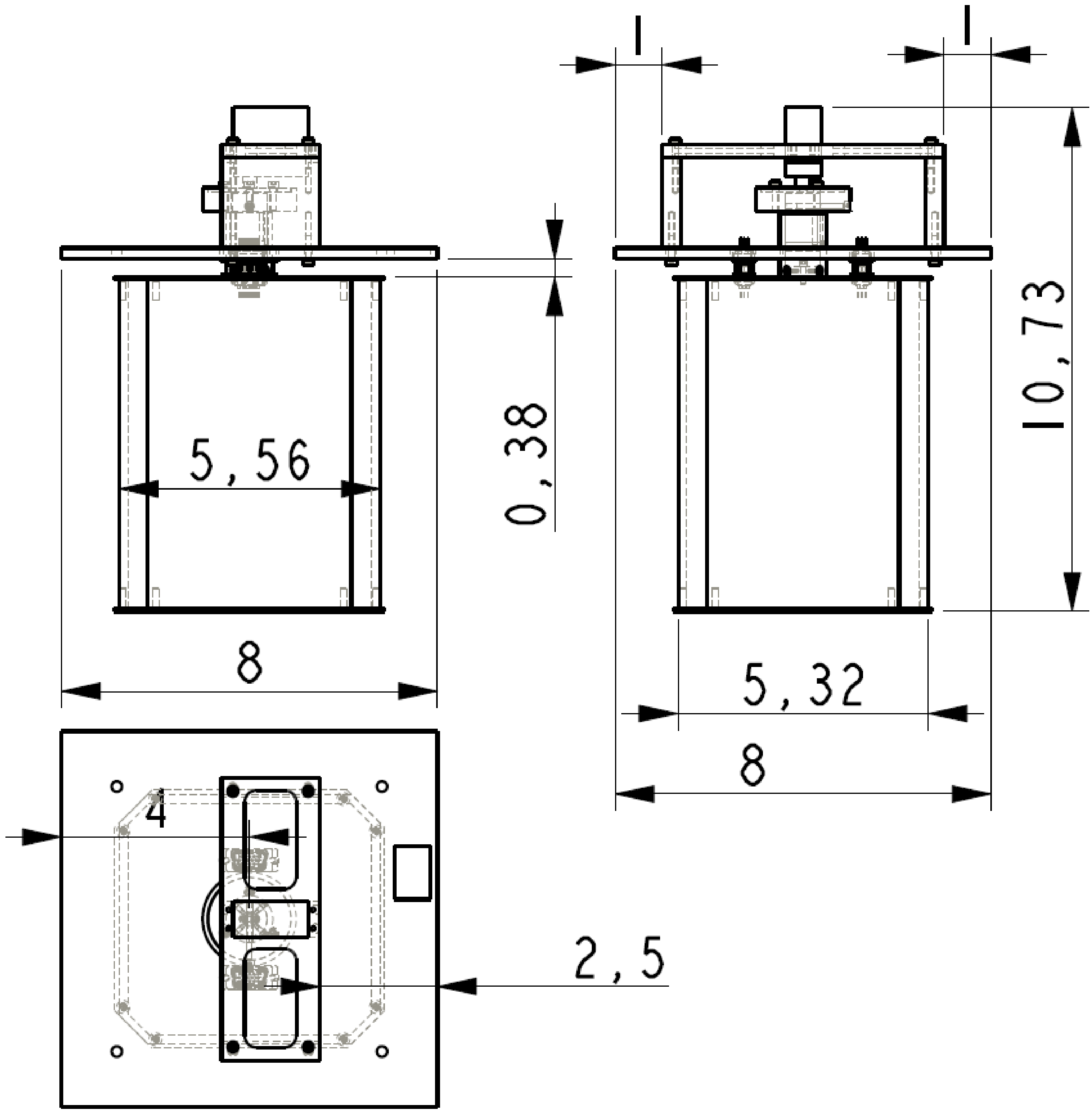
Total (Payload Only)	1591.7		Max. Payload	2327	

The above table represents measured quantities with a 1% error, quantities from technical documentation with 5% error, and approximate quantities with 20% error.

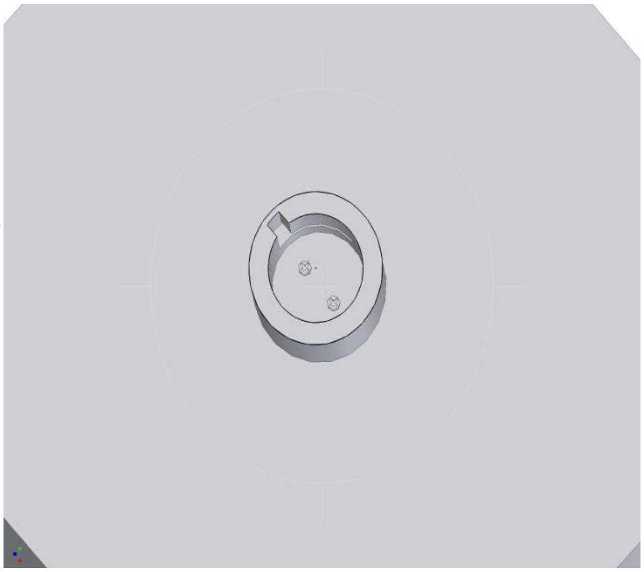
B. Provide a mechanical drawing detailing the major components of your payload and specifically how your payload is attached to the payload mounting plate

The payload will be mounted underneath the outrigger on the bottom-side of the payload plate. (See next page)

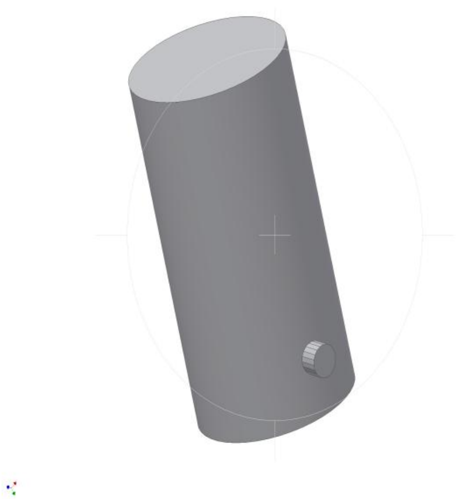
Drawing dimensions are in inches.



