HASP Payload Specification and Integration Plan

Payload Flight Number: 2016-10	**Institution:** University of Colorado Boulder
Payload Title: High Elevation Light Intensity Observation System V	
Student Leader: Haleigh Flaherty Aerospace Engineering 1776 Kittredge Central Hall, 2480 Kittredge Loop Drive Boulder, Colorado, 80309 Haleigh.Flaherty@colorado.edu Cell: (719) 660-8177	**Faculty Advisor:** Chris Koehler Colorado Space Grant Consortium 520 UCB Boulder, Colorado, 80309 Koehler@colorado.edu Office: (303) 492-4750

Payload class:	LARGE	**Payload ID Number:**	10
Mass:	16.034 kg	**Current:**	1.83 Amps
Serial Downlink:	YES	**Analog Downlink:**	NO
Serial Commands:	YES	**Discrete Commands:**	NO

Payload Specification & Integration Plan	**Due: 6/24/16**	**Delivered:**
Payload Integration Certification	**Scheduled: 8/5/16**	**Actual:**
Flight Operation Plan	**Due: 7/29/16**	**Delivered:**
Final Flight / Science Report	**Due: 12/09/16**	**Delivered:**

Abstract:
Currently, solar observation is done either from the ground, where it is subjected to extensive atmospheric interference, or from satellites, which are extremely expensive. Observing the sun from a high altitude balloon platform mitigates almost all atmospheric interference at a fraction of the cost of actually placing a payload into orbit.

HELIOS V is a continuation of the University of Colorado's HELIOS missions. It will use the solar tracking system developed during the HELIOS IV mission to capture valuable science and engineering data. Its science objectives include capturing high quality images of the sun in the hydrogen-alpha wavelength to observe sunspots and possibly solar flares. The HELIOS V team will have a faculty mentor, but all other members of the team shall be undergraduate engineering students, including the project manager, systems engineers, and team leads.

If accepted and flown, HELIOS V will occupy a large payload spot, will draw the allotted 30 V from the HASP platform, and will utilize serial uplink and downlink.

HASP Payload Specification and Integration Plan

Payload Title: High Elevation Light Intensity Observation System V

Payload Class: Small Large (circle one)

Payload ID: 10

Institution: University of Colorado at Boulder

Contact Name: Haleigh Flaherty

Contact Phone: 719-660-8177

Contact E-mail: haleigh.flaherty@colorado.edu

Submit Date: June 24th, 2016

I. Mechanical Specifications:

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

Component	Weight (kg)	Quantit	Combined Weight (kg)
Motor	1.050	2	2.100
Drivers	0.003	2	0.006
Diodes	0.003	4	0.012
Wires (Overestimated)	0.600	1	0.600
Power Board with Gertduino	0.468	1	0.468
ADCS Camera	0.138	1	0.138
Orion Telescope	1.431	1	1.431
Longpass Filter	0.040	1	0.040
Barrel & Filters	0.054	1	0.054
Hydrogen Alpha Filter	0.009	1	0.009
Science Camera	0.058	1	0.058
Focal Reducer	0.019	2	0.037
Rasperry Pi 2	0.043	2	0.086
Base plate	5.055	1	5.055
Base pillars	0.032	8	0.256
Intermediate Plate	1.802	1	1.802
Rotary Plate	0.567	1	0.567
Support Arm attached to Motor	0.245	1	0.245
Support Arm without Motor	0.273	1	0.273
Brackets	0.018	2	0.036
Upper Housing Base plate	1.252	1	1.252
Upper Housing Side Plate	0.347	2	0.694
Telescope Lower Mount	0.453	1	0.453
Telescope Upper Mount	0.236	1	0.236
Elevation Motor Mounts	0.082	2	0.164
Azimuth Motor Mount Base	0.064	1	0.064
Azimuth Motor Mount top	0.063	1	0.063
Azimuth Gear	0.522	1	0.522

Azimuth Pinion	0.039	1	0.039	
Elevation Miter Gears	0.039	2	0.078	
Azimuth Axle	0.312	1	0.312	
Elevation Axle	0.018	1	0.018	
Shaft Extension	0.043	2	0.086	
Flanged Hub	0.134	1	0.134	
Ball Bearing	0.019	4	0.076	
Side Photo Diode Housing (with c	0.218	1	0.218	
Bottom Photo Diode Housing	0.218	1	0.218	
CounterWeight Slot	0.068	1	0.068	
Side Counter Weight	0.122	1	0.122	
Back Counter Weight	1.930	1	1.930	
Large Nut	0.085	2	0.170	
Multilayer Insulation	0.300	1	0.300	
Thermal Gap Feller	0.050	2	0.100	
Copper Braid	0.150	2	0.300	
Total			20.890	± .500 kg
HASP Weight Limit			21.5	kg

Baseplate: 5.055 kg

Payload: 16.034 kg

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

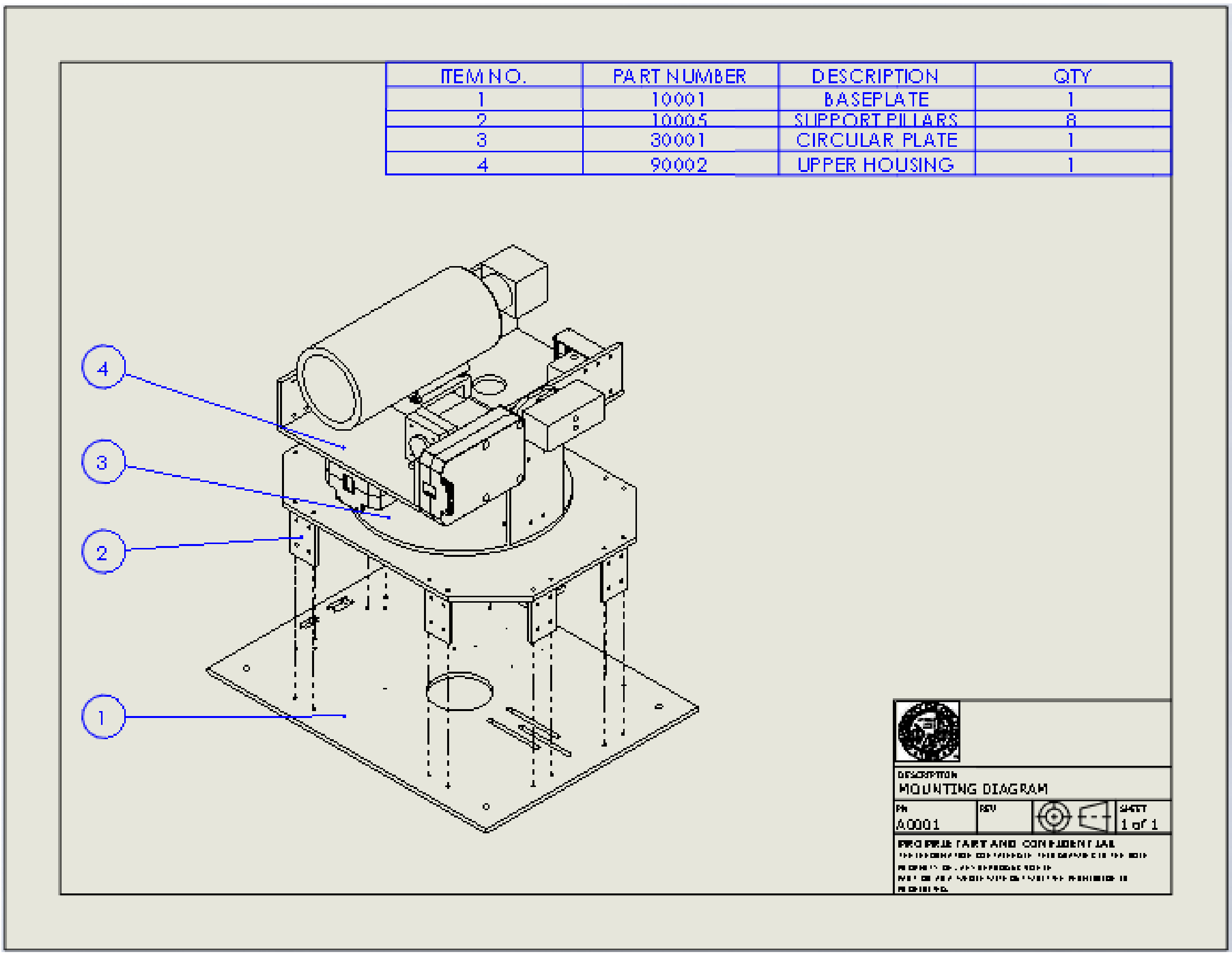
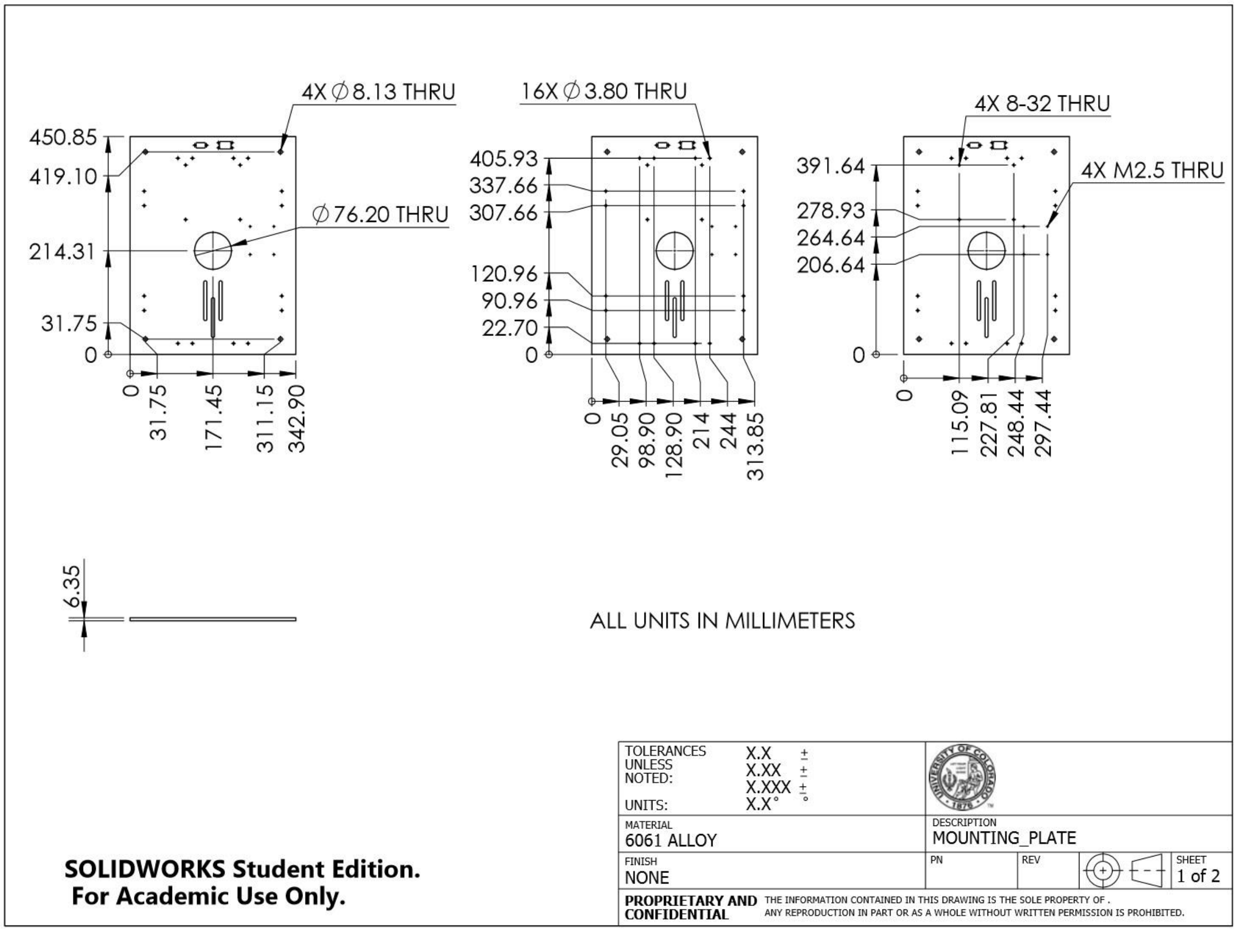


