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December 17, 2007

Dr. T Gregory Guzik
Department of Physics & Astronomy
Louisiana State University
Baton Rouge, LA 70803-4001

Dear Dr. Guzik,

Thank you for taking the time to read our proposal and we look forward to hearing from you. We are excited to have this opportunity to further the research our team started in the Fall 2007, using the HASP platform. Additionally this opportunity allows for members of the team to continue to working with Dr. Robert Fesen and Dr. Yorke Brown of Dartmouth College and Dr. Eliot Young of Southwest Research Institute on high altitude astronomy observatories. We find this platform the most suitable to furthering investigations into light intensity at high altitudes and the actual imaging of celestial bodies from within the atmosphere during the day and night.

Sincerely,

Grant Fritz Systems Lead Engineering Lead	Viliam Klein Elec. & CD&H Lead	Evan Townsend Thermal
Joshua Hecht Integration Lead Engineering	Brock Kowalchuk Project Manager	Scott Randolph Systems
Kyle Kemble Science Lead	Gavin Kutil Science Engineer	Matthew Zemel Structures Lead

HASP Student Payload Application for 2008

Payload Title: Demonstrating Intensity of Electromagnetic High Altitude Radiation Determination			
Payload Class: (circle one) Small (Large)	Institution: University of Colorado		Submit Date: 12/17/07

Project Abstract

The University of Colorado at Boulder student HASP team will determine the viability of high altitude observatories by diurnal imaging of celestial bodies, measuring and recording light intensity in the stratosphere as a function of altitude, and by nocturnal imaging of celestial bodies to determine atmospheric turbulence and light intensity due to residuals in the atmosphere.

This will be achieved by mounting four photometers at 45° from the horizon. During ascent and descent these photometers will record data for broadband viewing while at night, an astronomical filter wheel will record data for five different wavelengths of light. Two CCD cameras will record video during the flight. One large angle field of view (FOV) CCD will find points of reference in the night sky while the other smaller FOV CCD will make more detailed observations. Additionally, accelerometers and gyroscopes will record the vibration and stability of the observation platform. This student lead team will continue to work with scientific advisors from Dartmouth College and the Southwest Research Institute to build upon flight experiences from Fall 2007 student flight. The DIE HARD team will require little C&DH control from HASP, little power, and will meet the structural envelope and requirements of the HASP Interface Manual.

Team Name: DIE HARD		Team or Project Website: spacegrant.colorado.edu/HASP
Student Team Leader Contact Information:		Faculty Advisor Contact Information:
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Department:	Aerospace Engineering	Colorado Space Grant Consortium
Mailing Address:	Discovery Learning Center, 270A 520 UCB	Discovery Learning Center, 270A 520 UCB
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DIE HARD Mission Statement:

The University of Colorado at Boulder student team will determine the viability of high altitude observatories by diurnal imaging of celestial bodies, measuring and recording light intensity in the stratosphere as a function of altitude, and by nocturnal imaging of celestial bodies to determine atmospheric turbulence and light intensity due to residuals in the atmosphere.

Scientific Objectives and Mission Premise:

The two current astronomical observation methods limit the quality of space observations or have an extreme cost. The first is ground based telescopic arrays, which are plagued with distortion in the atmosphere and are at the mercy of the weather. The second method is to use orbiting telescopes, while these provide the superior resolution for scientific observation, they are very expensive. A third option for astronomical observation could be based on a lighter than air platform. By comparison, it costs $600 to put 1 kg up to high altitude on a lighter than air platform, where it costs $20,000 for 1 kg to be launched on a rocket to Low Earth Orbit (LEO) for an orbiting platform. Though the differences are great between ground-based telescopes and orbiting platforms the major deficiency of the ground based arrays lies in the atmospheric distortion. It becomes difficult to perform scientific observations due to this distortion, but that distortion disappears as altitude increases. Making measurements above the atmosphere would eliminate this difficulty. The students on DIE HARD will investigate this third option if selected for this HASP flight.

Determining if a high altitude observatory is possible will require qualitative and quantitative observations of the sky brightness as a lighter than air vehicle ascends through the atmosphere. To qualitatively measure the sky brightness or intensity will require CCD imaging equipment and observing the sky during the flight with the purpose of capturing and recording stars. A photometer array devised by Prof. Brown of Dartmouth College and tested by student teams at the University of Colorado at Boulder will quantitatively determine sky brightness measured in Watts per unit area ($^{W}/_{m^2}$). When flown by students from the University of Colorado on November 10, 2007, this method was filtered to give results beginning at 575 nm and into the IR. An astronomical filter wheel will be used on the DIE HARD design for this HASP flight, building on what was learned in the Fall of 2007, to provide more empirical data in different parts of the electromagnetic spectrum.

While missions to high altitude observatories entails a higher cost than a ground based array, by going as little as 30 km up in the atmosphere the vehicle is above 95% of the atmosphere. This effectively reduces 95% of the distortion as compared to a ground-based array. The size of the array now can be changed to be more mass effective. As an example, the Subaru telescope is an 8 m array 4 km above sea level, and the Keck telescopes are 10 m in diameter composed of 36 hexagonal mirrors. However a high altitude observatory at 30 km would only require a 0.5 m mirror to provide superior imaging quality. Before this step can be taken, empirical data has to be compiled, comparing the qualitative and quantitative data of star images compared to the intensity of light at varying altitudes. At the HASP dwell altitude, the weather is 18km below the platform and the sky is essentially black. This means that there is no interruption of the observatory due to poor weather and even the sun because there is little scattering of light.

A high altitude observatory is the next step in astronomical science. It offers the most cost effective option as compared to orbiting platforms and has superior imaging capability as compared to ground based telescopes. Lighter than air observatories cannot be made in one step and the DIEHARD team will obtain the empirical data and build upon the original tests preformed at the University of Colorado at Boulder this fall by students.

Previous Experience:

This is not the first time the University of Colorado has worked with high altitude payloads; the advising body of this team *The Colorado Space Grant Consortium* sponsors a class titled "Gateway to Space" which is designed to immerse students in the meticulous nature of engineering and to produce a final functioning high altitude payload. The Fall 2007 Gateway to Space class and students worked closely with Dr. Yorke Brown, Dr. Robert Fesen, and Dr. Elliot Young, who are interested in mounting telescopes on lighter than air vehicles, to develop many of the concepts being proposed by the DIE HARD team. The class composed primarily of freshman aerospace engineers took on different tasks to justify the practicality of such an observatory. Ten teams dedicated their 800 – 1200 gram payloads to discover the stability of small payloads at high altitude (Fig. 1-7). This approach will be used again on larger payload platforms to determine the stability of observatories at altitude. Other teams determined at what altitude it is possible to image stars, if at all, during daytime mission using CCD imaging equipment. A third group of teams measure quantitative light intensity due in large part to the photometer designed by Prof. Yorke Brown.

Fig. 1: ***An image of a star as seen by the camera onboard one of our previous high altitude flights. The image appears washed out because of the angle of the sun with respect to the camera.***

On November 10, 2007, the ten payloads flew to a height of 30 km with a total flight duration of four hours. Qualitative and quantitative data were recovered, but further experiments are necessary to draw a solid conclusion about practicality of high altitude observatories. It has been shown that the systems and their respective components will survive in these types of environments without data collection errors. The goal of this longer, DIE HARD mission, especially dwelling at an altitude of 30 km, is to collect more empirical data during the day and night. While the Gateway class flew for four hours on a day mission this platform presents an opportunity to investigate nighttime light intensity, atmospheric residuals and the level of turbulence in the upper atmosphere causing the twinkling of stars.

All flight hardware flown in November 2007 proved itself in this flight as a means to gain greater insight into the possibility of high altitude observatories. The major limiting factor of this November flight was its duration and that not enough data could be collected. With a longer mission, more resources and with the proven hardware, great insight into the next generation of astronomical observations can be made.

Fig. 2: An internal view of a BalloonSat, which attempted to stabilize the craft about the vertical axis and capture video for the duration of flight.