Tube attachment to payload (note that a compression spring will be inserted and attached at the bottom of this tube to provide a significant separation force when the servo is actuated):



Dowel attachment to servo:



C. If you are flying anything that is potentially hazardous to HASP or the ground crew before or after launch, please supply all documentation provided with the hazardous components (i.e. pressurized containers, radioactive material, projectiles, rockets…)

The UMD payload will be operated in a similar manner to an unmanned independent balloon flight. In order to keep our payload under FAR101 exemptions, we will be satisfying the following requirements relevant to our payload:

(4) Except as provided for in §101.7, any unmanned free balloon that—

(i) Carries a payload package that weighs more than four pounds and has a weight/size ratio of more than three ounces per square inch on any surface of the package, determined by dividing the total weight in ounces of the payload package by the area in square inches of its smallest surface;

(ii) Carries a payload package that weighs more than six pounds;

The payload itself is currently 5.1 lbs and will not be over 6 lbs in any scenario. With a 5.1 lb payload, payload density will be equal to 2.697 oz/in^2. This also meets the exemption requirements for the payload. Since the UMD payload can now be treated as an independent balloon flight, the FAA can be notified similarly.

The FAA will be notified of preliminary flight path and descent trajectory. A NOTAM will be filed as requested. The responsible ATC will be notified with the updated flight path (of the dropped payload) and timing prior to release. We will be using BalloonTrack for Windows distributed by EOSS to update our prediction of landing site and choosing a point to release our payload based on predicted landing site, and approval from the HASP/CSBF team. ATC will also be notified when the payload passes below 60 kft and when it is on the ground.

The parachute for the UMD payload will be the 36” TopFlight Regular parachute. This parachute is rated for a specific descent rate of 17-22 ft/s at sea level. Based on drop testing and test flights with our payload, we may use a 45” TopFlight regular parachute to achieve a slower descent rate. Ft Sumner is at an altitude of 4,165 ft above sea level which will also increase descent rate slightly.

The GPS for the UMD payload will be placed on the top of the payload itself and under the HASP plate. Space on top of the PVC plate is taken up by the aluminum structure to hold the servo, the servo PCB, and the parachute tube. However, ¼ of the space is left clear. The GPS will be positioned in this corner of the payload away from the metal on top of the plate. The GPS chosen has been tested at 120,000 ft for an hour of float and has successfully achieved and maintained a lock at altitude. A second GPS will be placed on the top of the payload under the portion of the plate covered by the servo driver PCB. While this GPS may or may not achieve a lock before the drop, to be tested during our preliminary flights, it adds a redundant system and the second GPS will be able to acquire a lock after the drop occurs.

The payload will also be equipped with visual identification for recovery in case a recovery is not possible in a timely manner. A tag with UMD team contact information will be attached to one side in case the payload is located by someone other than the UMD or CSBF team.

D. Other relevant mechanical information

i. See Appendix A for storyboard of detachment procedure

ii. See Appendix B for engineering drawing measurements

iii. See Appendix C for preliminary mechanical detach visuals

iv. Our design specification is based on the force needed to disconnect two DB-15 connectors. With this force, we subtracted the weight of the payload and the remaining force was the force generated by the spring Finally, once the spring force was known, we could find the torque needed to turn the dowel to disconnect.

Our design's specifications began with measurements of the disconnect force needed to separate two DB-15 connectors. This measured force was between 2.2 (4.85lbs) and 2.7 kilograms (5.95 lbs) per connector, or approximately 5.5 kg (12.2 lbs) total needed force. As we knew the weight of the payload would be approximately 2.25 kg (5 lbs), the remaining 3.25 kg (7.2 lbs) of force was generated from our spring.

In finding the correct spring, our calculations followed the assumption that the spring would compress nearly 1.25 cm (0.5 in). This yielded a spring constant of about 2.6 kg/cm (15 lbs/inch). The spring we are using has a maximum compression of about 1.5 cm (9/16 inch) at which it generates 4 kg (8.8 lbs) of force (advertised spring constant of 19 lbs/inch ± 8% lbs/in or 2.7 kg/cm).

Next, as our spring will likely generate forces between 2.5 and 2.8 kg/cm (8 to 9.5 lbs) due to manufacturing uncertainty, this implies the constraint on our servo motor that it must generate at least between 0.05 and 0.07 N-m (75 and 95 oz-in) of torque (center of dowel to outermost edge of pin is 1.25 cm) in order to overcome the static friction of the steel pin on the steel sheath – friction coefficient of about 0.8.

Lastly, as most servo motors typically have a linear relation of current draw to torque produced, the current high power servo that we have found produces 0.25 N-m (344 oz-in) of torque at 3.8A and has an idle current draw (no torque) of 220mA. Given the linear relation shown below, this produces a current draw of between 1 and 1.2A needed to overcome the initial static friction. Once the static friction has been overcome, the necessary torque needed to continue turning the dowel is between 0.025 and 0.04 N-m (40 and 65 oz-in) of torque (0.65A to 0.9A). To lower the torque needed – and hence lower the current draw – we are currently looking into changing the connectors to lower the disconnect force and/or introducing a lubricant to the dowel-pin-sheath assembly. We are also looking into stronger servo motors which use gearing to increase available torque – 0.5 N-m (700 oz-in) of torque or greater . Also, these calculations do not take into account the friction of the spring surface on the dowel or the dowel on the inner surface of the sheath. These numbers are known to be low, but will increase the torque needed to initiate the release.

II. Power Specifications:

A. Measured current draw at 30 VDC

i. We do not currently have all our components operational at 30V DC. The following is our current power budget:

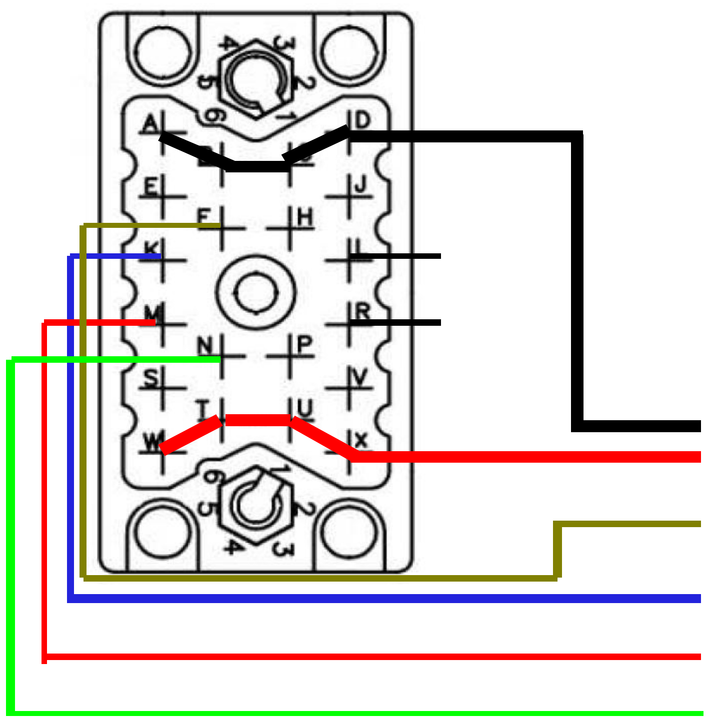
Board	Component	Voltage (V)	Theoretical Worst Current Draw (mA)	Measured Current Draw (mA)	Max Current Draw (mA)	Margin of Error
CPU	Main Processor	5	822	850	858.5	1%
HDD	HDD1	5	222		233.1	5%
HDD	HDD2	5	222		233.1	5%
Motor	Atmega328	5	30		31.5	5%
Motor	Servo	5	444		532.8	20%
Comms	Atmega1280	3.3	11		13.2	20%
Comms	Inventek ISM300	3.3	28		29.4	5%
Comms	Xtend	5	811		851.55	5%
Comms	SRB MX 146LV	5	350		420	20%
Power	Relays	5	267		320.4	20%
Power	Atmega328	5	30		31.5	5%
CPU	PCM-3621	5	111	150	151.5	1%
			Total HASP Max Draw (@5V) (mA):		2527	
			Battery Max Draw (@5V) (mA):		1284.75	
			Total HASP Max Draw (@30V) (A):		0.42	
			Average HASP Draw (A):		0.29	

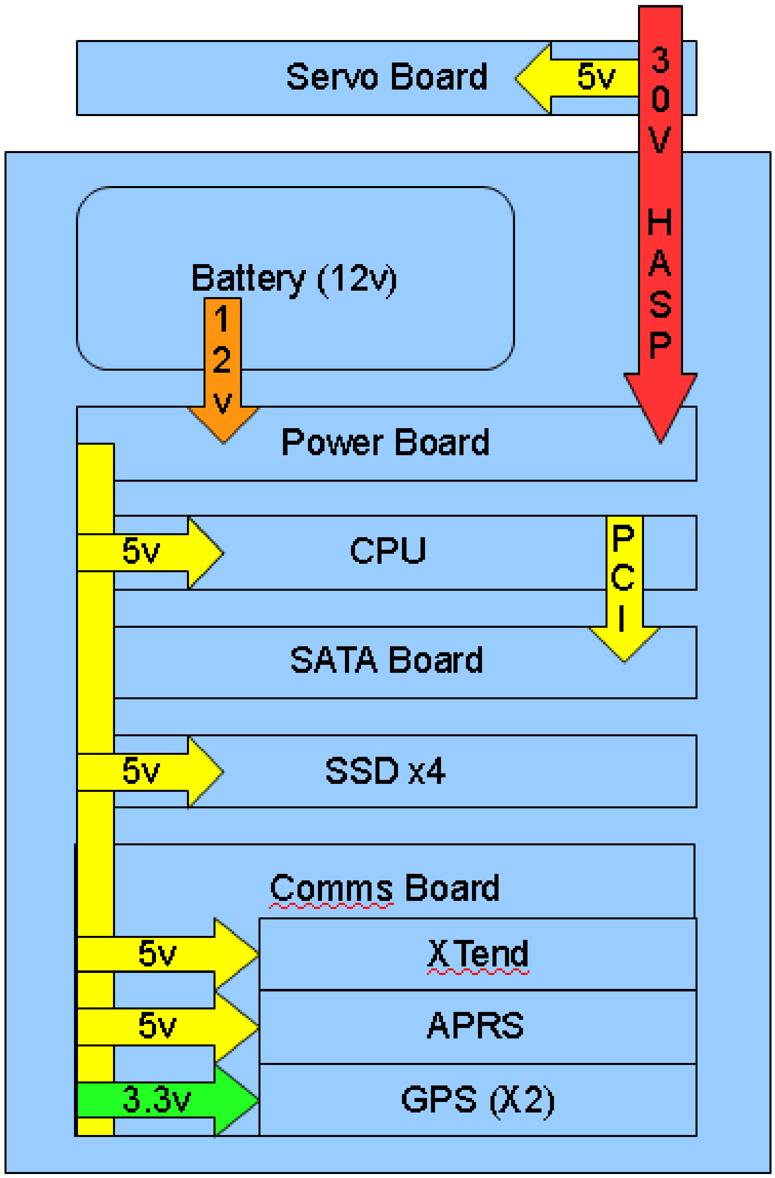
Margin of error for components in the above table is represented by 1% for measured, 5% for data sheet or components used by UMD in other applications, and 20% for approximate. The table is a summary of our full power budget which takes into account regulator efficiency and duty cycle.