Figure 1: Full structure


4X ∅8.13 THRU
16X ∅3.80 THRU
4X 8-32 THRU
4X M2.5 THRU
∅76.20 THRU
450.85
419.10
214.31
31.75
0
0
31.75
171.45
311.15
342.90
405.93
337.66
307.66
120.96
90.96
22.70
0
0
29.05
98.90
128.90
214
244
313.85
391.64
278.93
264.64
206.64
0
0
115.09
227.81
248.44
297.44
6.35
ALL UNITS IN MILLIMETERS
TOLERANCES UNLESS NOTED:
X.X ±
X.XX ±
X.XXX ±
X.X° ±
UNITS:
MATERIAL
6061 ALLOY
DESCRIPTION
MOUNTING_PLATE
FINISH
NONE
PN
REV
SHEET
1 of 2
PROPRIETARY AND CONFIDENTIAL
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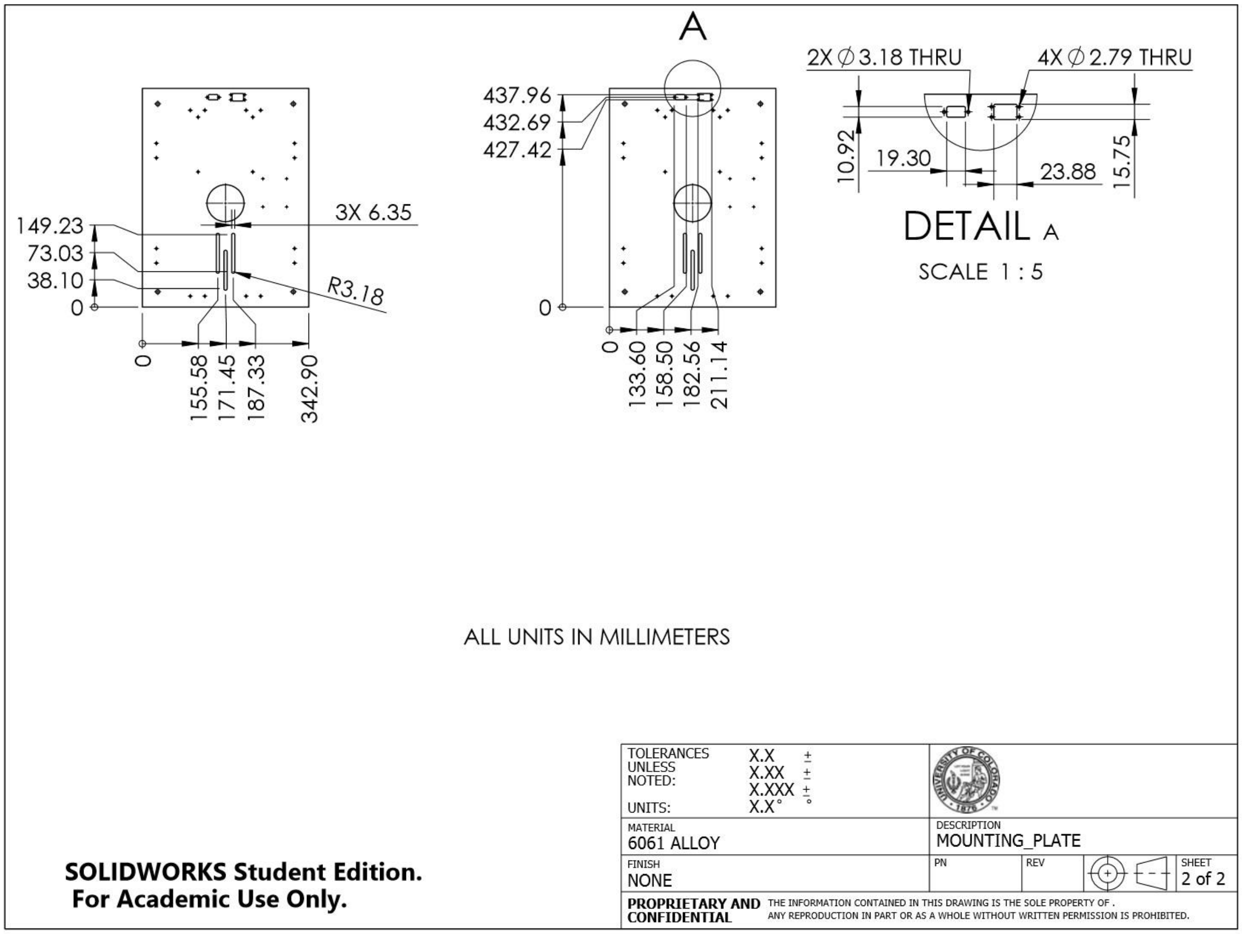


Figure 2: Base Plate

Note: This is the same custom baseplate that HELIOS IV flew in 2015

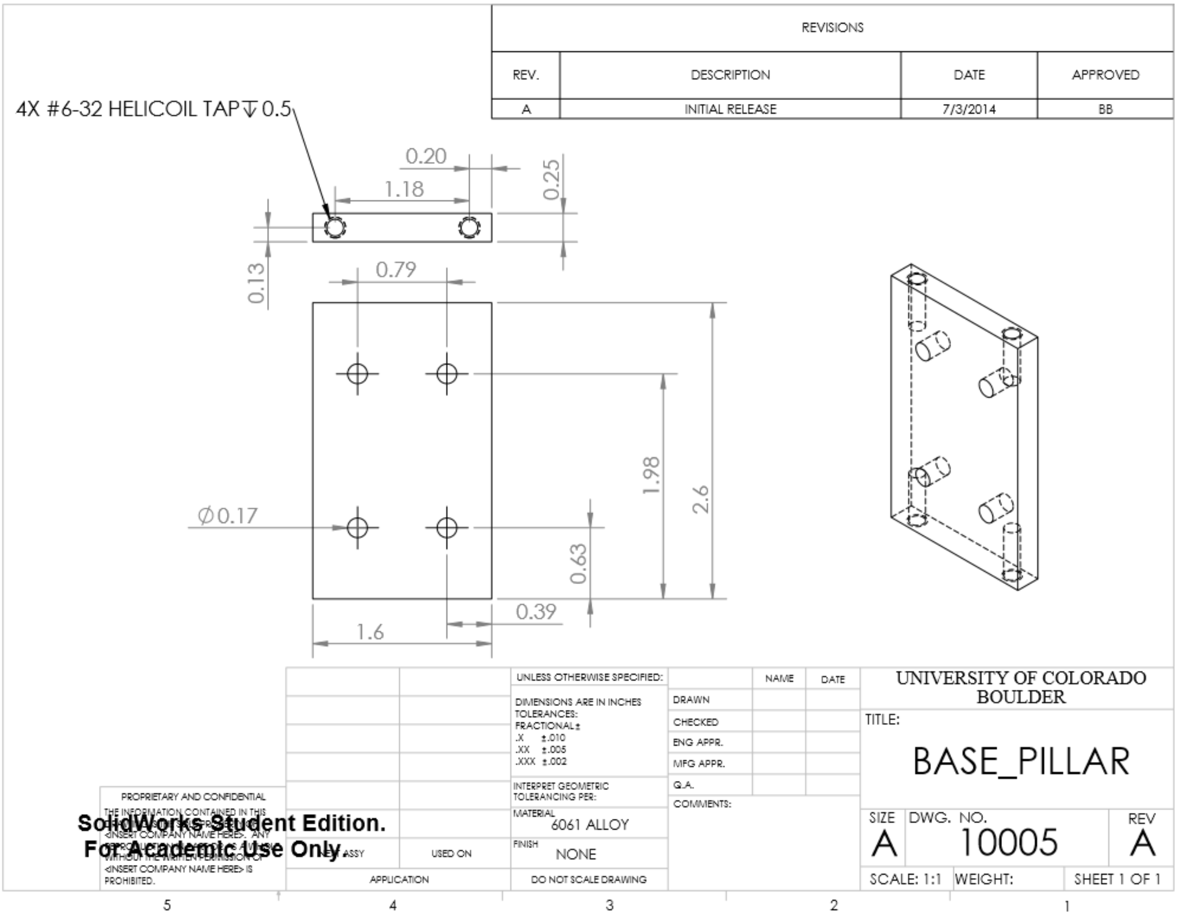
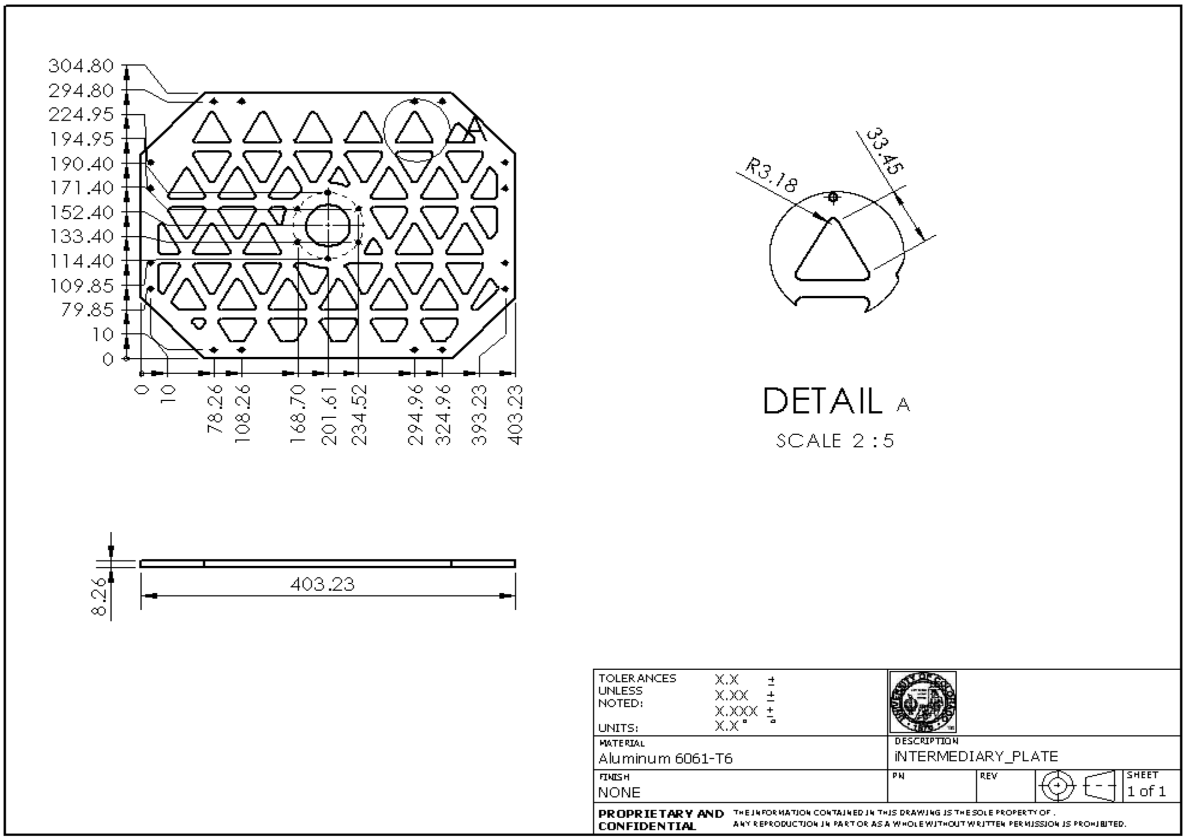