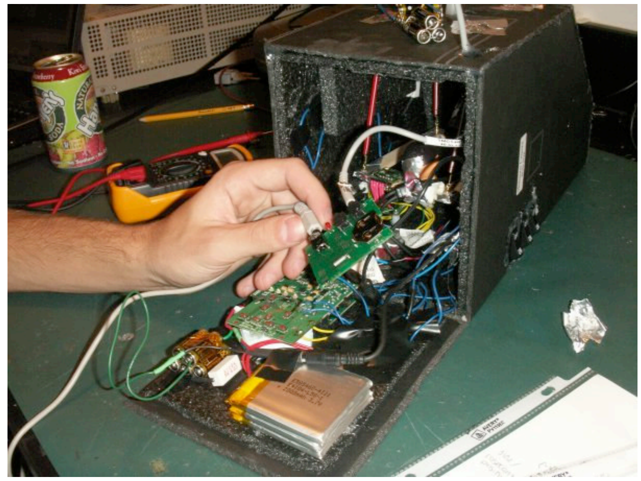


Fig. 3: The internal components for a stabilization and CCD camera imaging system.

Fig. 4: Picture at an altitude of roughly 29.5 kilometers from one of our previous BalloonSat missions.

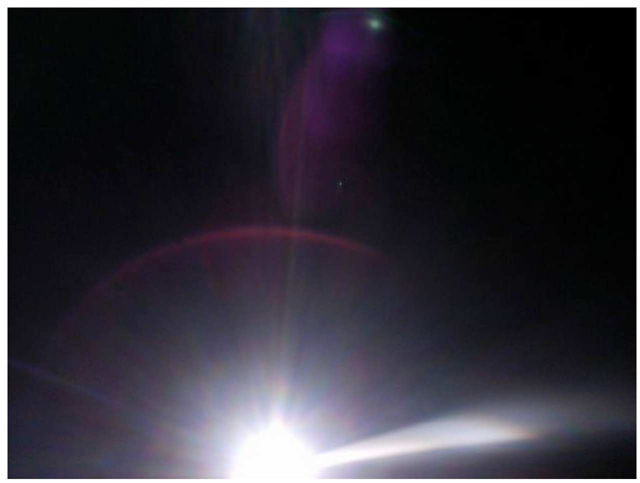


Fig. 5: This picture taken after burst shows the sun over the horizon of the Earth.

Fig. 6: CCD Camera system similar to what will be present onboard the DIE HARD payload.

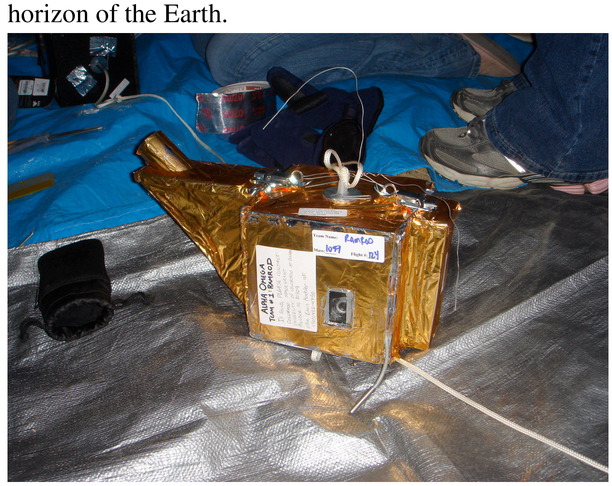
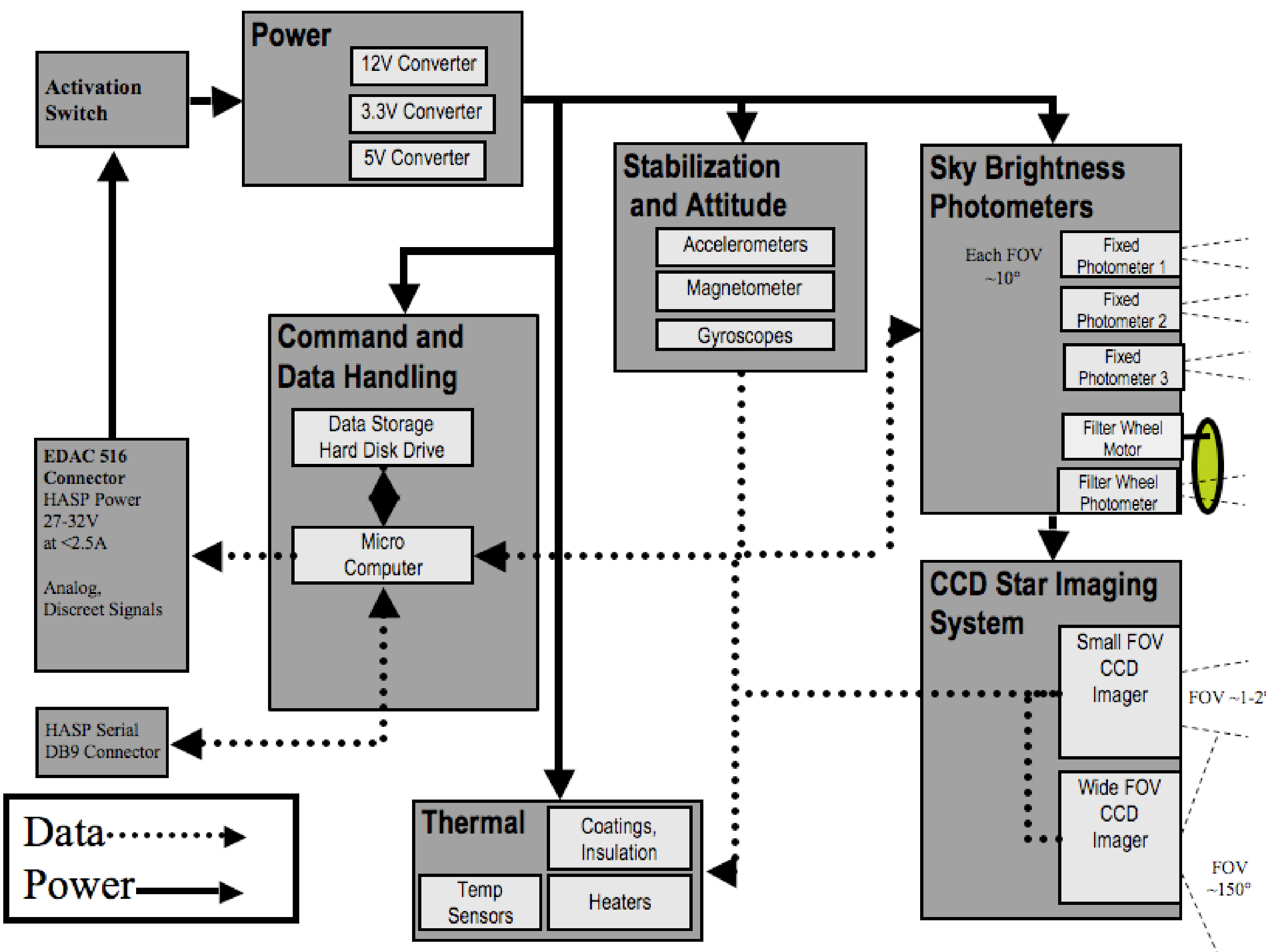


Fig. 7: Payload containing photometer payload similar to what will be present onboard the DIE HARD payload.

Payload Description:

The University of Colorado at Boulder student team envisions a project to provide more empirical data on light intensity at high altitude and the capability to image celestial bodies with CCD imaging equipment. During diurnal operation a bank of photometers will test sky brightness as a function of altitude while two CCD cameras attempt to image celestial bodies to provide and answer to at what altitude stars become visible. Nocturnal operations will use the photometers to determine the light intensity due to residuals in the atmosphere due in large part to aerosols and hydroxyls. The CCD cameras on the other hand will continue to image stars with the intent of determining the turbulence of light at 36 km. With a 20-hour elapsed time all, mission goals can be achieved with the goal of conclusively determining the viability of high altitude telescopic platforms.

High Level Review of Payload Systems:



Principle Operation of Experiment:

The systems working upon the DIE HARD satellite will be primarily independent of one another. The accelerometer works independently of a video recorder or any other device by recording the acceleration of the craft in its own memory. The photometers will work by recording constant light intensity throughout the flight. The photometers will be recording with no filter during the ascent of the balloon and during the daytime. During nighttime operations, a filter wheel will rotate one of five different filters in front of the photometers. These filters will repeat constantly for the duration of the flight, and will change the filter type every three minutes. The data from the photometers will be sent down to mission control in packet form. Based on the data recorded from the satellite, DIE HARD will decide whether uplink communication is necessary to change the operation of the photometer (different filter time intervals, different time frame for photometer recordings) to achieve better results.