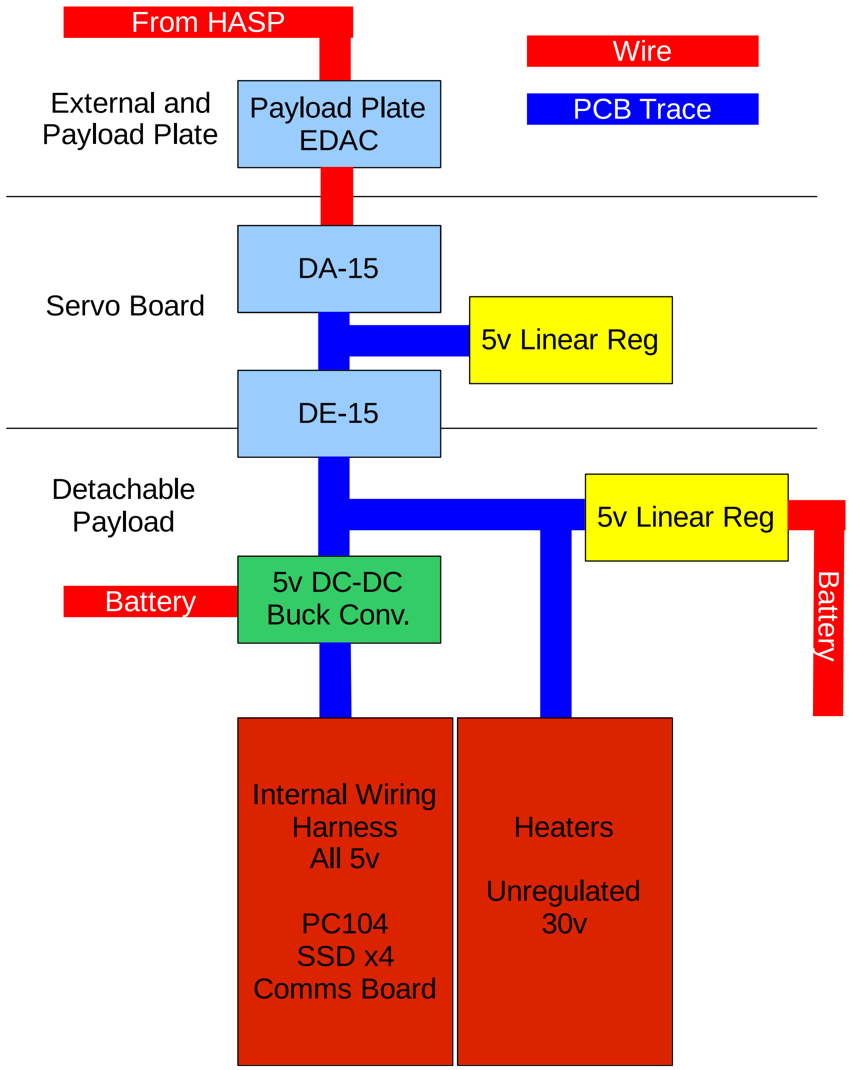
The maximum and average numbers at the bottom of the above table are based on the maximum possible draw. This point occurs when all components except for the CPU and SATA board are active.

B. If HASP is providing power to your payload, provide a power system wiring diagram starting from pins on the student payload interface plate EDAC 516 connector through your power conversion to the voltages required by your subsystems.

The EDAC Connector is used in the specified manner with all 4 power and ground lines being used to power the payload. The discrete signals will be used to activate the detach servo and to turn the heater on and off. The analog lines will both be used for LM19 (or similar) temperature sensors as used on previous UMD payloads. One of these sensors will be positioned next to the detach servo and the other will read the ambient temperature internal to the main payload.




Servo Board
5v
30V HASP
Battery (12v)
12v
Power Board
5v
CPU
PCI
SATA Board
5v
SSD x4
Comms Board
5v
XTend
5v
APRS
3.3v
GPS (X2)



C. Other relevant power information
   i. Contact Ratings:
      1. The contacts used in the payload are designed to carry more current than will be used. This is more a factor of the connectors that are convenient to use being larger and thus can carry more current than needed. The multiple pins used to connect to the power coming from the HASP gondola are to accommodate the four power wires trough the EDAC and to eliminate the chances of having a total system failure due to the failure of a single solder joint or crimp failure.

2.

Connector	Pins	Current/Pin	Total Current	Connection
EDAC	4	5 A	20 A	HASP
DA-15	4	5 A	20A	Plate to Servo Board
DE-15	3	5 A	15 A	Detach Connectors
Molex KK	1	7A	7A	Internal Wiring
Mate-N-LOK	1	13A	13A	Solid State Hard Drives

ii. Relays:

1. The relays used to control and distribute power are variants of the TX-2 signal relay that the UMD team has significant experience with. The signal relays have the advantage of being compact and requiring a relatively small triggering voltage. The maximum current rating for the contacts is 2A which is sufficient for all the scenarios that will be encountered in our payload, although we have the ability to use both throws of a DPDT relay to get a maximum of 4A if it is deemed necessary after the thermal system design is completed. The relays are latching so the state is maintained between switching power sources and to keep the power consumption of the payload lower. The relays and their low power ATMega controller are powered off of a 5v linear regulator to keep them independent of the DC-DC converter that they control.

iii. Linear Regulators:

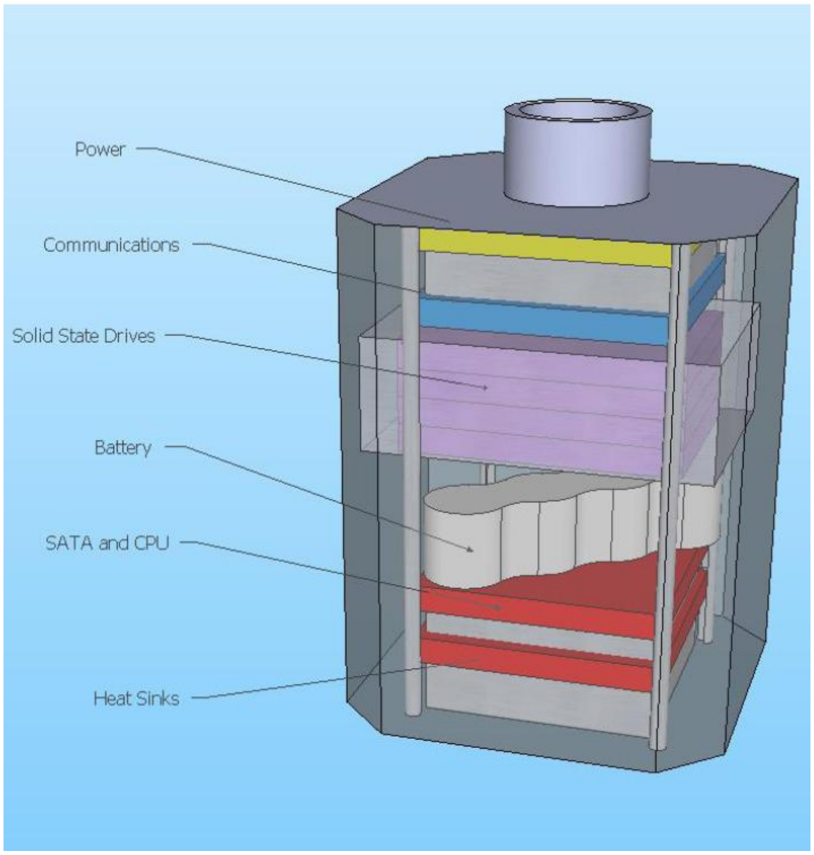
1. The linear regulator used for the 3.3V line is a variant of the NCV5501 LDO regulator from OnSemi. The regulator used for the 5V line is an LM7805S for the servo and power PCBs. Both these regulators function over an extended temperature range of -40C to +125C.