Figure 3: Support pillars


304.80
294.80
224.95
194.95
190.40
171.40
152.40
133.40
114.40
109.85
79.85
10
0
0
10
78.26
108.26
168.70
201.61
234.52
294.96
324.96
393.23
403.23
A
R3.18
33.45
DETAIL A
SCALE 2 : 5
8.26
403.23
TOLERANCES UNLESS NOTED:
X.X ±
X.XX ±
X.XXX ±
X.X° ±
UNITS:
MATERIAL
Aluminum 6061-T6
DESCRIPTION
INTERMEDIARY_PLATE
FINISH
NONE
PN
REV
SHEET
1 of 1
PROPRIETARY AND CONFIDENTIAL

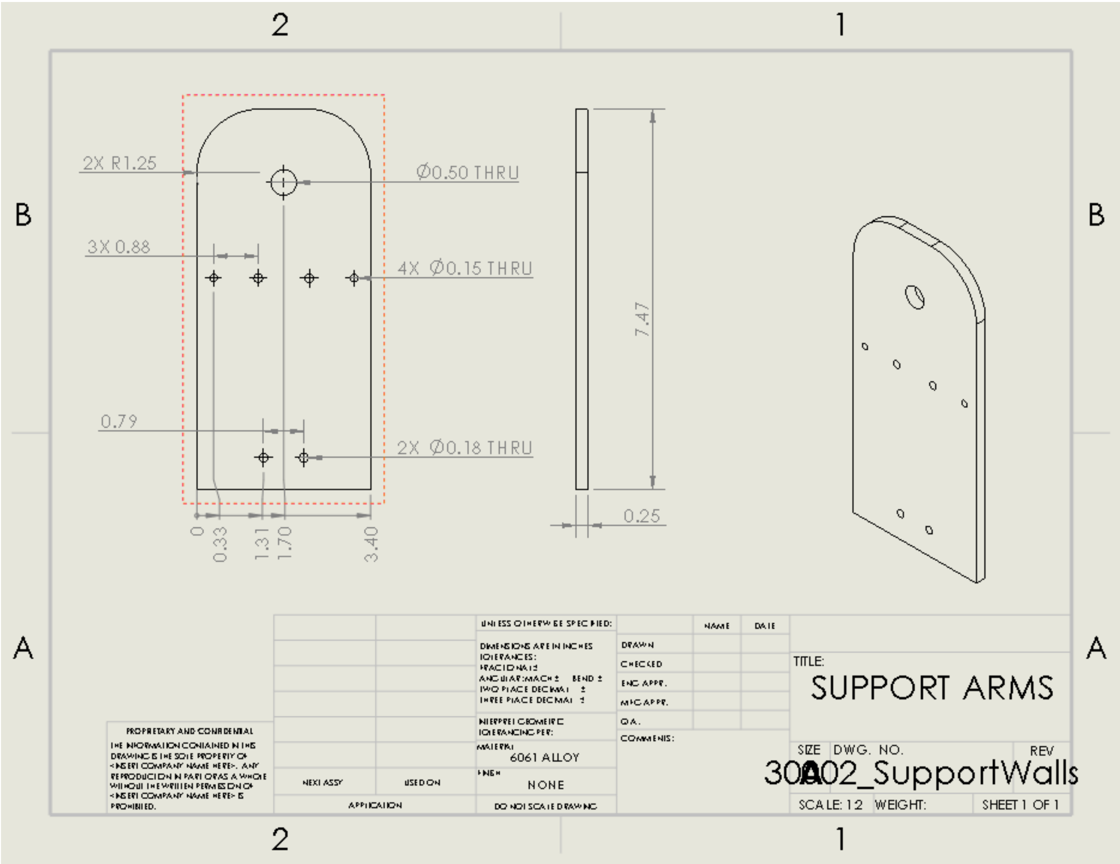


Figure 5: Support arms

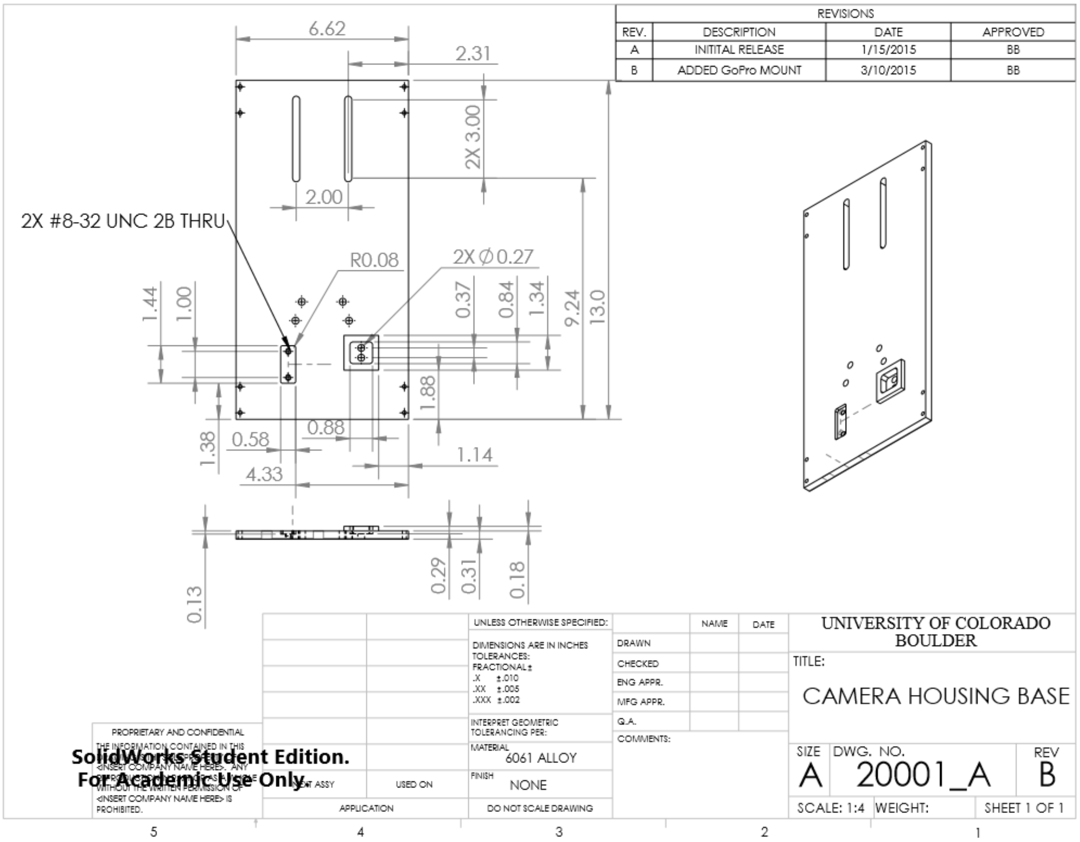


Figure 6: Upper housing plate

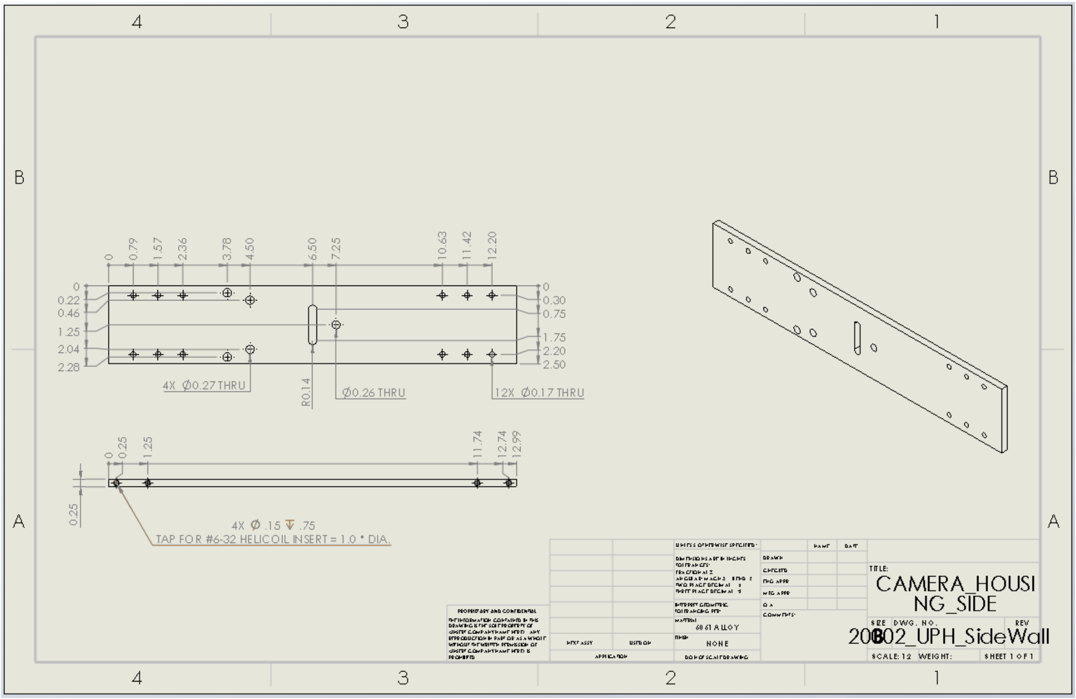
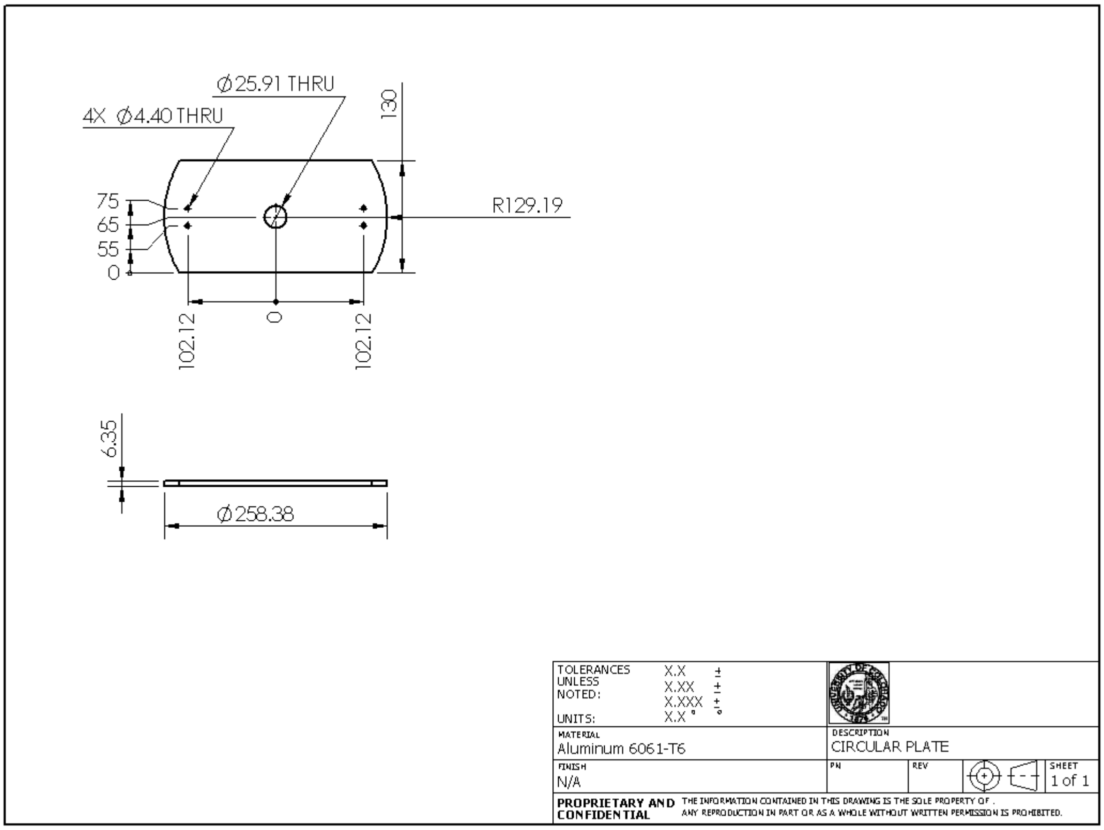
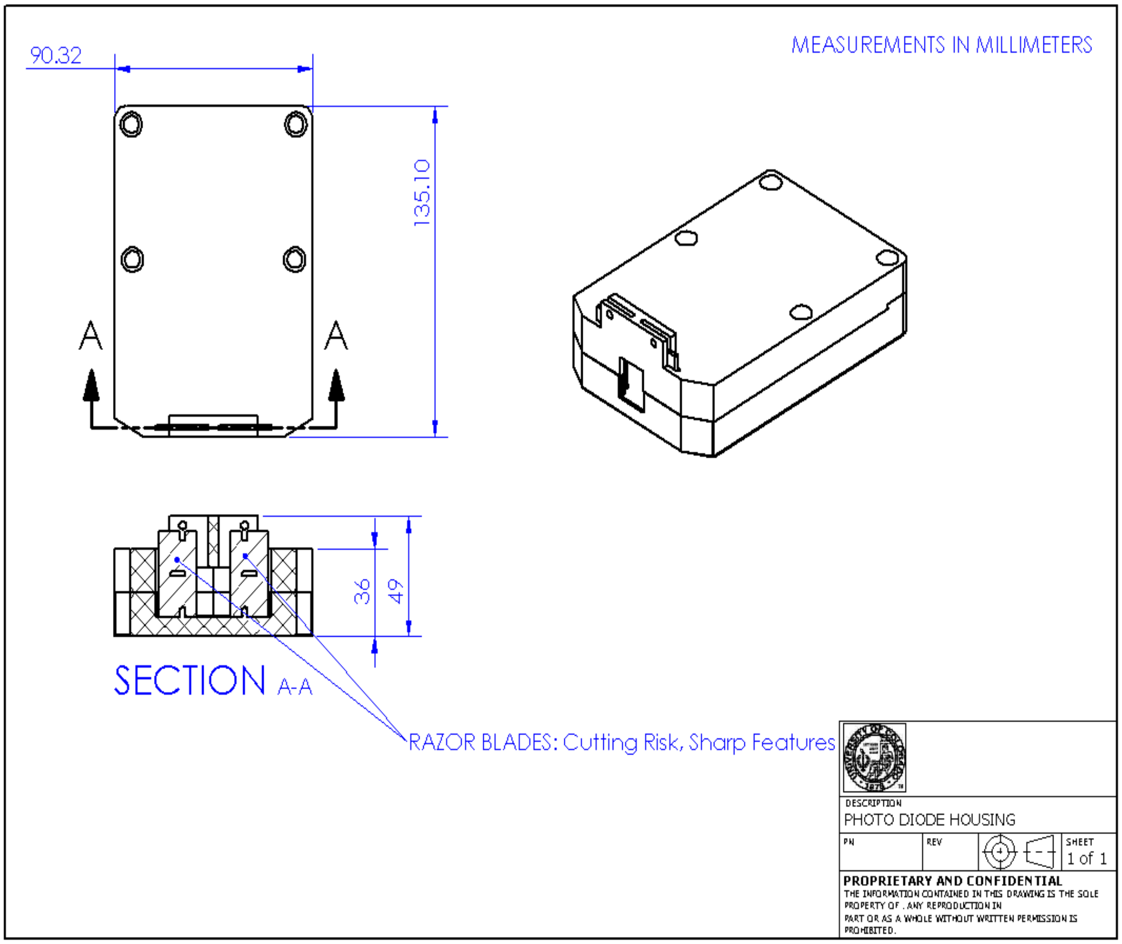