The CCD cameras will also record images to the hard drive during the entire flight. There will be two CCD cameras operating, each pointing out of the two open face directions of the payload. These CCD cameras are faced ninety degrees away from one another in order to minimize the chances that the CCD cameras will be pointing towards the sun.

Each of the systems will be turned on with discreet commands an hour before flight. The systems will all be operating on a time or pressure basis, allowing the satellite to operate nominally without any human commanding or control. However, the DIE HARD student team will be able to monitor and optimize control of the payload by monitoring Health and Status packet data sent down through the HASP telemetry system.

Requirements Flowdown

I) Mission Requirements
  a. To determine the feasibility of a high altitude observatory.
  b. To comply with HASP requirements.
  c. To have a functioning payload by 06/22/08.

II) Primary Objectives
  a. To measure sky brightness (I.a).
  b. To image celestial bodies at high altitude (I.a).
  c. To measure the stability of the DIEHARD system (I.a).
  d. To meet HASP interface requirements (I.b).
  e. To meet HASP structure requirements (I.b).
  f. To maintain the payload at a working temperature (I.c).
  g. To internally store the data from our experiment (I.c).

III) Secondary Objectives
  a. To measure sky brightness using a combination of photometers and photodiodes (II.a).

b. To use an accelerometer and a magnetometer to measure the stability and positioning of the payload which will be correlated to CCD and photometer data (II.b).
c. To use accelerometers and magnetometers to determine the positioning and stability of the payload (II.c).
d. The payload must not draw more than 30 volts at 2.5 amps (II.d).
e. The payload must not weigh more than 20 kg and be no bigger than 38cm*30cm*30cm (II.e).
f. To construct a payload to withstand the expected horizontal and vertical forces in excess of 5Gs (II.e).
g. To use heaters to keep the internal temperature of the payload above 0°C (II.f)
h. Any data that can’t be sent down using the communication suite shall be stored using an on board hard drive (II.g).

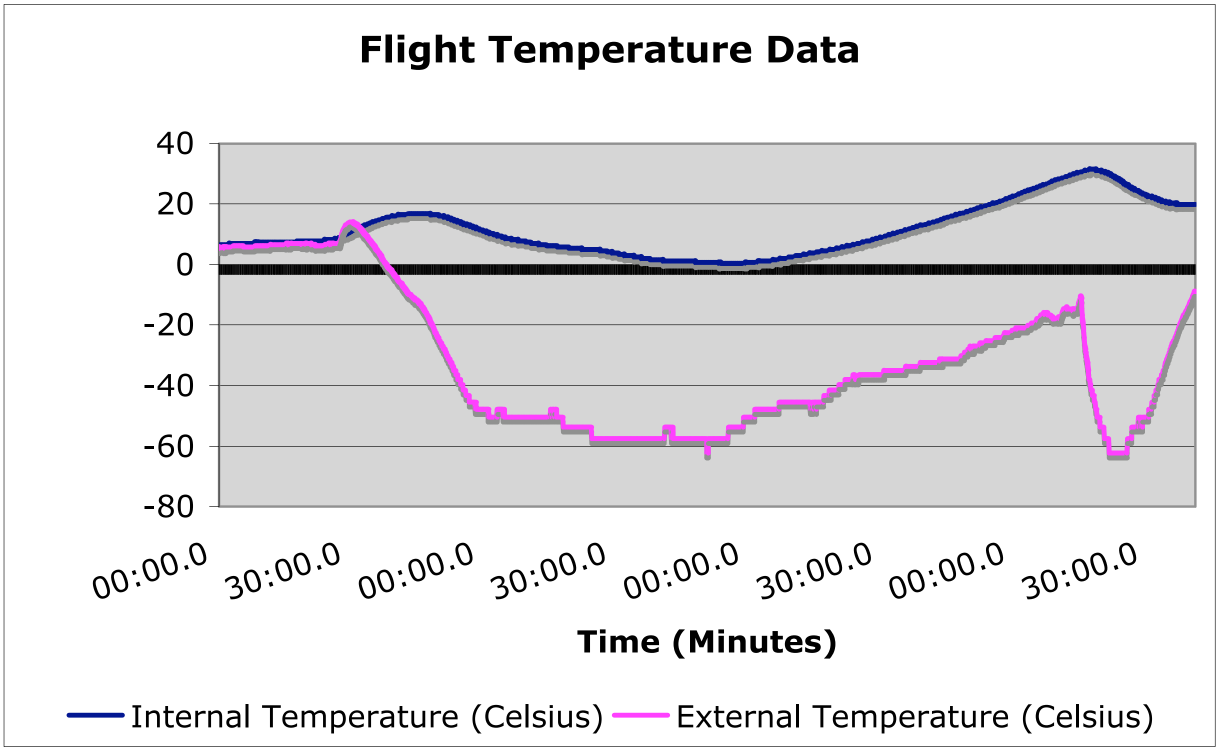
IV) Science Objectives

a. Sky brightness during the day determined as a function of altitude over intensity.
b. Sky brightness during the night determined by residuals in the atmosphere.
c. CCD cameras during the day shall test imaging of celestial bodies.
d. CCD cameras at night shall detect turbulence in the atmosphere
e. MEMS Accelerometers and Gyro used to test stability of a payload this size

Thermal Plan:

The internal temperature shall remain above 0°C for the duration of flight. An electrical heating system consisting of ceramic resistors connected by wire to a 9V power supply shall heat the satellite. The heating system will be thermostatically controlled. The dimensions of the structure that shall be heated are approximately 30 cm x 38 cm x 10 cm, which prompts the use of 6 – 9 resistors dispersed throughout the interior of the structure where they are needed most. Mylar and foam insulation shall be utilized to insulate the interior from the outside environment.

Figure 8:

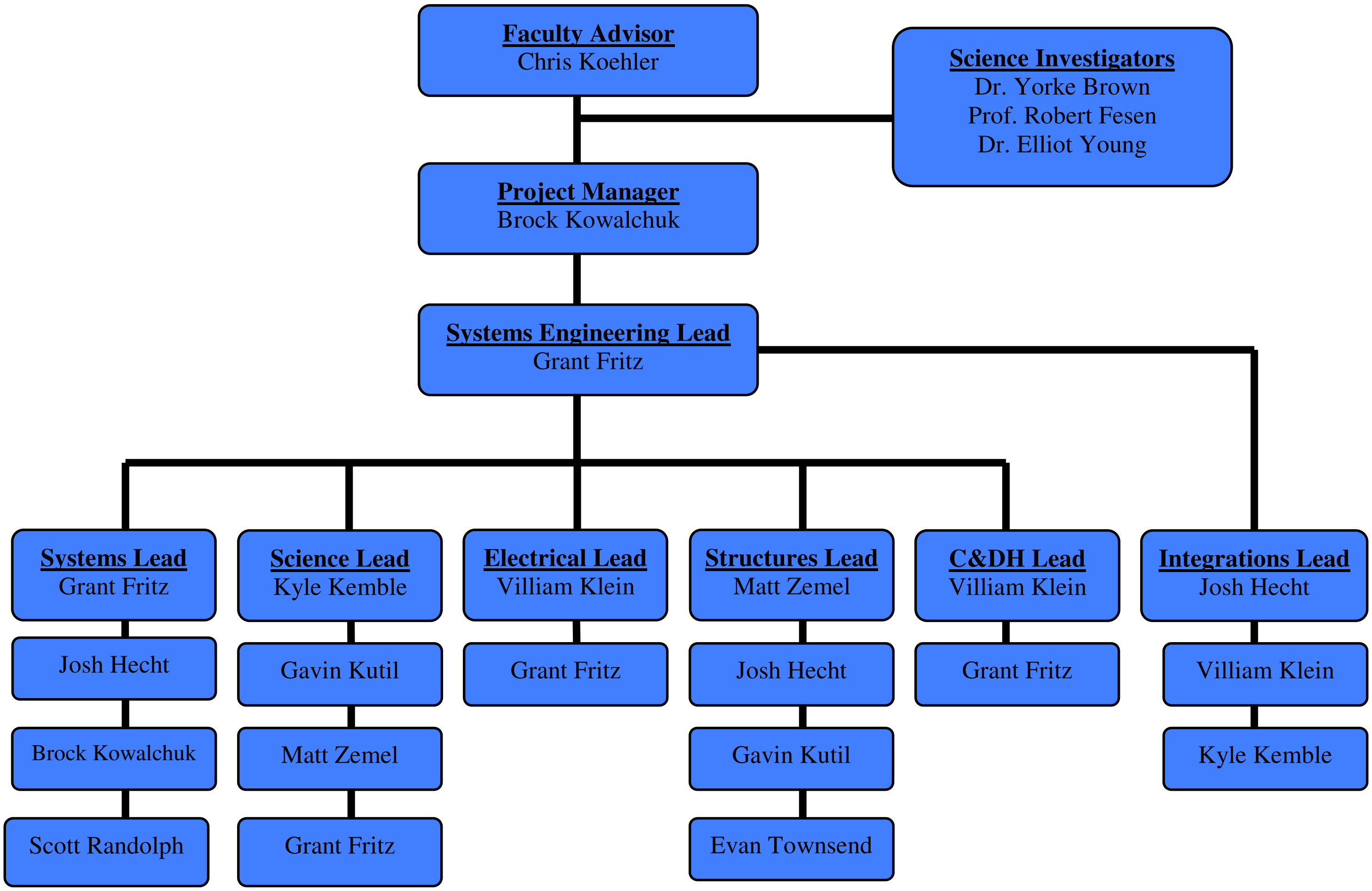


As mentioned earlier, this team has previous flight experience with high altitude balloon payloads. On previous missions team members maintained an internal temperature above freezing. Included above (Fig. 8) is the flight data from one BalloonSat whose lowest internal temperature during a four hour flight was 0.2 °C while the lowest external temperature recorded was -62.25°C. This flight occurred November 10, 2007 and reached an altitude of 29.7 km.

Although the HASP mission calls for a more complex heating system than what was on this previous mission, DIE HARD can build upon its prior experience to meet the higher demands for this longer duration flight.

Team Management and Structure

Team DIE HARD is the concept of students, being so; all written work, prototyping, and final construction will be completed by the student team members. Collaboration from faculty advisors and science investigators will be key, but at the grass roots this is a student run program.



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Villiam Klein	Villiam.Klein@Colorado.edu	(303) 827-6422

Team Effort Organized and Management:

The DIE HARD student team will meet with faculty advisors at a minimum of once a week. During these meetings all team members shall be present to discuss the project at all levels. Meetings with science investigators will occur bi-weekly to ensure that all systems and components are progressing at a satisfactory pace and that the project continues to meet key scientific goals.

The student Program Manager will hold weekly student team meeting, will maintain a monetary budget, and project schedule. Individual team leads will determine when and how often their teams will meet. Team leads will assign common working hours every week to perform research, construction, and testing.

Project Schedule:

Date	Description
12/17/07	Proposal Due
1/15/08	Results of Competition Announced
1/29/08	Concept Design Review
2/12/08	Critical Design Review
2/19/08	Finalize Hardware Orders / Make Orders
3/4/08	Begin Sub System Construction
3/18/08	Begin Sub System Testing
4/8/08	Begin Integration
4/12/08	Begin System Testing
4/29/08	*Flight Test of Photometer Software/Hardware with Colorado Space Grant
5/6/08	Perform Mission Simulation Operations Test
5/20/08	Finish Integration
5/27/08	Launch Readiness Review
6/3/08	Finish Final System test and Fight Simulation testing
6/22/08 – 6/28/08	Student Payload Integration at CSBF
8/21/08 – 8/29/08	HASP Flight Preparation
9/1/08	Target Launch Date
12/31/07	Final Science Report Due

** Flight test will be done aboard an Edge of Space Sciences 3000 gram, latex balloon, capable of reaching an altitude of 30 km. This will be done to ensure programming for photometer is correct in preparation for flight aboard HASP. This flight would test the instruments only and not the full HASP payload.*

Personnel at Integration and Launch:

At the Columbia Scientific Balloon Facility, DIE HARD will have their integrations lead, systems engineer lead, structures lead, and C&DH lead present. The Integrations Lead will supervise the operation, making sure each step follows the proper integration procedure. The System Engineering Lead will connect the necessary wires from HASP to our structure. Additionally, he will make sure all systems are up and running after integration. The Structures

Lead will properly attach the structure to HASP. The C&DH Lead will test communication equipment during integration.

Payload Interface Specifications:

Position	1 Large Student Payload
Approximate Weight	20 kilograms
Mounting Footprint	See Figures
Height	30 centimeters
Length	38 centimeters
Width	30 centimeters
Power	72W (2.5A at 29V)
Telemetry Rate	1200 bps
Uplink	4800 Baud

HASP Resources:

This payload will stay within the power requirements provided by HASP. The DIE HARD payload will use no more than 27-32V and 2.5 Amps, or 72W, during any point of flight. The flight estimated power consumption can be seen below.

The DIE HARD payload will only need the basic discrete commands of on and off. No other discrete commands will be necessary for this flight. We will require one of the serial channels that will send down packaged data from the temperature sensors, and photometers. This data will help us determine whether the experiments are functioning properly. The uplink will be used to change the photodiode sampling rate based on the data downlink

Component	Volts	Amps	Watts
PC 164 CCD Camera (x2)	12.0	240mA	2.88
Photodiodes (x4)	3.3	400uA	.00132
Temperature Probes (x4)	3.3	10mA	.033
Accelerometer	3.3	1-10mA	.033
Stepper Motor	5.0	100 mA	.50
Gyro	3.3	1-10mA	.033
Computer System	5.0	500mA	2.5
Heaters	9.0	800mA	7.2
Hard Drive	5.0	250mA	1.25
TOTALS	**<30 V**	**1.820 Amps**	**14.43 Watts**

Mass Budget:

Component	Mass (kg)
Hard Drive	1.000 kg
Computer System	5.000 kg
Accelerometer	.250 kg
PC 164 CCD Camera (x2)	.192 kg
Lenses	.150 kg
Temperature Probes (x5)	.100 kg
Photodiodes (x4)	.656 kg
Astronomical Filter Wheel	2.000 kg
Heater	.500 kg
Power Converters	1.000 kg
Structure (Aluminum 3003)	6.200 kg
Mass Allowance	2.952 kg
TOTAL	**20.000 kg**

Anticipated Procedure During HASP Integration:

To integrate the payload to the satellite will be relatively easy. Each of the four corner sides will have a metal hinge bolted onto the side. These hinges come out two inches and go down at a ninety-degree angle to a final height of two inches below the structure. These hinges will come down directly into the integration holes, creating four points of integrated stability. These rods will be attached to the mounting plate with nuts that will screw onto the bottom of the mounting plate in order to create a secure integration of the satellite to the payload.

Anticipated Procedures for Flight Operations

Time	Satellite Subsystem	Function
T- 02:00:00	System Checkout	Computer: Turn On Hard Drive: Turn On Accelerometer: Begin Recording Photometers: Begin Recording CCD Cameras: Begin Recording
T 00:00:00	Satellite	Launch
T+ 10:00:00	Photometers	Filter wheel will begin rotation on an automated timer.
T+ 10:00:00	Communication	Packets of data will be sent down every fifteen minutes to be analyzed by mission control.
TBD	Photometer/Communication	If data is flawed, DIEHARD will send command to change recording time interval of photometer.
TBD	Photometer/Communication	If data remains flawed, DIEHARD will send command to change the filter wheel to place the "blank" filter in front of the photometers for duration of flight.
T+ ~22:00:00	Satellite	Satellite touchdown and recovery

The payload DIE HARD will be fully automated during the flight. Each of the systems will be turned on and operated by discreet commands, leaving the operation team with limited responsibilities during flight. Only the photometer data sent from the satellite will be checked for reasonableness during the flight. If the data appears erroneous, the team will have a chance to use an uplink command to change one of two variables on the photometer. The first configuration variable is to change the recording duration of the photometer. A photometer is able to record how many charges are accumulated during a timeframe, chosen by the team. If the timeframe appears too large, with too many charges for the photometer to record, the data will be erroneous, and DIE HARD will have the option to shorten the recorded timeframe, allowing for the data to be within the photometer's parameters. Conversely the team can lengthen this sampling interval. The other photometer command will force the system to use the "blank" filter slot with the other five filters cycling in front of the photometers. This blank slot has no filter in it, and will allow for more light to be recorded by the photometer. The last command will allow this blank slot to go in front of the photometers. This will hopefully allow for some type of data to be found if the photometers are failing to send back any type of light data, for the photometer could hopefully allow for the more intense light to be recorded if the filters were blocking all the light, giving team DIE HARD some type of data. However, these two options only come into play if the data appears erroneous during the flight. Otherwise, the satellite will operate itself, leaving the operations team to observe and wait until the payload returns.