iv. Switching Regulator:

1. The main supply for the computer (during flight on HASP) and the communication (during independent descent) is the PTN78060W that provides high efficiency conversion from either the 30v HASP source or the 12v batteries to 5v DC. This is a larger 3A version of the PTN78000W (1.5A) that was flown on the two previous UMD HASP flights. Efficiency for this converter is expected to be close to 90%.

v. The above power calculations take into account skeletal thermal calculations. The servo will be encased in aluminum for heating prior to activation. The payload has the capability to add heaters for the SSDs and SATA expander board. These additions should not add enough current draw to overdraw from HASP.

vi. Our internal arrangement is as follows:



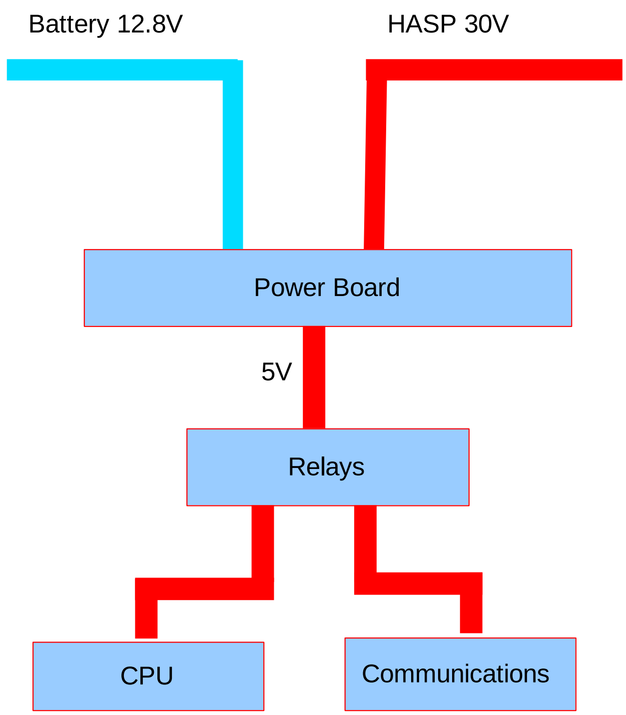
The electrical connections will be wired up to the top of the payload. The hard drives will be enclosed in their own aluminum enclosure as needed. This will help spread out heat generated and allow for 1 relay switch to turn on/off hard drive heat if needed. The batteries will be placed in between the board stack and the hard drives.

Thermally, our main concerns are the commercially rated SATA expander board, CPU, and servo. We may need to warm up the expander board and use a radiator or the sides of the payload to cool the CPU. The servo will need to be heated at least 20 mins prior to activation.

The UMD payload is designed for 4 SSD’s. On this flight, unless more SSD’s are bought, the UMD team will be flying 2 hard drives. However, the thermal, mechanical, electrical, and power systems design supports 4 attached drives. Due to budget and time, only 2 will be flown on this year’s HASP flight.

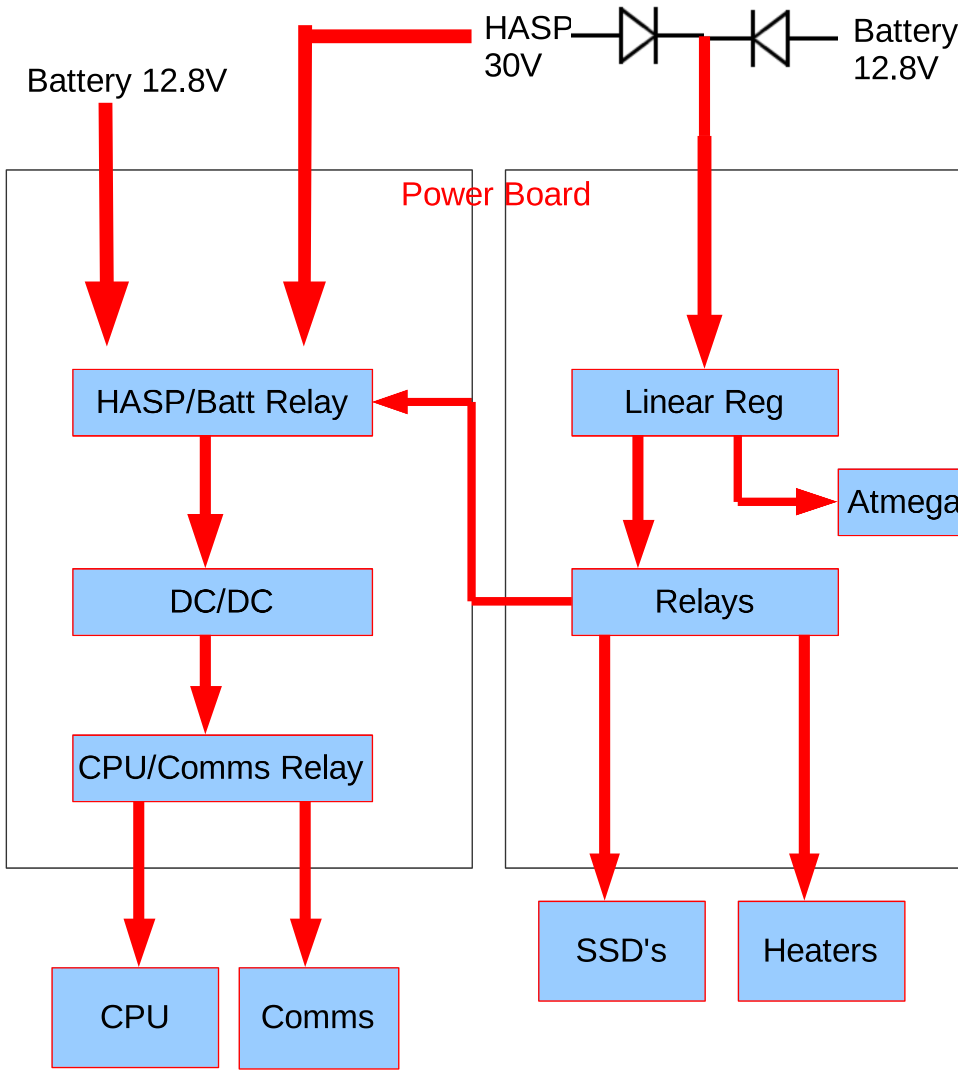
There will be batteries inside the payload for the flight. The batteries will be turned on continuously for descent. We are using a LiFePO4 battery pack with 12.8V and 3000 mAH. The battery has a max discharge rate of 7A. If the payload transmits 1x per second for 100ms continuously, the battery will last for 23 hrs. If the transmit rate is turned down when the payload hits the ground, the battery will last for far longer due to the lowered duty cycle. The transmit rate for both radios will be reduced to 1x per 5 or 10 seconds once the payload is on the ground.

vii. To solve the issue of power overdraw in our previous design, the power distribution has been reformatted. Only the CPU or the communications board will be active at a given time. However, we need to make sure that the scenario of them both being on at the same time does not occur while retaining system control of both boards. The Comms and CPU will both be regulated by the power board through a relay as follows:



With this method, there is no possibility of the CPU and communications systems being active at the same time.