Figure 7: Upper housing side walls



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…)

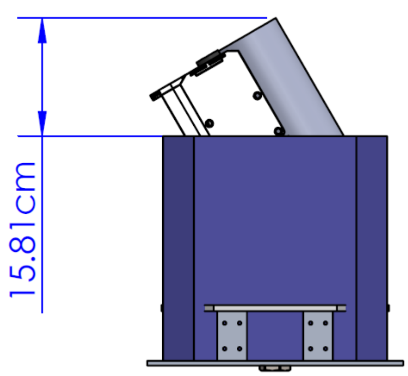
Photodiode Housing with indicated of where the razors are. Razors will be labeled “Cutting Risk, Sharp Features”.



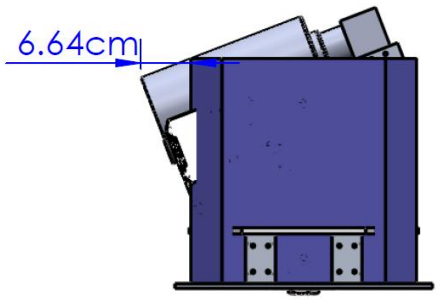
D. Other relevant mechanical information

Encroachment of size envelope with dimensions

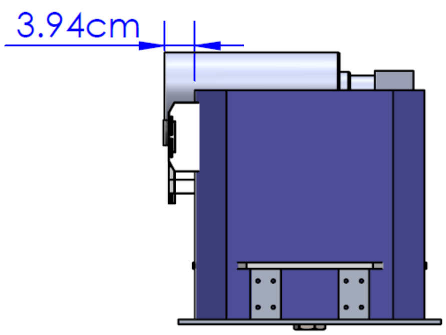
a. Vertical encroachment: (occurs at maximum angle)



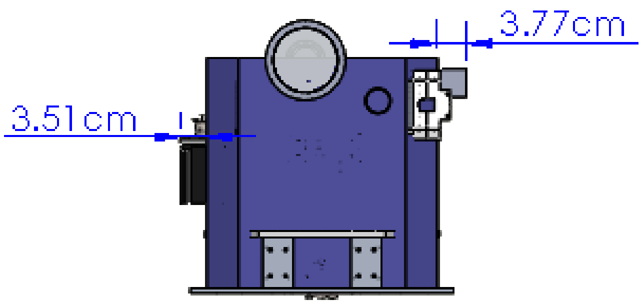
b. Horizontal encroachment: (occurs at minimum angle)



c. Flat Angle Encroachment:

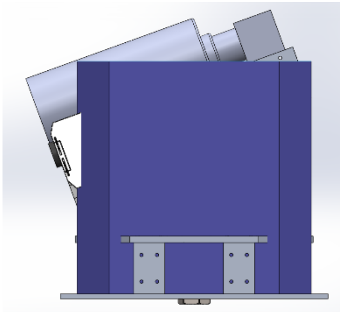


d. Front Facing Encroachment:

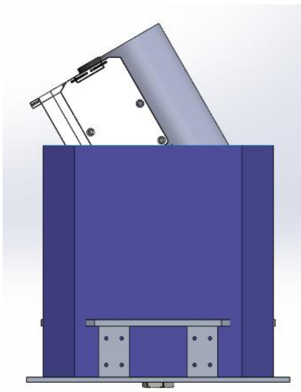


Range of motion

a. Lowest elevation: -20°



b. Highest elevation: 60°



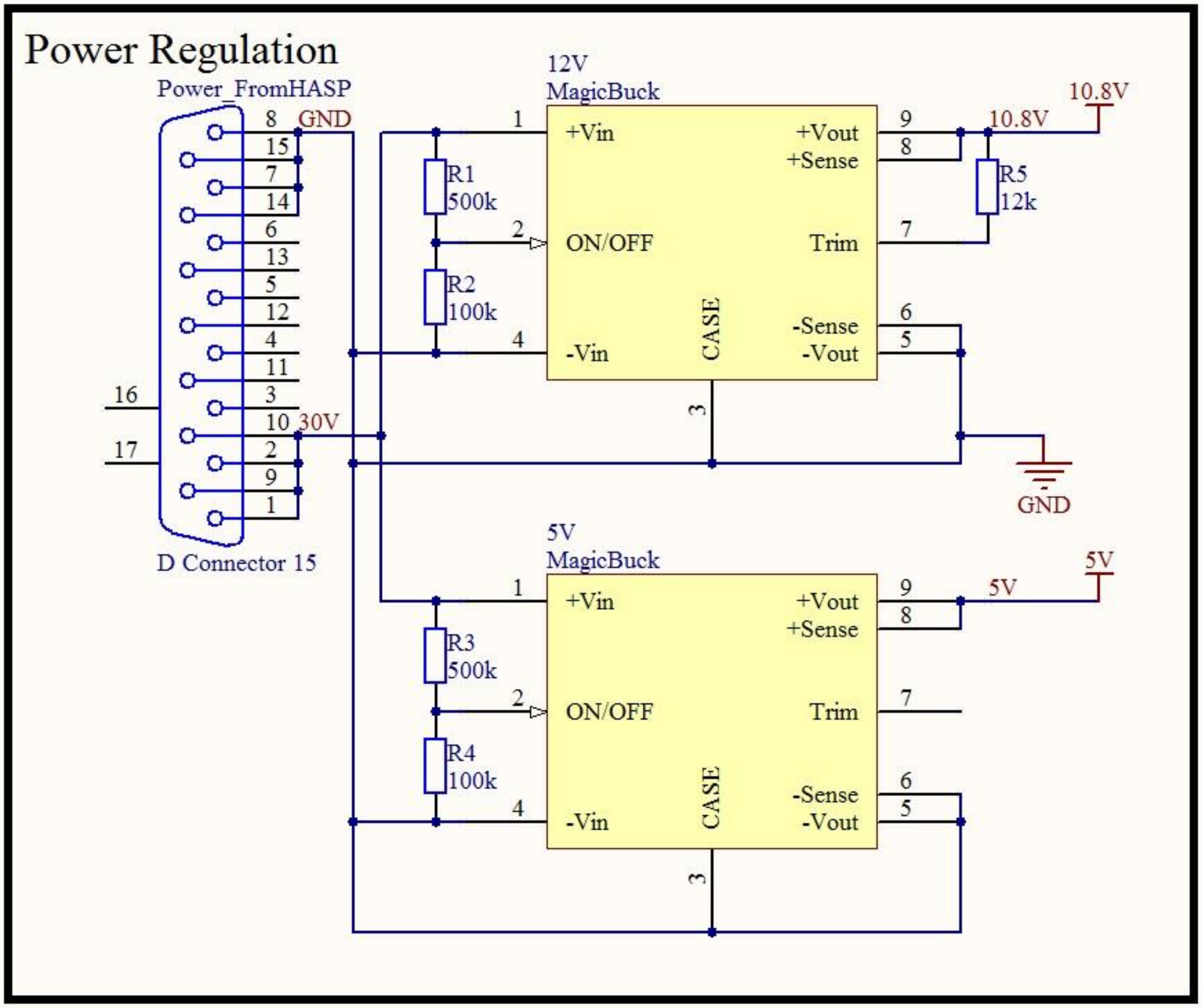
c. Azimuth: 360° of motion

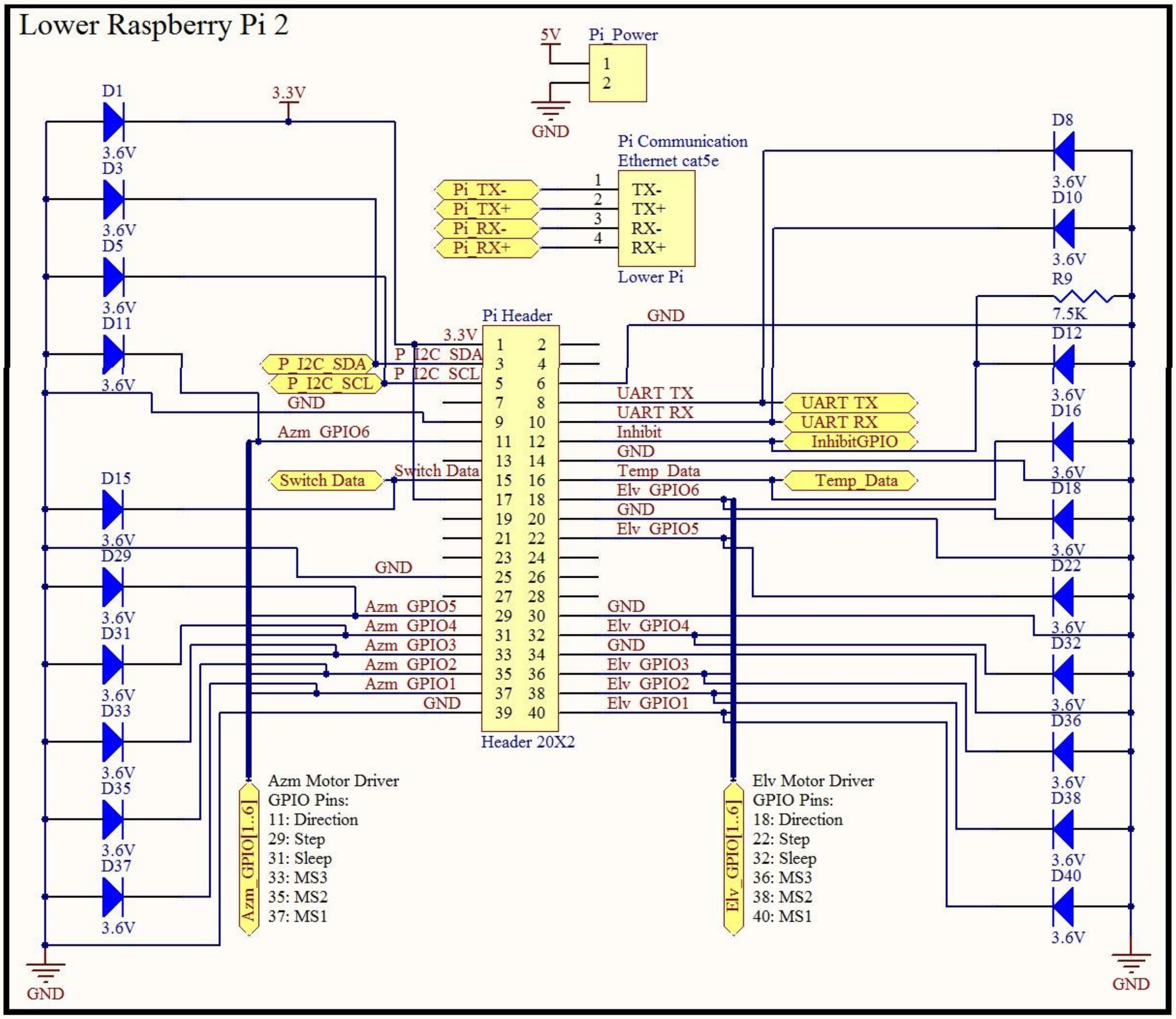
II. Power Specifications:

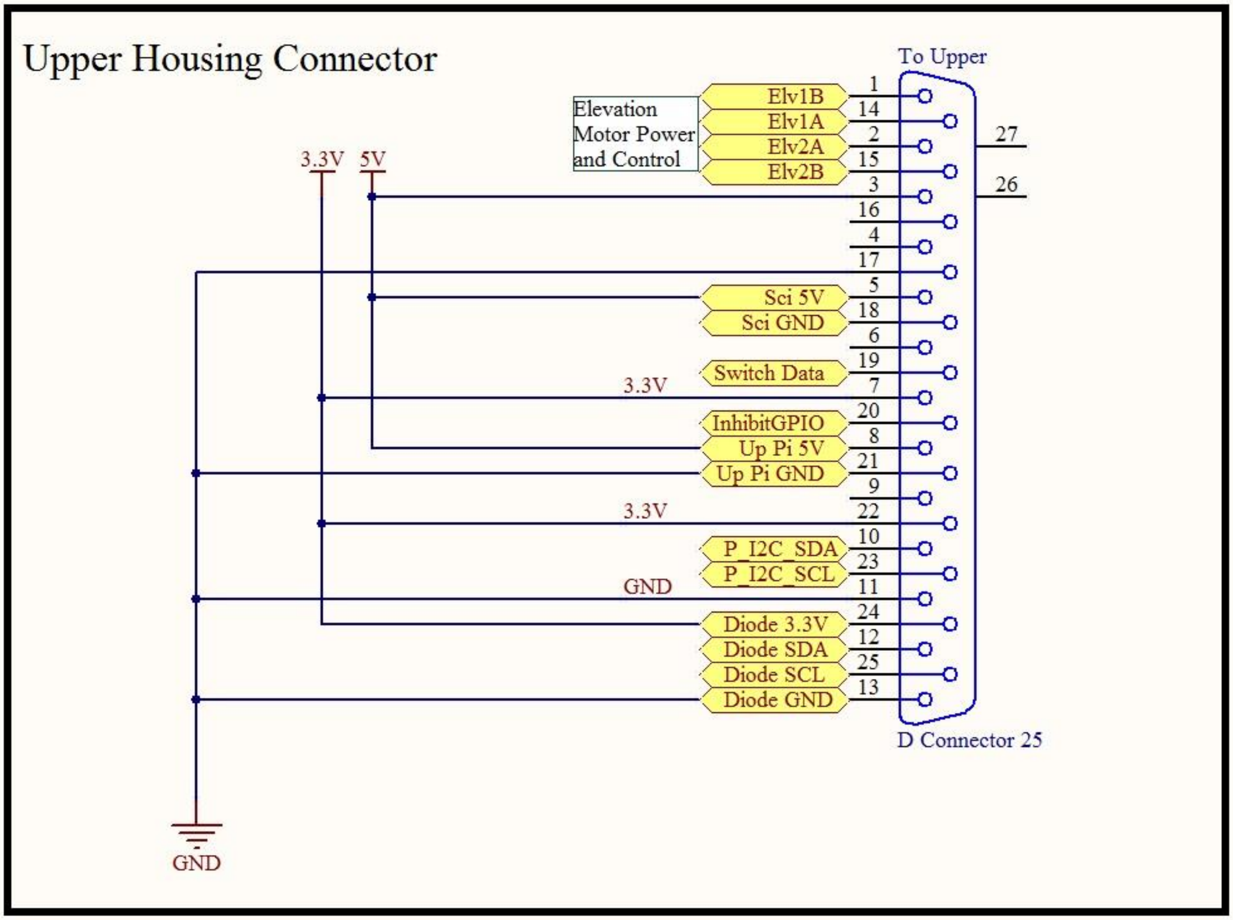
A. Measured current draw at 30 VDC

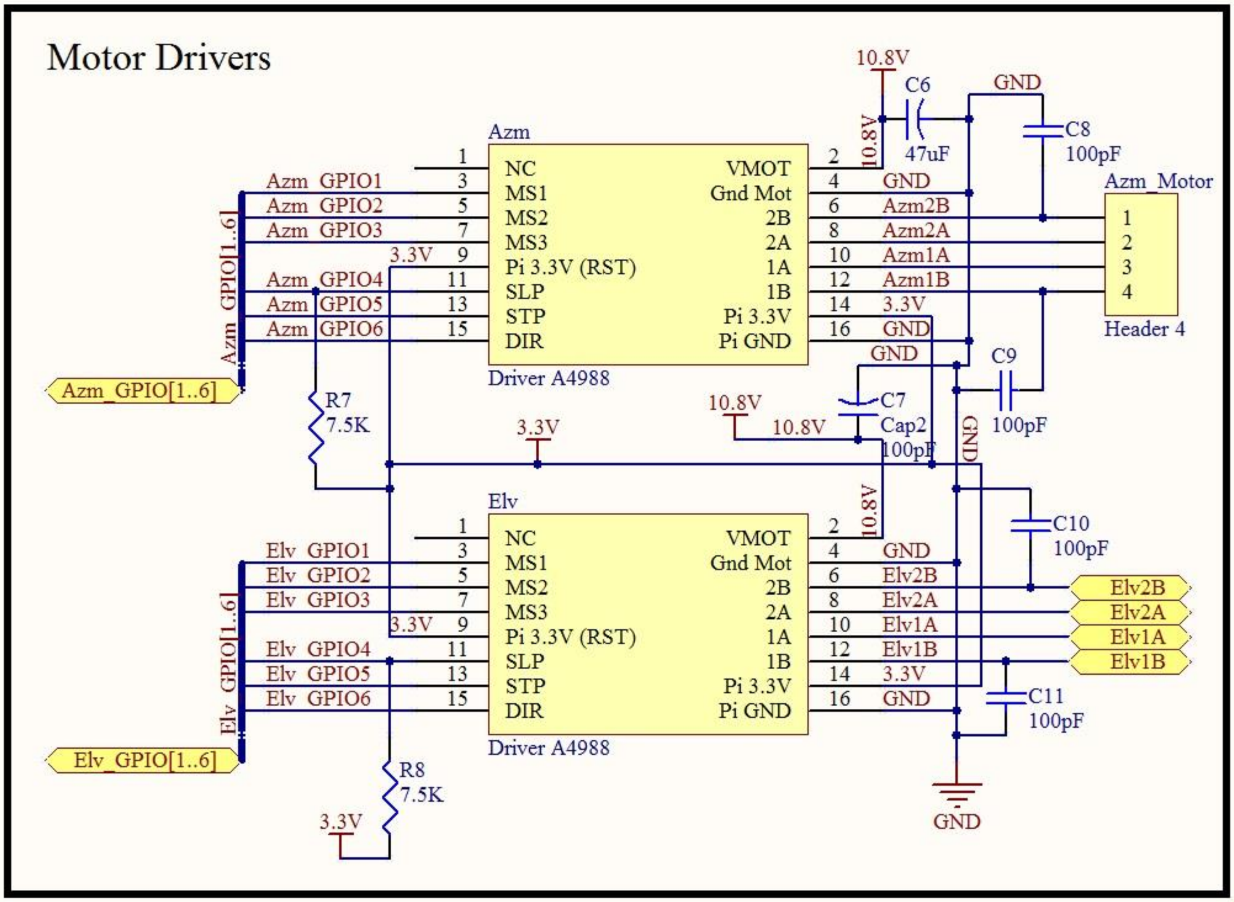
0.75 A

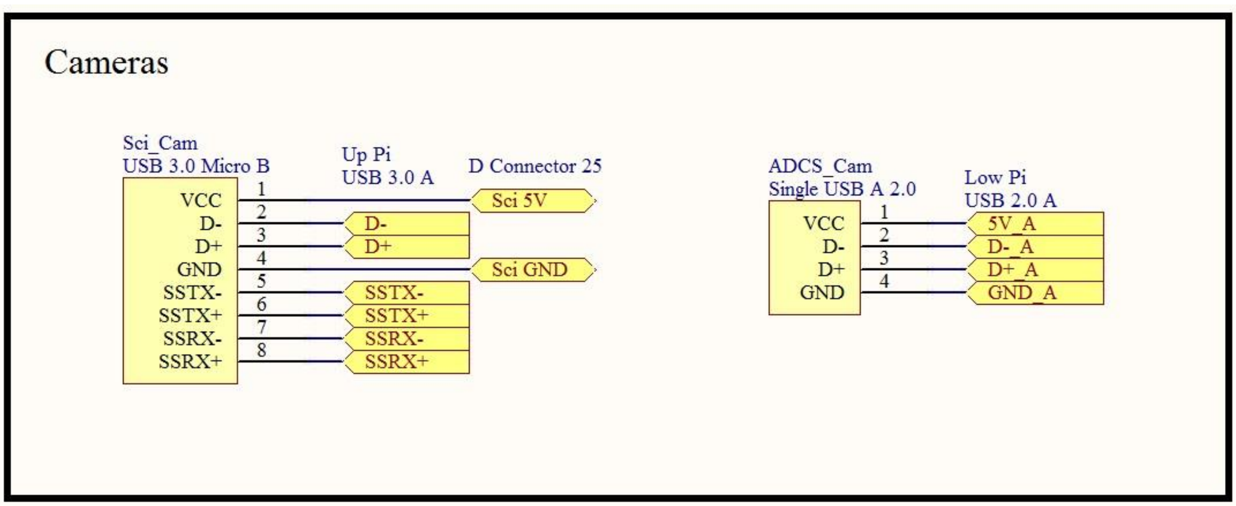
B. If HASP is providing power to your payload, provide a power system wiring diagram starting from pins on the student payload interface plate EDAC 516 connector through your power conversion to the voltages required by your subsystems.

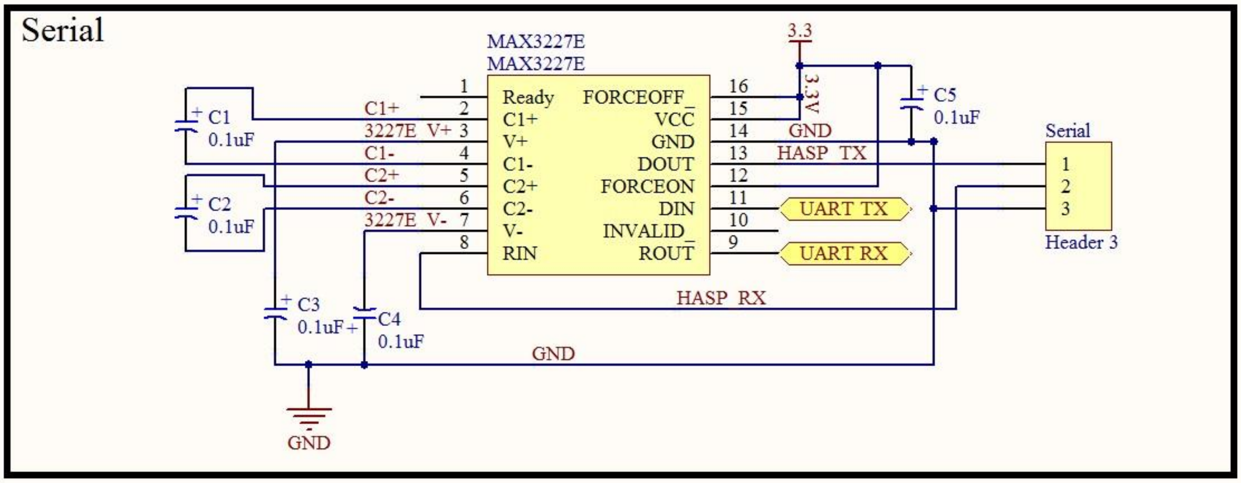

Power Regulation
Power_FromHASP
D Connector 15
GND
30V
12V
MagicBuck
5V
MagicBuck
+Vin
ON/OFF
-Vin
CASE
+Vout
+Sense
Trim
-Sense
-Vout
R1
500k
R2
100k
R3
500k
R4
100k
R5
12k
10.8V
5V
GND