Preliminary Drawings

Drawing 1: An isometric drawing of the DIE HARD structure. Included are all of the internal components of the structure.

Drawing 2: Represents bottom section of structure with all its components secured inside.

Drawing 3: Represents top level of structure with the four photometers and one astronomical filter wheel. The photometers will fixed to the roof at angles of 45° relative to the platform.

Drawing 4: This is the structure completely assembled. The photometers can be seen protruding from the top section of the structure while the CCD cameras can be seen looking through the corners. The reason for placing the CCD cameras inside the structure is that they require an ambient temperature of no less than -10°C to function properly while the photometers work best with an ambient temperature of -20°C.
Drawing corresponds to Figure 2 of HASP – Student Payload Interface Manual.

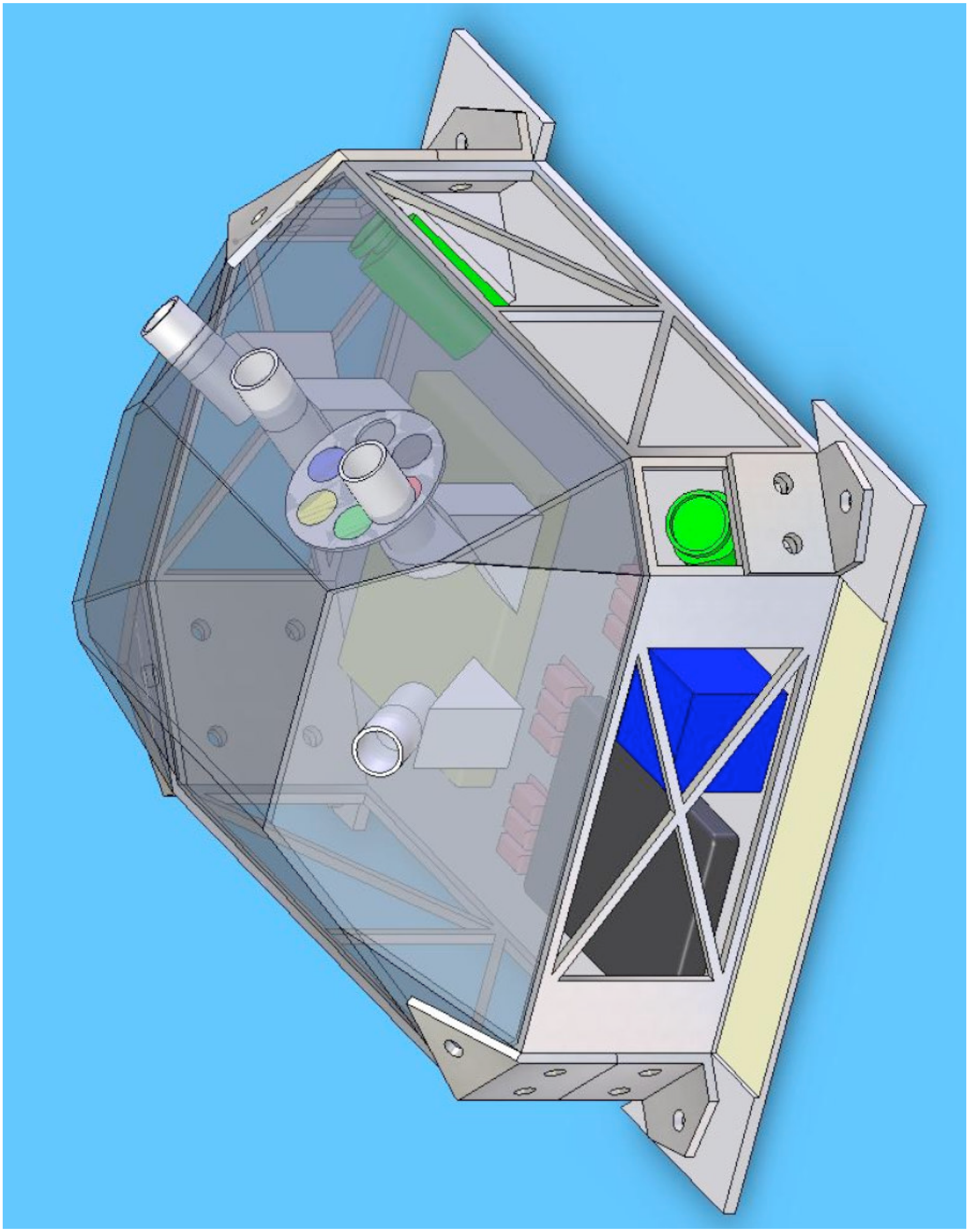
Drawing 5: This is the mounting plate assembly. The payload will be secured to the HASP by means of the included mounting plate. No changes to the mounting plate are anticipated at this point. The payload will be connected with heavy duty bolts on the four corners that will hold the payload secure while potentially encountering 5 g horizontal and 10 g vertical shock.

The exoskeleton of the bottom section of the structure is included above. This will house all components that are sensitive to the cold temperatures. The interior shall be covered with Mylar and foam insulation to aid in attempting to maintain an internal temperature above 0°C. The entire structure is made from Aluminum for strength and mass purposes.
Drawing corresponds to Figure 2 of HASP – Student Payload Interface Manual.

Drawing 6: This is the top portion of the structure. This will fit directly on top of the bottom section. DIE HARD will place the four photometers at 45° angles relative to the structure. This is the optimal viewing angle to record accurate electromagnetic radiation readings.

Drawing 7: This is the astronomical filter wheel to be fitted to one of the four photometers. The wheel will consist of five different wavelength filters and an empty slot for broadband viewing. The empty slot will be utilized during ascent and descent. Upon reaching altitude and entering nocturnal operations, the astronomical filter wheel will begin to rotate at set time intervals to record different wavelengths of light.

Drawing 1:



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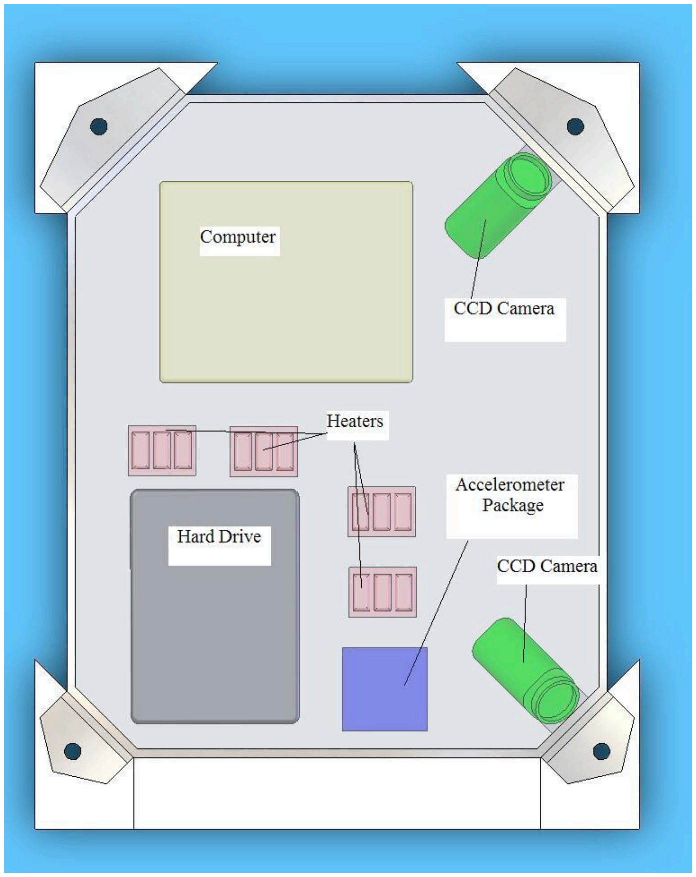