In order to retain continuous regulation of the power for all systems through the power board and the change from HASP to battery power, the power PCB layout diagram is as follows:



The power board is designed such that the Atmega and associated components off of the linear regulator always receive power. The relays off of the linear regulator control the power to the SSD's, heaters, and the selection between using HASP power and battery power. The HASP/Batt relay controls the ON/OFF power to the DC/DC converter. Finally, the CPU/Comms Relay controls power to either the CPU and SATA board or the communications board. The diode arrangement between HASP and battery power for the linear regulator allows a passive switch to battery power when HASP power is turned off. This power board arrangement allows the UMD team to have full control over all the critical components in the payload while reducing the maximum power draw from HASP.

III. Downlink Telemetry Specifications:

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

B. Approximate serial downlink rate (in bits per second)

  i. 160 bits/sec at 1200 baud

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

Format:

- 1 – Packet Type
- 2-9 – Time
- 10-11 – Size
- 12 – Checksum
- 13-16 – Error Notification
- 17 -… -Data

Thermal Status Packet (ASCII)		
Byte	Data Type	Length (bytes)
17-19	CPU Temperature ID	3
20-21	CPU Temperature	2
22	Comma	1
23-25	SATA board Temperature ID	3
26-27	SATA board Temperature	2
28	Comma	1
29-31	SSD 1 Temperature ID	3
32-33	SSD 1 Temperature	2
34	Comma	1
35-37	SSD 2 Temperature ID	3
38-39	SSD 2 Temperature	2
40	Comma	1
41-43	Battery Temperature ID	3
44-45	Battery Temperature	2
46	Comma	1
47-49	Radio Temperature ID	3
50-51	Radio Temperature	2

52	Star Character	1
53	Endline Character	1

	Total Data Length:	37
	Total String Length:	53

Data Status Packet (ASCII)		
Byte	Data Type	Length (bytes)
17	SSD 1 ID	1
18	Comma	1
19-20	SSD 1 Usage	2
21	Comma	1
22-25	SSD 1 Transfer Errors	4
26	Comma	1
27-30	SSD 1 Storage Errors	4
31	Comma	1
32	SSD 2 ID	1
33	Comma	1
34-35	SSD 2 Usage	2
36	Comma	1
37-40	SSD 2 Transfer Errors	4
41	Comma	1
42-45	SSD 2 Storage Errors	4
46	Star Character	1
47	Endline Character	1
	Total Data Length:	31
	Total String Length:	47

D. Number of analog channels being used: 2

E. If analog channels are being used, what are they being used for?

   i. Internal Payload Temperature

   ii. Servo Temperature

F. Number of discrete lines being used: 2

G. If discrete lines are being used what are they being used for?

    i. Servo heater

    ii. Detach

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

    i. Yes

    ii. ISM 902-928 FHSS – 1 W

    iii. ISM 144.39 MHz – 350mW

I. Other relevant downlink telemetry information.

    i. We will have short external antennas hanging directly underneath the payload mounted on the payload enclosure.

IV. 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*)

    i. 6 commands per hour

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

Command	Checksum	ID#	Description
0	0	5	Stop Accepting Requests
1	1	5	Resume Accepting Requests
2	2	5	Simulated Data Transfer Mode
3	3	5	CPU on
4	4	5	CPU off
5	5	5	Comms board on
6	6	5	Comms board off
7	7	5	SSD's on
8	8	5	SSD's off
9	9	5	Servo on
10	A	5	Detachment Command
11	B	5	CPU Off (Software Command)
12	C	5	Payload Mode 2
13	D	5	Payload Mode 3

E. Are there any on-board receivers? If so, list the frequencies being used.
   i. Yes
   ii. ISM 902-928 FHSS – 1 W
   iii. ISM 144.39 MHz – 350mW
F. Other relevant uplink commanding information.
   i. When attached to HASP, both radios will be transmitting at a rate of approximately 1x per 10 seconds for short periods of time. During the drop period, both radios will transmit at a rate of 1x per second. Once the payload is on the ground, both radios will transmit at a rate of 1x per 5 or 10 seconds.
   ii. The 900 MHz FHSS radio is the radio used by the University of Maryland on HASP for the past two years.

V. Integration and Logistics

A. Date and Time of your arrival for integration:
   i. August 1, 2010
B. Approximate amount of time required for integration:
   i. ~6 hrs
C. Name of the integration team leader:
   i. Connie Ciarleglio
D. Email address of the integration team leader:
   i. Connie@nearspace.net
E. List **ALL** integration participants (first and last names) who will be present for integration with their email addresses:
   i. Dr. Mary Bowden bowden@umd.edu
   ii. Connie Ciarleglio connie@nearspace.net
   iii. Jason Hagler llewod@gmail.com
F. Define a successful integration of your payload:
   i. Secures mechanically to HASP outrigger
   ii. Payload powers on
      1. CPU, SATA expander, and SSD’s power on
      2. Power Board Microcontroller powers on

3. Communications board powers on
4. Mechanical Detachment board powers on

iii. Payload interfaces to HASP mini-SIP
1. Uplink
2. Downlink

iv. Payload interfaces to Science Payload
1. Uplink

v. CPU is operational
1. Runs program
2. Stores UMD and Science Payload data

vi. Radios working
1. Uplink
2. Downlink
3. Reasonable signal strength for both

vii. Detachment Successful
1. Servo microprocessor runs program
2. Payload detaches from gondola
3. Parachute clears all surrounding objects
4. Payload clears all surrounding objects