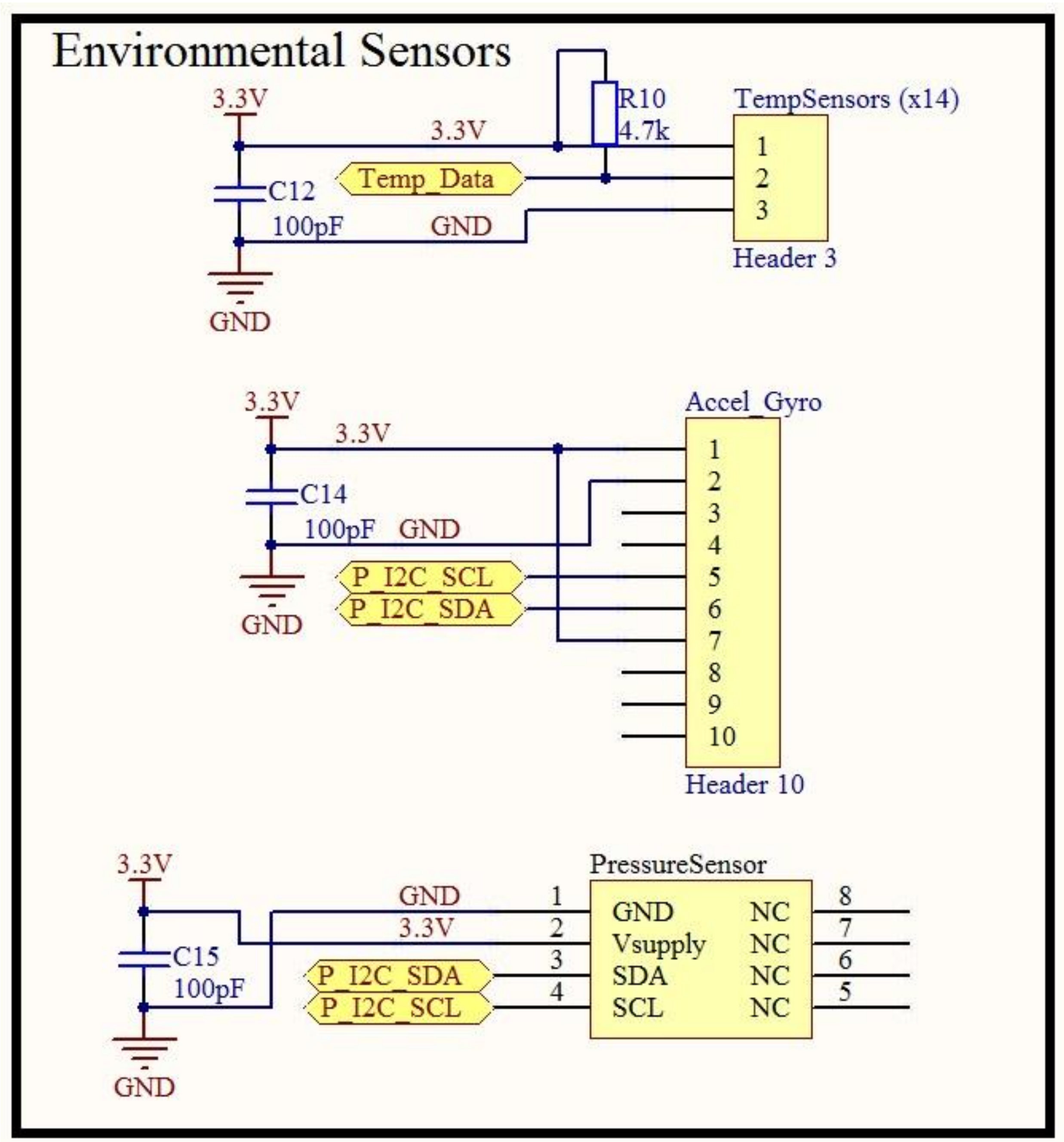

Lower Raspberry Pi 2
5V
Pi_Power
1
2
GND
3.3V
D1
3.6V
D3
3.6V
D5
3.6V
D11
3.6V
D15
3.6V
D29
3.6V
D31
3.6V
D33
3.6V
D35
3.6V
D37
3.6V
Pi Communication
Ethernet cat5e
Pi_TX-
Pi_TX+
Pi_RX-
Pi_RX+
TX-
TX+
RX-
RX+
Lower Pi
D8
3.6V
D10
3.6V
R9
7.5K
D12
3.6V
D16
3.6V
D18
3.6V
D22
3.6V
D32
3.6V
D36
3.6V
D38
3.6V
D40
3.6V
Pi Header
3.3V
P_I2C_SDA
P_I2C_SCL
GND
Azm_GPIO6
Switch Data
Azm_GPIO5
Azm_GPIO4
Azm_GPIO3
Azm_GPIO2
Azm_GPIO1
UART TX
UART RX
Inhibit
InhibitGPIO
Temp_Data
Elv_GPIO6
Elv_GPIO5
Elv_GPIO4
Elv_GPIO3
Elv_GPIO2
Elv_GPIO1
Header 20X2
Azm_GPIO[1..6]
Azm Motor Driver
GPIO Pins:
11: Direction
29: Step
31: Sleep
33: MS3
35: MS2
37: MS1
Elv_GPIO[1..6]
Elv Motor Driver
GPIO Pins:
18: Direction
22: Step
32: Sleep
36: MS3
38: MS2
40: MS1
GND

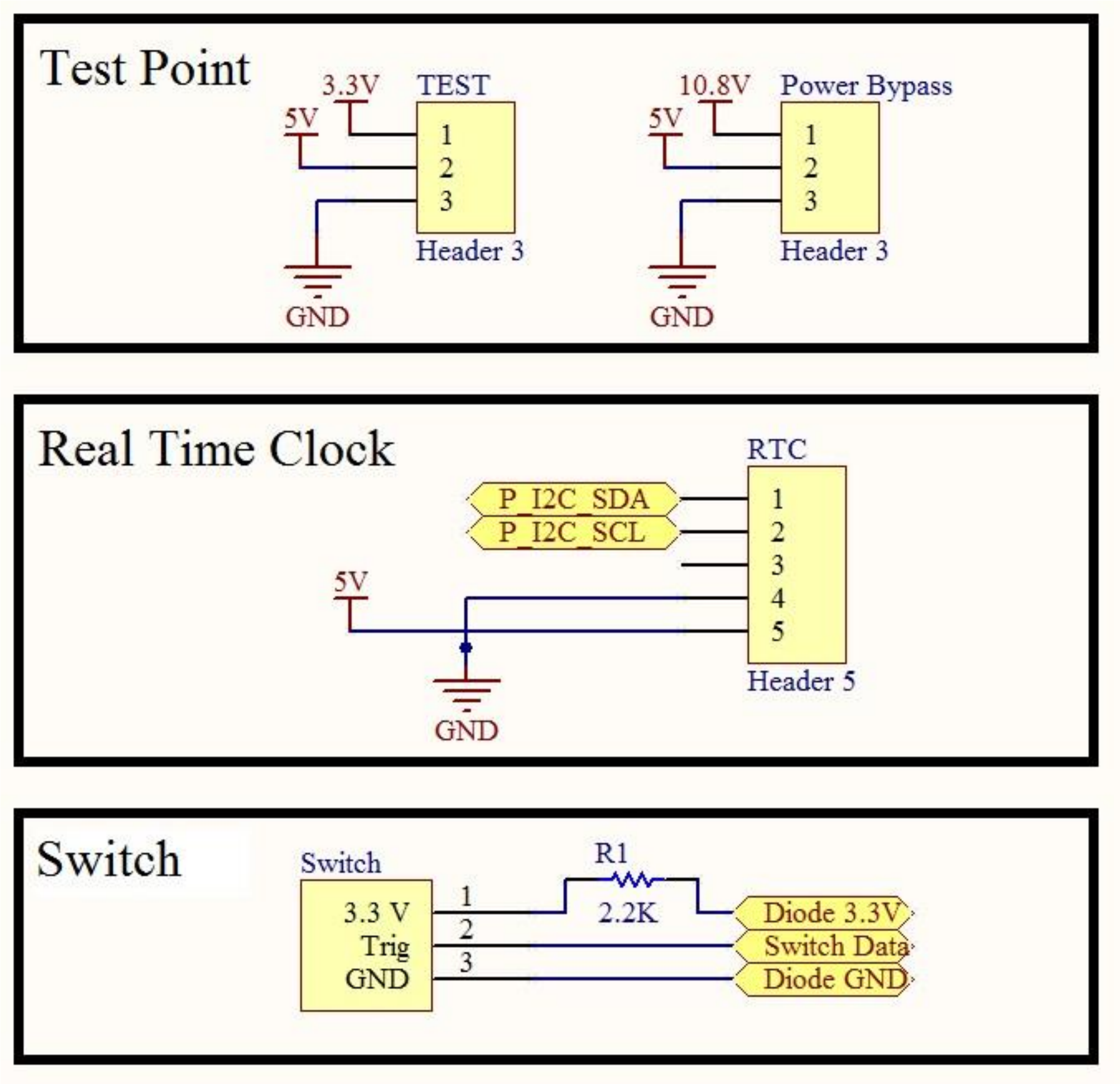

Upper Housing Connector
To Upper
Elevation
Motor Power
and Control
Elv1B
Elv1A
Elv2A
Elv2B
3.3V
5V
Sci 5V
Sci GND
Switch Data
3.3V
InhibitGPIO
Up Pi 5V
Up Pi GND
3.3V
P_I2C_SDA
P_I2C_SCL
GND
Diode 3.3V
Diode SDA
Diode SCL
Diode GND
1
14
2
15
3
16
4
17
5
18
6
19
7
20
8
21
9
22
10
23
11
24
12
25
13
27
26
D Connector 25
GND

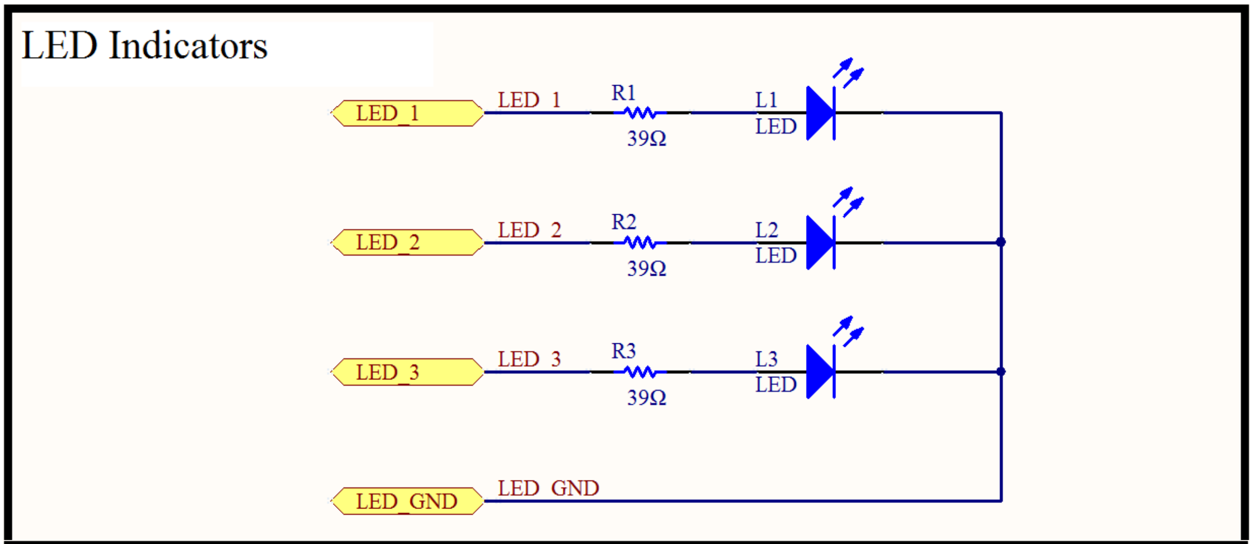

Motor Drivers
Azm
NC
MS1
MS2
MS3
Pi 3.3V (RST)
SLP
STP
DIR
VMOT
Gnd Mot
2B
2A
1A
1B
Pi 3.3V
Pi GND
Driver A4988
Azm_GPIO1
Azm_GPIO2
Azm_GPIO3
Azm_GPIO4
Azm_GPIO5
Azm_GPIO6
Azm_GPIO[1..6]
Azm2B
Azm2A
Azm1A
Azm1B
Azm_Motor
Header 4
C6
47uF
C8
100pF
C9
100pF
C7
Cap2
100pF
R7
7.5K
10.8V
3.3V
GND
Elv
Driver A4988
Elv_GPIO1
Elv_GPIO2
Elv_GPIO3
Elv_GPIO4
Elv_GPIO5
Elv_GPIO6
Elv_GPIO[1..6]
Elv2B
Elv2A
Elv1A
Elv1B
C10
100pF
C11
100pF
R8
7.5K