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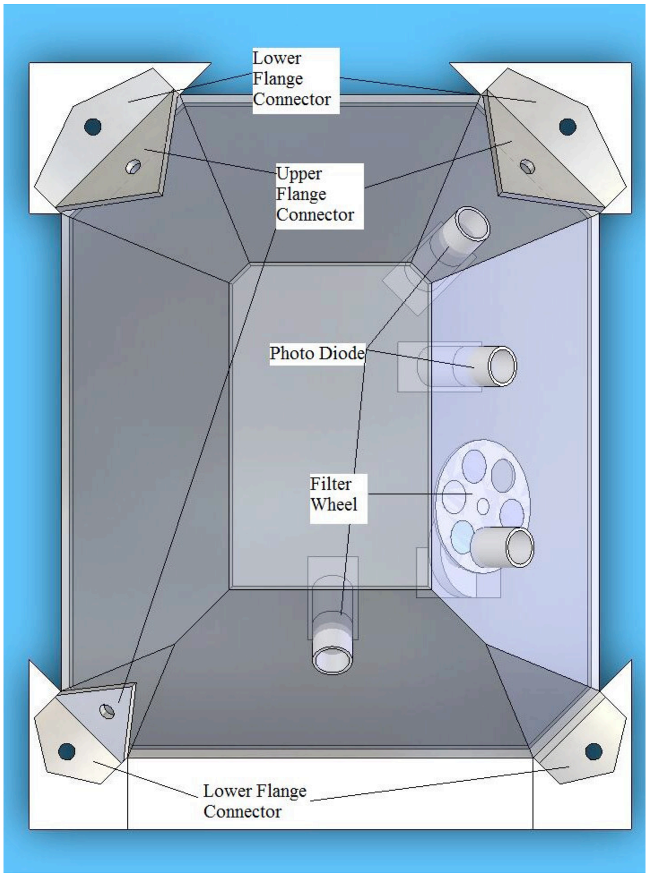