G. List all expected integration steps:
1. Attach payload plate mechanically to HASP
2. Attach payload mechanically and electrically to payload plate
3. Test power on/off through mini-SIP
4. Test serial uplink and downlink through mini-Sip
5. Test RF communications on mini-SIP and batteries
6. Test data transfer with science payload
7. Test detachment procedure on gondola

H. List all checks that will determine a successful integration:
1. Power Converter Produces 5V

2. CPU Powers on
3. Communication board powers on
4. Servo Board powers on
5. Mini-SIP uplink successful for all microprocessors
6. Mini-SIP downlink successful for all microprocessors
7. Ethernet uplink successful
8. Ethernet downlink successful
9. Radio 1 TX successful
10. Radio 2 TX successful
11. Temperature Sensors Working
12. Payload and parachute separate from payload plate

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…):

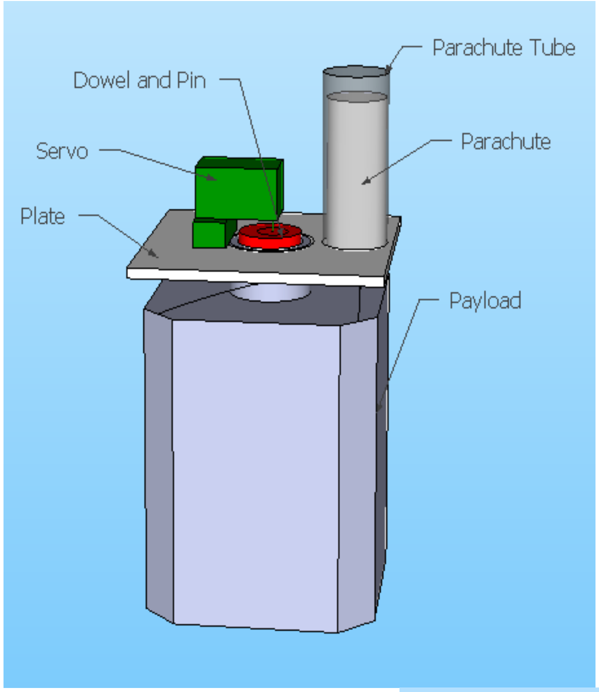
We will want to test the payload drop mechanism before and during the thermal vacuum test. We will be using a tethered payload in the TV test to show successful payload detach and parachute clearance.

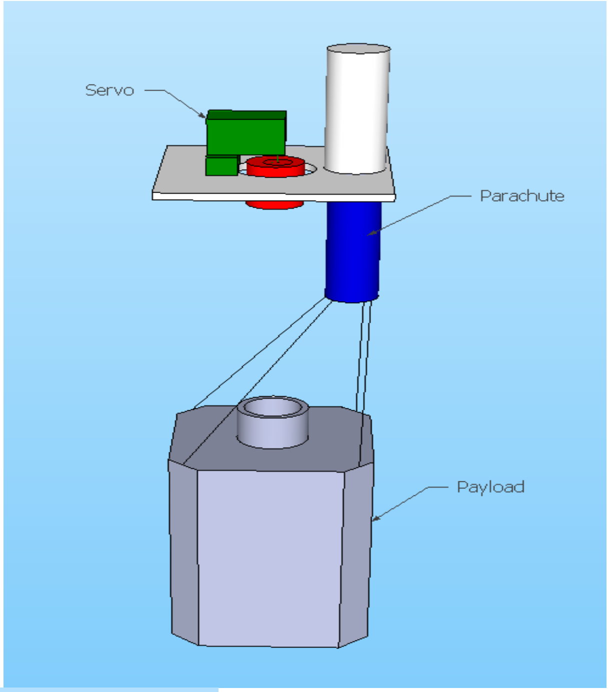
J. List any LSU supplied equipment that may be needed for a successful integration:

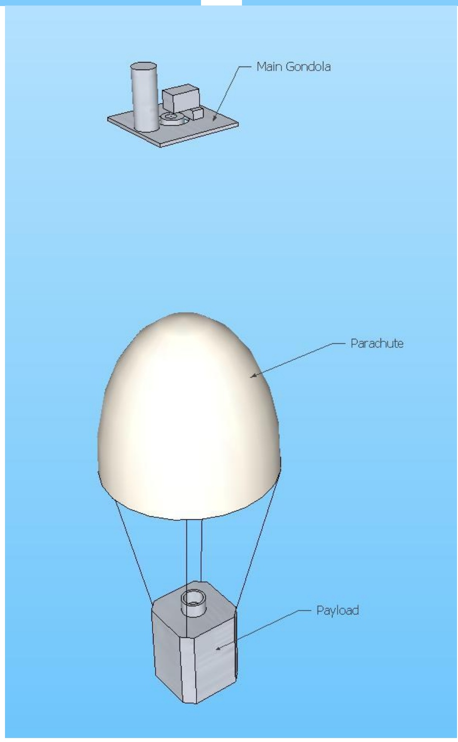
Appendix A

Detachment Procedure

*Parachute tube not to scale-Max height above plate is 3” (Total height with plate is 10.2”)