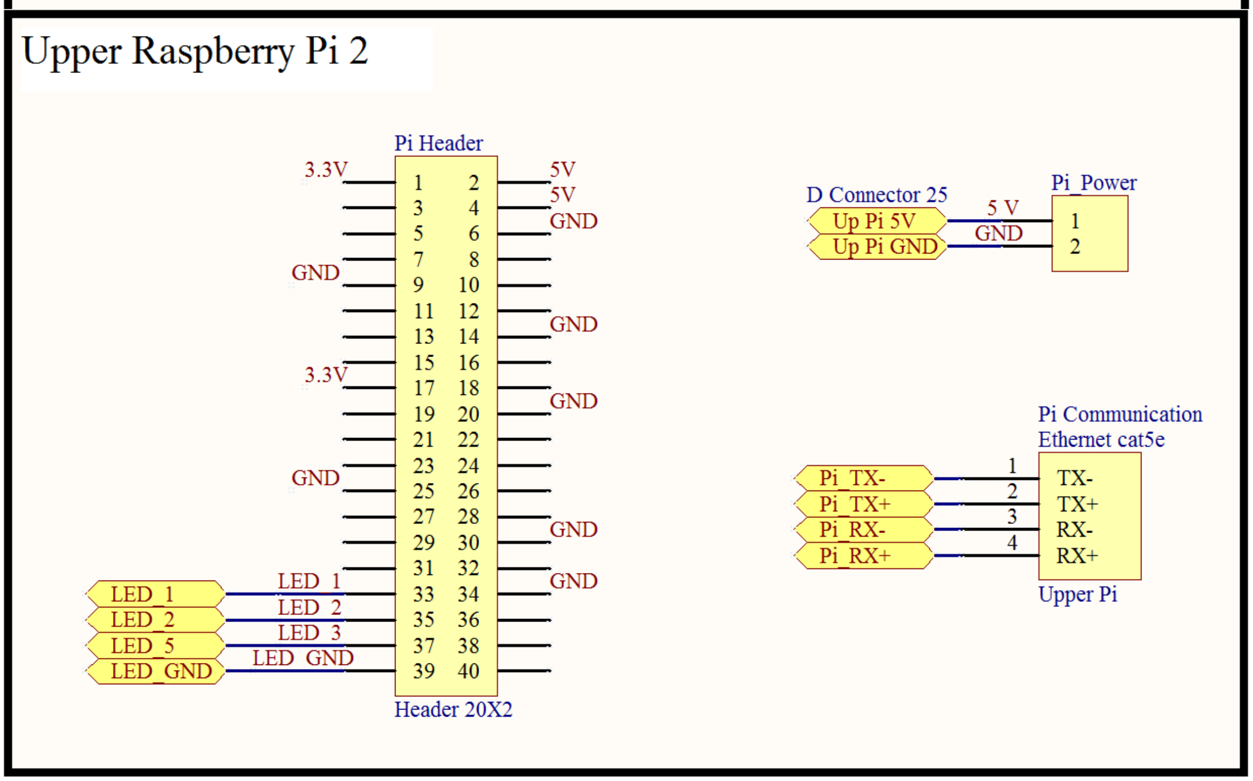

Cameras
Sci_Cam
USB 3.0 Micro B
VCC
D-
D+
GND
SSTX-
SSTX+
SSRX-
SSRX+
Up Pi
USB 3.0 A
D Connector 25
Sci 5V
Sci GND
ADCS_Cam
Single USB A 2.0
Low Pi
USB 2.0 A
5V_A
D-_A
D+_A
GND_A


Serial
MAX3227E
MAX3227E
Ready
C1+
V+
C1-
C2+
C2-
V-
RIN
FORCEOFF_
VCC
GND
DOUT
FORCEON
DIN
INVALID_
ROUT
C1 0.1uF
C2 0.1uF
C3 0.1uF
C4 0.1uF
C5 0.1uF
3.3
3.3V
GND
HASP TX
HASP RX
UART TX
UART RX
3227E V+
3227E V-
Serial
Header 3


Environmental Sensors
3.3V
3.3V
R10
4.7k
TempSensors (x14)
1
2
3
Header 3
C12
100pF
Temp_Data
GND
GND
3.3V
3.3V
Accel_Gyro
C14
100pF
GND
GND
P_I2C_SCL
P_I2C_SDA
1
2
3
4
5
6
7
8
9
10
Header 10
3.3V
PressureSensor
GND
3.3V
C15
100pF
P_I2C_SDA
P_I2C_SCL
GND
Vsupply
SDA
SCL
NC
NC
NC
NC
1
2
3
4
8
7
6
5
GND


Test Point
3.3V
TEST
5V
1
2
3
Header 3
GND
10.8V
Power Bypass
5V
1
2
3
Header 3
GND
Real Time Clock
RTC
P_I2C_SDA
P_I2C_SCL
1
2
3
4
5
5V
Header 5
GND
Switch
Switch
3.3 V
Trig
GND
1
2
3
R1
2.2K
Diode 3.3V
Switch Data
Diode GND


LED Indicators
LED_1
LED_1
R1
39Ω
L1
LED
LED_2
LED_2
R2
39Ω
L2
LED
LED_3
LED_3
R3
39Ω
L3
LED
LED_GND
LED_GND


Upper Raspberry Pi 2
Pi Header
3.3V
5V
5V
GND
GND
GND
3.3V
GND
GND
GND
GND
LED_1
LED_2
LED_5
LED_GND
LED_1
LED_2
LED_3
LED_GND
Header 20X2
D Connector 25
Up Pi 5V
Up Pi GND
5 V
GND
Pi_Power
Pi Communication
Ethernet cat5e
Pi_TX-
Pi_TX+
Pi_RX-
Pi_RX+
TX-
TX+
RX-
RX+
Upper Pi

C. Other relevant power information

Component	Voltage (V)	Current (A)	Power (W)
Raspberry Pi 2	5.0	1.1	5.5
Raspberry Pi 2	5.0	1.1	5.5
Elevation Motor Driver	10.8	1.2	12.96
Azimuth Motor Driver	10.8	1.2	12.96
ADCS Camera	5.0	.75	3.75
CMOS Monochrome Camera	5.0	2.5	12.5
Micro Switch	3.3	.33	1.65
Temperature Sensors	3.3	.014	.05
Photodiode Sensors	3.3	<.0001	<.01
Total Power	**30**	**1.83**	**54.87**

III. Downlink Telemetry Specifications:

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

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

1600 bps

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

Bytes	**Content**	**Example**
0	Start Header	0x01
1-6	Payload Identifier	CU HE
7-9	Thread Identifier*	EX
10-12	Record Type*	EX
13-23	Timestamp (from epoch)	1400019944
23-26	Length of data string	37
26-30	Adler32 Checksum	-71889546

31	Start Transmission	0x02
32-(N-1)	Data*	The red fox jumped over the brown log.
N**	End Transmission	0x03

*Possible combinations in table below
**The maximum value of N is 127

Sender	ID	Record	ID	Content	Typical Data
Uplink	UP	Bootup	BU		uplk
		Error	ER	Invalid target and cmd	<2 bytes>
Downlink	DW	Bootup	BU		dwnl
Sensors	SE	Bootup	BU		sens
		Temperature	T14	Data from temperature sensors	Data package
		Pressure	PR	Pressure	Data package
		Humidity	HU	% R.H.	Data package
		Accel/Gyro	AG	Acceleration and rotation on X, Y, and Z axis	Data package
ADCS	AD	Bootup	BU		adcs
		Motor Counts	MC	Azimuth and Elevation step count	Data package
		Diode Readings	DI	Azimuth and Elevation diode readings	Data package
		Ack	AC	Command executed	<1 byte>

	Error	ER	Command with error	<1 byte>

D. Number of analog channels being used:

N/A

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

N/A

F. Number of discrete lines being used:

N/A

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.

None

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*)

5 to 20+ total (Dependent on need to examine/resolve errors during flight)

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

Payload command	Hex command	Description
Ping lower Pi	0xAA 0xAA	Pings payload to test communication
Ping upper Pi	0xFF 0x02	Confirms boot-up/communication with upper Pi
Toggle diode pair-phi	0xBB 0xA1	Toggle between main and backup diodes
Toggle diode pair-theta	0xBB 0xA0	
Azimuth nudges	0xC0 0x00-0xB4	Counter-Clockwise Nudge
	0xC1 0x00-0xB4	Clockwise Nudge
Elevation Nudges	0xD0 0x00-0x41	Nudge Up
	0xD1 0x00-0x41	Nudge Down
Reset motor count	0xBB 0xBF	Restart count to re-establish accuracy
Pan mode ON	0xBB 0xFA	Toggles panning mode for total diode failure
Pan mode OFF	0xBB 0xFB	
Query Safe Mode	0xAA 0xA0	Check whether night mode is on right now. 00 is OFF, 01 is ON
Safe mode ON	0xBB 0xD1	Inhibits motion, leaves motors on
Safe mode OFF	0xBB 0xD0	(To be used at night to keep the system idle)
Reboot upper Pi	0xFF 0x01	Reboots upper Pi
Reboot both upper and lower Pi	0xFF 0x08	Restart in case of an error
Turn on image analysis	0xBB 0xB1	Turn image analysis on
Turn off image analysis	0xBB 0xB0	Turn image analysis off
Faster image capture rate	0xFF 0x06	Take pictures every 2 seconds
Slower image capture rate	0xFF 0x07	Take pictures every 5 seconds
Picture Status	0xFF 0x09	Displays time and pictures taken since last query
CPU	0xFF 0x03	Checks upper Pi CPU usage
Temperature	0xFF 0x04	Checks upper Pi temperature
Memory Storage	0xFF 0x05	Checks fullness of memory card

10°: 0x0A 30°: 0x1E 45°: 0x2D 60°: 0x3C 90°: 0x5A 180°: 0xB4

E. Are there any on-board receivers? If so, list the frequencies being used.

N/A

F. Other relevant uplink commanding information.

None

V. Integration and Logistics

A. Date and Time of your arrival for integration:

Monday August 1st at 9am CDT

B. Approximate amount of time required for integration:

Pre-T-Vac: 1 hour shall be needed to weigh in, verify current draw, verify proper downlink, transport the payload to the T-Vac area, mount the payload to the platform, and test uplink of commands.

Post-T-Vac: 1 hour shall be needed to run a systems test to verify proper functioning after the T-Vac test. The ADCS and science camera will be checked for correct alignment and the science camera will be cleaned prior to shipping. The payload will then be packed for shipping to Fort Sumner, NM.

C. Name of the integration team leader:

Haleigh Flaherty

D. Email address of the integration team leader:

haleigh.flaherty@colorado.edu

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

Haleigh Flaherty	haleigh.flaherty@colorado.edu
Virginia Nystrom	virginia.nystrom@colorado.edu
Ross Kloetzel	ross.kloetzel@colorado.edu
Logan Thompson	logan.thompson@colorado.edu
Dawson Beatty	dawson.beatty@colorado.edu

F. Define a successful integration of your payload:

A successful integration of the payload includes delivering the functioning and fully intact HELIOS payload to the integration facility, where it will mechanically integrate with the HASP platform, downlink data to the HASP platform and ground station, appropriately respond to uplinked serial commands, and maintain operations during Thermal Vacuum testing. HELIOS will meet all HASP requirements and remain functional after extensive testing.

G. List all expected integration steps:

1. Deliver payload for weighing and confirmation of serial communication with HASP
2. Deliver payload to be integrated on platform
3. Collect downlinked data during thermal vacuum testing
4. Remove REMOVE BEFORE FLIGHT pin from motors
5. Run through Integration Verification Procedure

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

1. Ensure that all requirements specified by the HASP Payload Integration Certificate are met
2. Ensure that the mass of the payload does not exceed the weight limit
3. Ensure payload properly mechanically integrates into HASP platform

4. Integration Verification Procedure has been completed

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…):

N/A

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

A table and wall outlet to perform Integration Verification Procedure.