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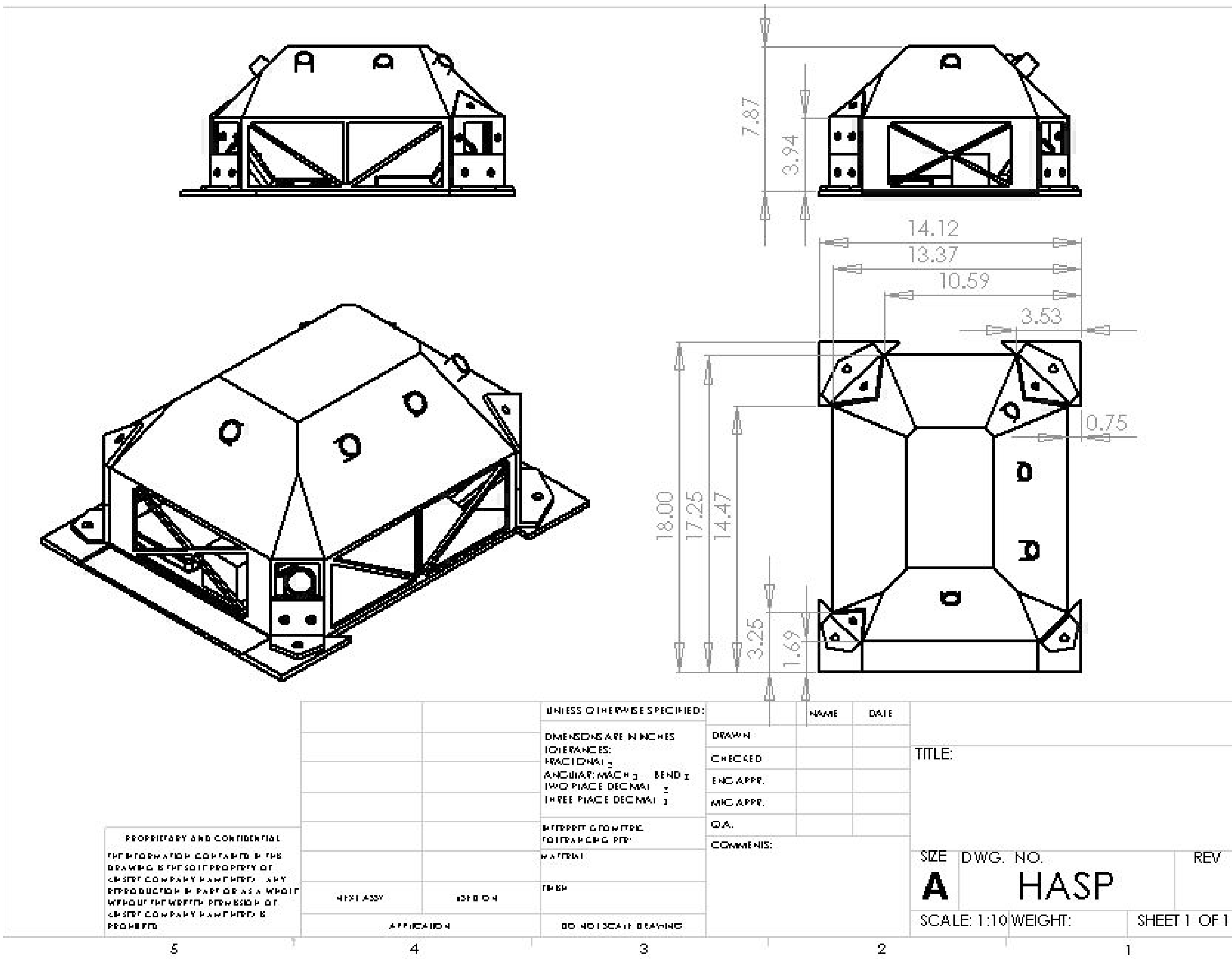
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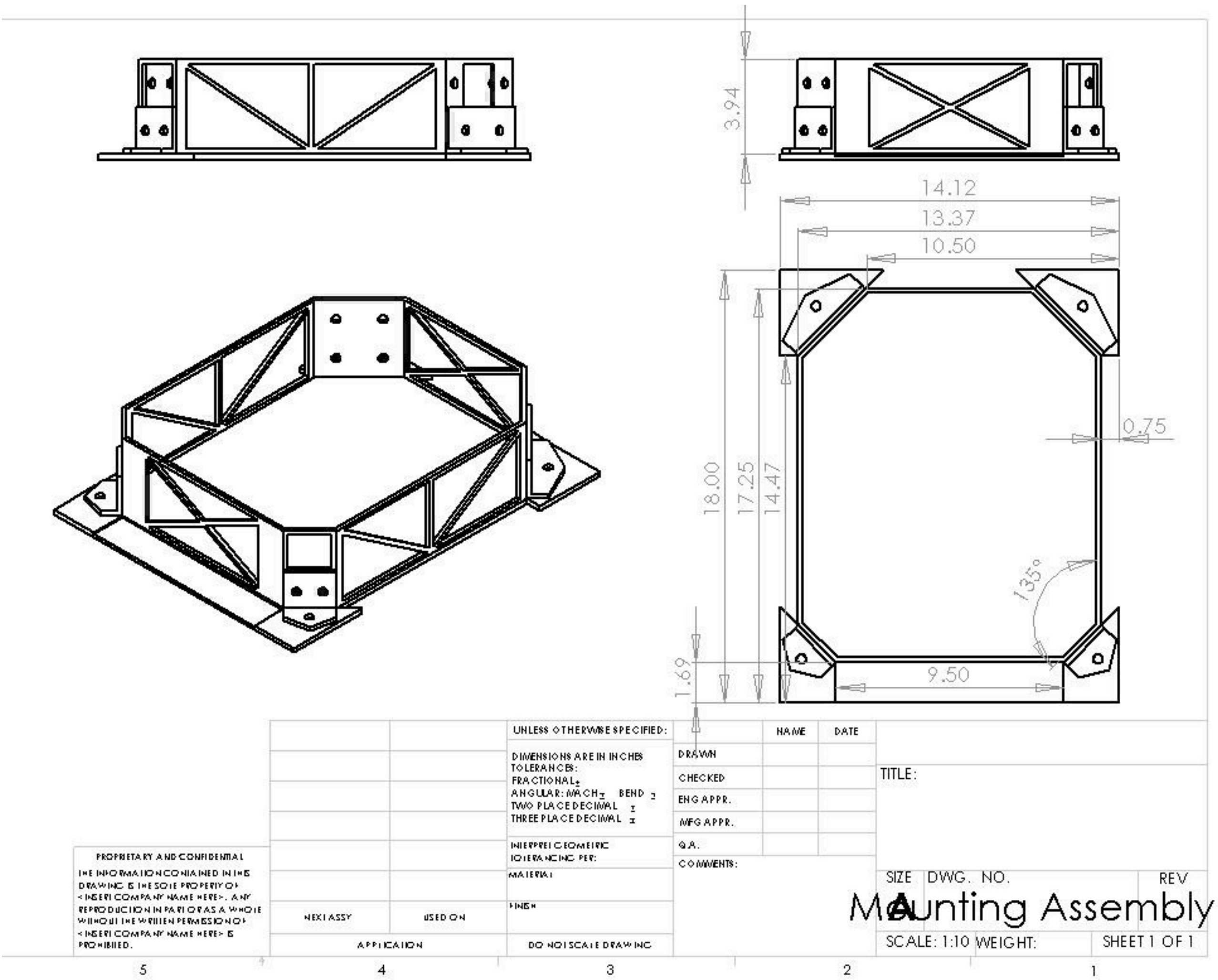
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135°
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THREE PLACE DECIMAL ±
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PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
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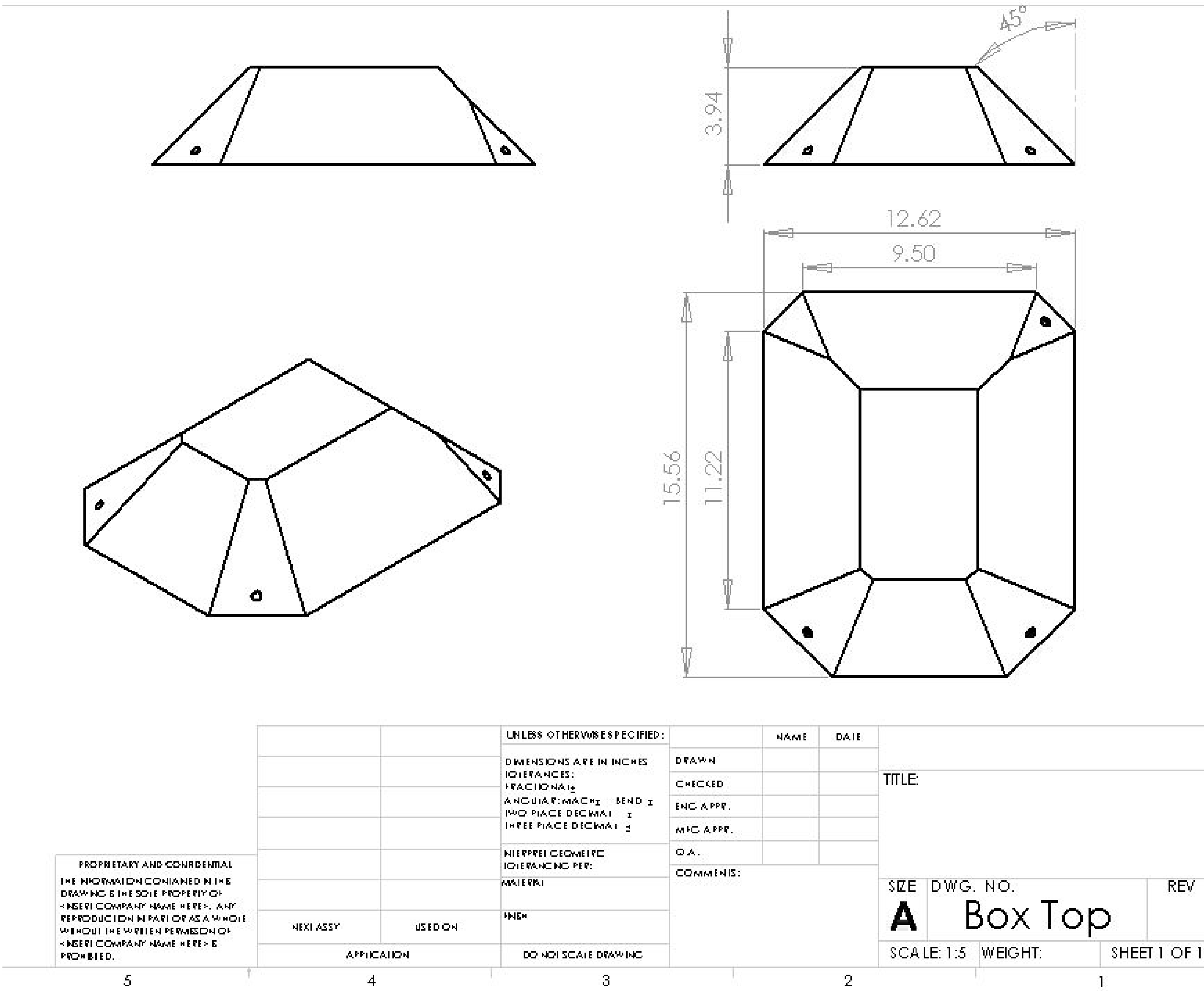
Drawing 6: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3.94
12.62
9.50
15.56
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PROPRIETARY AND CONFIDENTIAL
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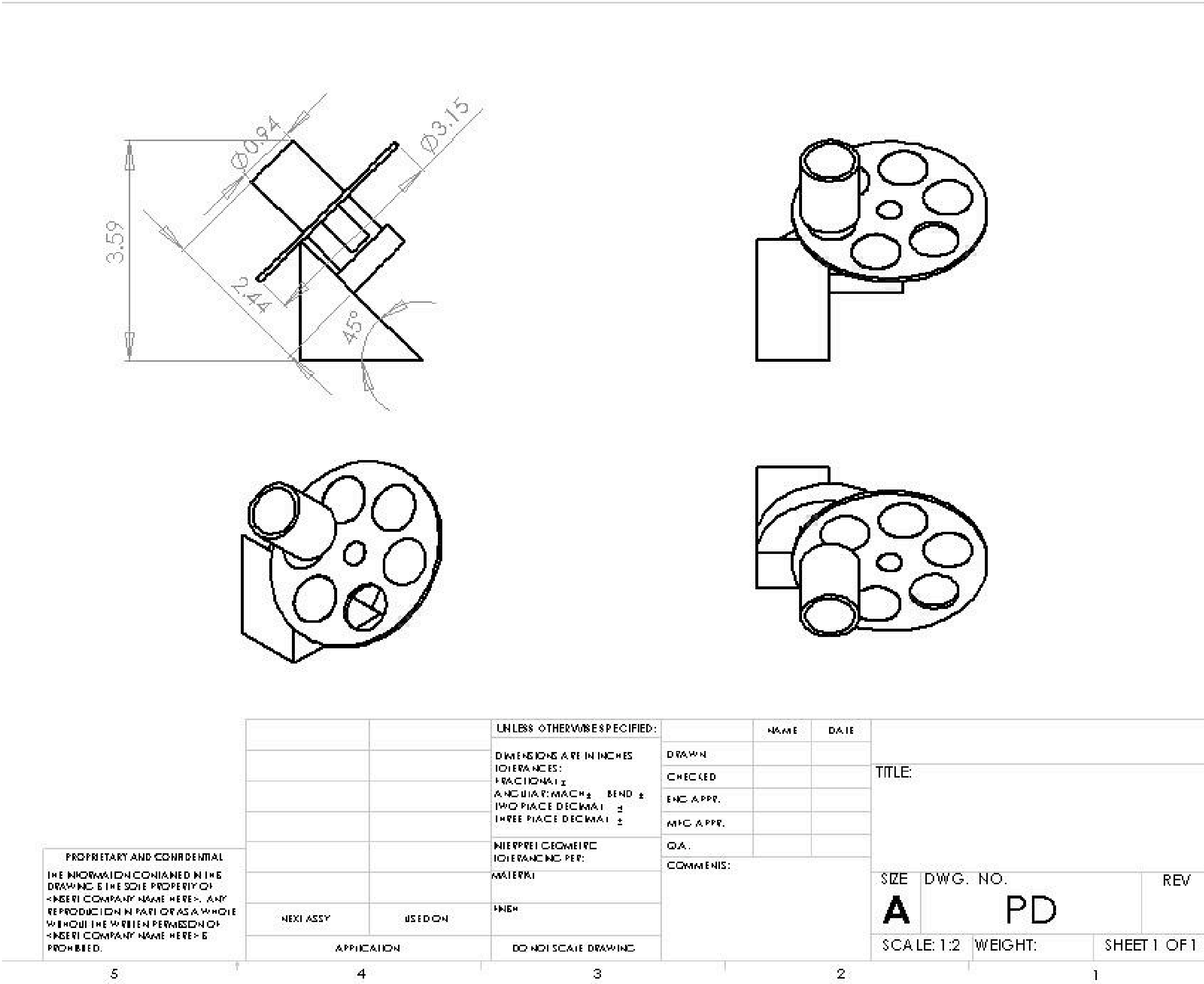
Drawing 7:


Ø0.94
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3.59
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DIMENSIONS ARE IN INCHES
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SHEET 1 OF 1
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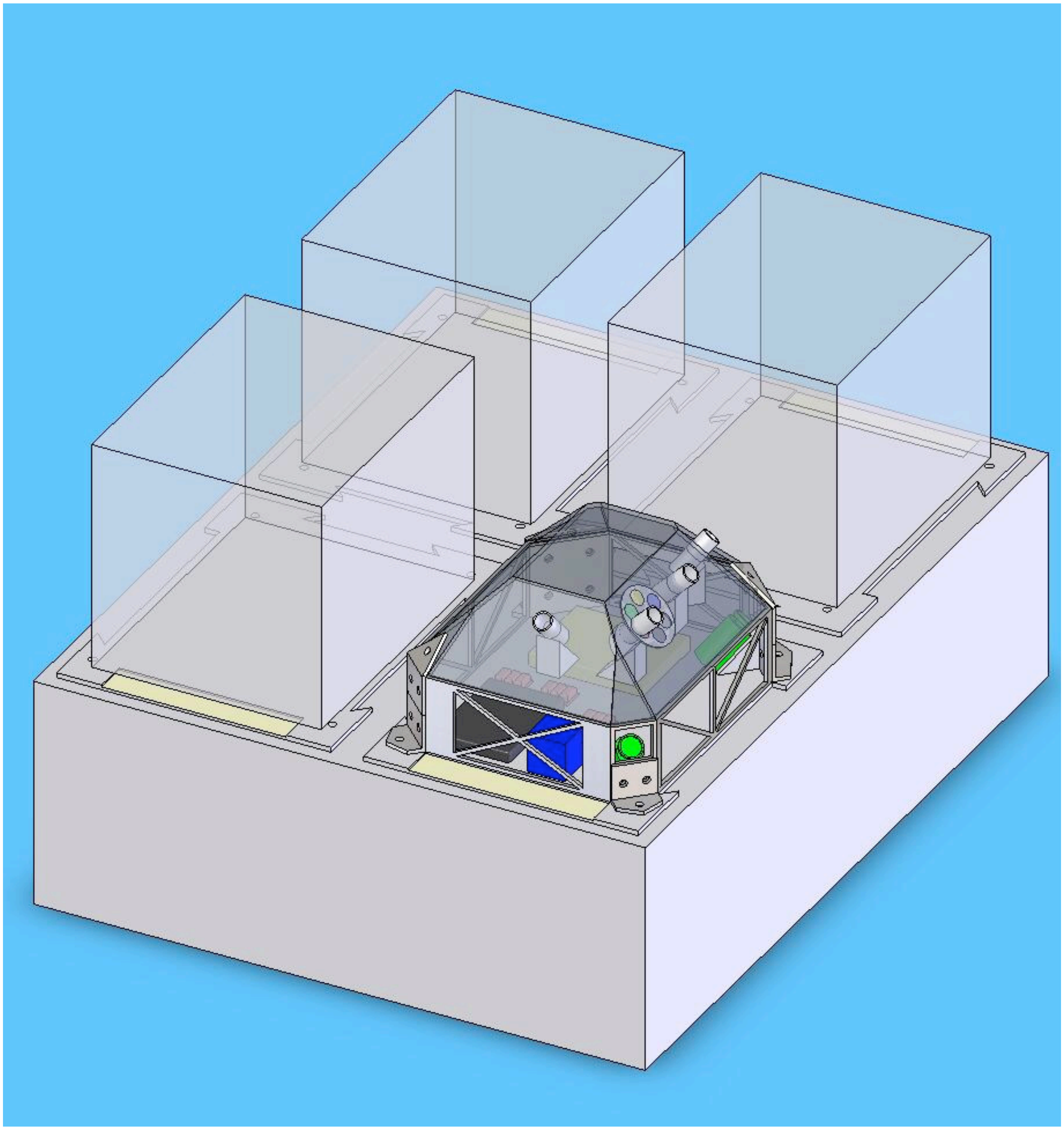
Desired Payload Location and Orientation:

The payload built and operated by the University of Colorado – Boulder can be fitted onto any one of the large payload positions onboard HASP. The experiments onboard only require that two of the four faces have an unobstructed view of the sky.



Conclusions

Using the HASP platform, the DIEHARD team hopes to image and record stars during the night and day, as well as measuring the sky brightness. We hope to advance the research of Professor Robert Fesen and Dr. Yorke Brown and to prove that a relatively inexpensive platform can image stars from a stable high altitude platform, during the day and night. The HASP platform is perfectly suited to accomplish these goals because of the extremely high altitudes, the long duration flight, the day and night observations and the invaluable resources it provides which allows the DIEHARD team to focus on our scientific objectives. In conclusion we believe that the HASP platform is a perfect opportunity to accomplish our scientific goals.

Dartmouth College HANOVER • NEW HAMPSHIRE • 03755
Department of Physics and Astronomy

14 December 2007

Christopher Koehler, Director
Colorado Space Grant Consortium
University of Colorado at Boulder
Boulder, CO

Dear Chris:

I am excited about your proposed balloon payload project for HASP. Taking measurements of the sky brightness during both the day and night would really help give us concrete data to support the use of high-altitude LTA platforms for astronomical observations. There is a growing realization that placing a 1 meter class telescope at 65 to 85 kft would be effectively a sort of "Hubble-lite" observatory yielding superb wide-field optical imaging (< 0.15 arcsecond), something not possible using adaptive optics from the ground. Thus the value of your student led project goes may serve as a stepping stone to cutting-edge astrophysical science.

Best wishes,

-Robert A. Fesen
Professor

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DIVISION 15 - SPACE SCIENCE AND ENGINEERING • DEPARTMENT OF SPACE STUDIES

December 16, 2007

Christopher J. Koehler
Director, Colorado Space Grant College
University of Colorado at Boulder
520 UCB
Boulder, CO 80309-0520

Dear Chris,

I understand that I am named as a collaborator in your proposal to the High Altitude Student Payload (HASP) balloon opportunity. I agree to uphold my commitments as outlined in your proposal. Good luck!

Sincerely,

Eliot F. Young

SAN ANTONIO, TEXAS (210) 684-5111 • HOUSTON, TEXAS (713) 977-1377 • WASHINGTON, DC (301) 881-0226

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ETNA, NH 03750
(603)643-0618
yjb@yorkebrown.com
www.yorkebrown.com

17 December 2007

Prof. Christopher Koehler
Director, Colorado Space Grant Consortium
University of Colorado at Boulder
520 UCB
Boulder, CO 80309

Dear Professor Koehler:

I am very pleased that you and your students have agreed to include me as a consultant on your proposal to the High Altitude Student Payload program for 2008. I very much enjoyed working with your very resourceful students on their recent Gateway to Space projects, and look forward to supporting their efforts on HASP. The sky brightness measurements that you propose will be very helpful in evaluating the scientific potential of astronomical observations made from the stratospheric platforms.

Sincerely,

Yorke Brown

Yorke Brown