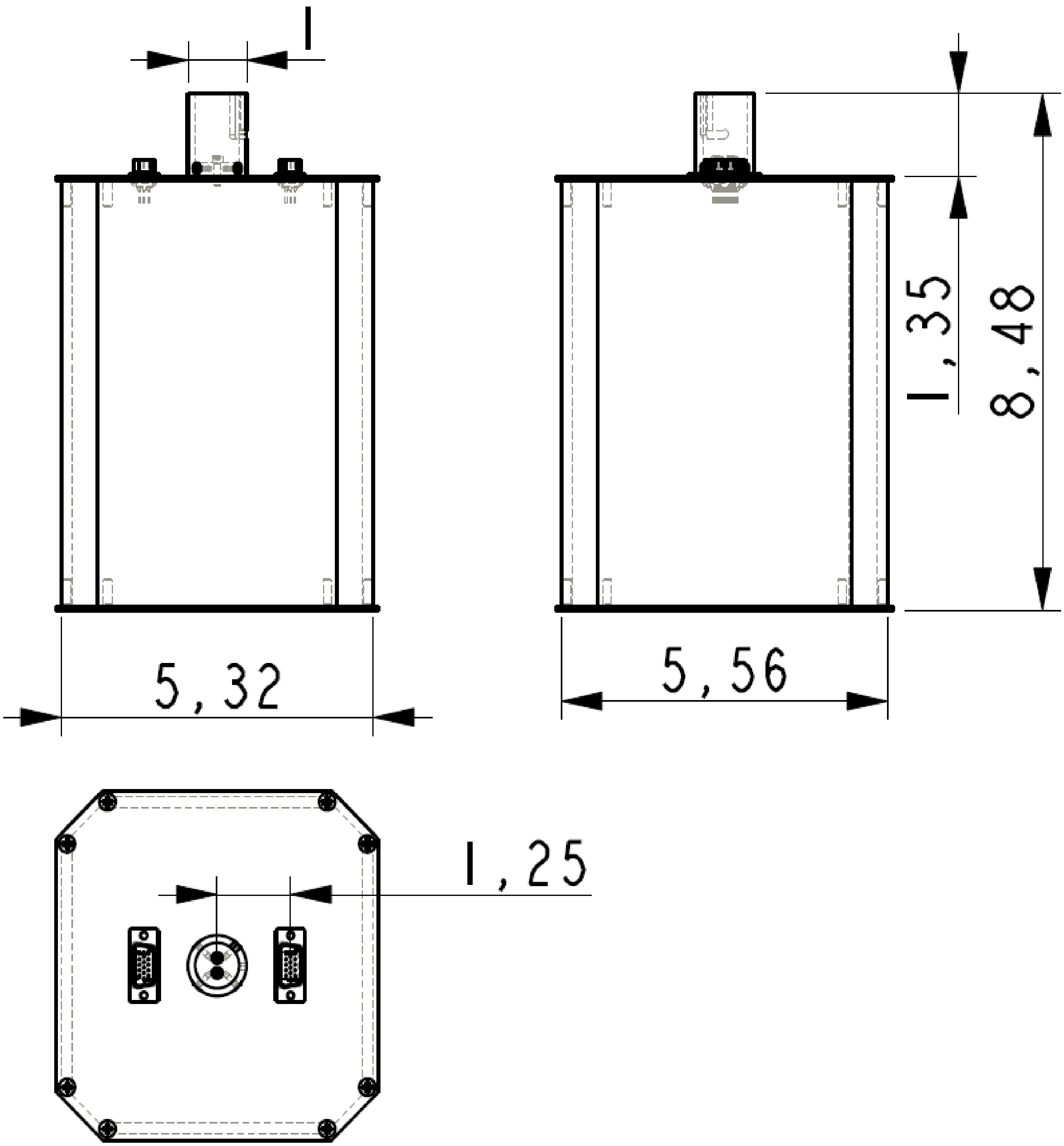




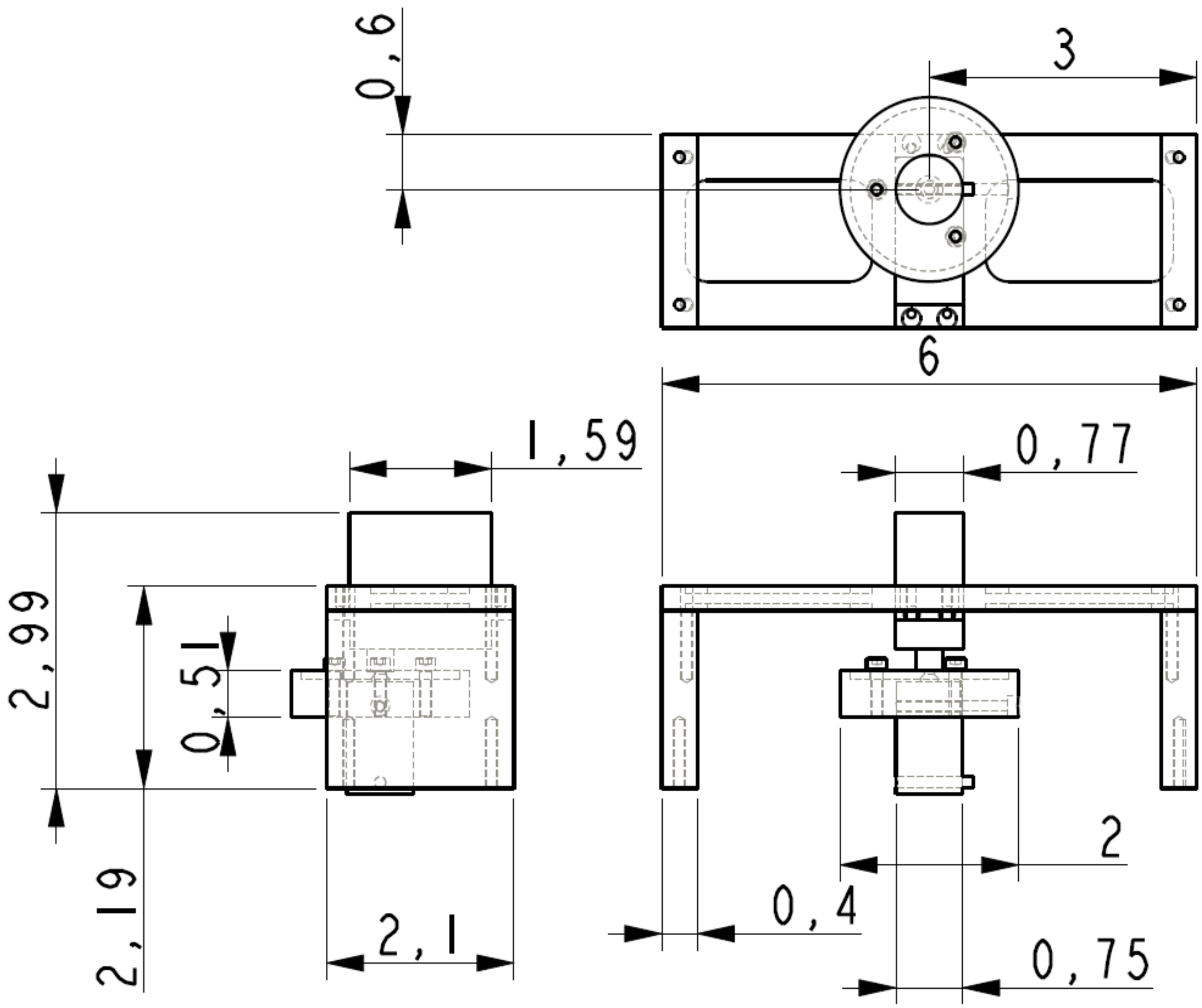
Appendix B

Engineering Drawings:

Payload: (Dimensions defined in inches)



Servo and Mount: (Dimensions defined in inches)



Appendix C