HASP Student Payload Application for 2007

Payload Title: UAH Thermal Imaging Balloon Experiment (TIBE)

Payload Class: (circle one) **Large**	Institution: University of Alabama in Huntsville	Submit Date: 12/15/06

Project Abstract

The purpose of the University of Alabama in Huntsville (UAH) HASP infrared project is to gain a better understanding of the thermal effects that a high-altitude balloon experiences during flight. These thermal effects directly effect the flight duration, altitude changes and ballast requirements. Successful acquisition of the thermal data could help improve future balloon endeavors and possibly span other applications. Our project will build upon the past experiments and introduce new techniques to acquire more meaningful and accurate data. Our previous infrared experiment utilized three infrared temperature sensors, which was downsized from our original from our original plan to have one thermal imaging camera. For this experiment the main focus of the study will center around the thermal imaging camera and for this reason, it is proposed that the project will require a large payload footprint. The students involved with the project will manage mechanical, thermal, and instrument components for the duration of the project and throughout the data analysis. Previous balloon testing experience coupled with the information gathered from previous models, will greatly add to the understanding of high altitude balloon dynamics towards achieving longer duration balloon flights. This project is supported by the Alabama Space Grant Consortium.

Team Name: TIBE	Team or Project Website: Will be connected to www.eng.uah.edu/~richaga/BalloonSat

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Payload Description
UAH / HASP Infrared Thermal Instrument

We propose a student designed and built thermal imaging system for measuring the temperature of the high-altitude balloon. All components will be designed and fabricated by University of Alabama in Huntsville (UAH) students, with the exception of the off the shelf thermal imaging camera. Our project is supported by the Alabama Space Grant Consortium and will be supervised by two faculty advisors with possible involvement from a NASA mentor with a background in high-altitude balloon instrumentation.

One of the main problems to achieving ultra-long duration balloon flights is the lack of understanding of balloon flight dynamics based on the thermal performance of zero-pressure balloons during flight. Our student group is the first to attempt temperature measurements of a high-altitude balloon. Attempts at thermal modeling have been performed and our goal is to determine the validity of these models (Cathey, AIAA 96-0695). The motivation for such a study is to better understand and as a result improve flight dynamics allowing longer duration balloon flights. The equipment we propose to use has been proven to perform in the harsh environment of these altitudes, while in some configurations; part of the project will be to verify this.

The instrument proposed is designed for a single payload configuration. The thermal imaging camera is a continuation of last years design and will take the place of three infrared temperature sensors that are heavily dependent on material emissivity. The possibility of including these sensors with the camera is wholly dependent on space and time requirements. The camera will be positioned to the outer most portion of the payload placing the viewing area on the outer edge of the main HASP gondola. We have included several configuration drawings with this proposal with regards to placement on the HASP gondola. The instrument will be fully automated and will not require uplink commands.

As outlined in our management plan, three student leads will manage the mechanical, thermal and systems components of our project. These students are part of our multidisciplinary UAH Space Hardware Club which consists of science, engineering and business/management students. The timeline also includes a post analysis plan for the data received from the flight.

Why, What and How

As mentioned above, the goal of this project is to measure the balloon surface temperature. This is important since the flight dynamics and duration depend on the thermal performance of the balloon including altitude changes and ballast requirements. Understanding the balloon thermal performance will allow improvements in balloon flight configurations and possibly provide other avenues of thermal research developments.

A thermal imaging camera has a focal plane composed of an array of infrared detectors. Some cameras have at least one mega pixel array of IR detectors. The output (thermal image) then consists of a picture of the temperature distribution as seen by the camera. The camera software is able to remotely measure the temperature corresponding to each pixel location of the image.

Furthermore, the sensitivity of the modern thermal imager is approximately in the milli-Kelvin range. Even slight gradients in the temperature can be determined. Modern software can automatically provide an image of the thermal gradients as well as the temperature field.

Our goal is to measure temperature gradients from the images collected using the thermal imaging camera. Due to the nature of this data acquisition, and the size of the equipment, the payload requires a large footprint. With imaging optics, thermal differences can be easily distinguished between the balloon and its environment. The thermal properties of the balloon material are not well known so a thermal imaging system will remedy the difficult task of narrowing down emissivity settings for the three infrared sensors flown on HASP 06. The system will be fully self contained and will house a processing unit for data transfer and thermal and power controls. All of our equipment has flown on previous flights, save for the thermal imaging camera, and are proven to work at these altitudes. Our previous flights on NASA funded Deep Space Test Bed (DSTB) and with HASP in 2006 support the possible detection of these measurements. Thermal imaging will provide grounds for comparison with our previous data. These comparisons will provide the necessary improvements needed for this particular study. In the DSTB flight, the IR sensors' field of view included the balloon and parachute which have different thermal properties. Last year with HASP this was remedied by moving the sensors farther away from the gondola and angling the sensors away from the balloon rigging. Without proper optics, however it is difficult to correlate the previous sensors' data with the actual temperature readings. We have also studied the balloon material considerably more since our previous flight and have a better understanding of the IR sensitivity setting and the elusiveness it provides for our previous equipment. NASA/Wallops have performed initial testing on the balloon material and have provided this information to us. This did not include thermal imaging however, since this study was performed over ten years ago. The data collected from this instrument will require analysis. Our student teams will be responsible for this analysis as is laid out in the management plan.

This proposal includes the following components; the team structure and management section outlines our management plan, student team members and team responsibilities. This section includes Figure 1, a flow chart showing our management structure. The payload specifications section includes Table 1 showing our basic requirements. Also included in this section are descriptions of our thermal control, power management and structural plans. Figure 2 is an illustration of our integration configuration. Figures 3 and 4 are technical drawings of our sensors and modular components.

Team Structure and Management

The UAH student team will consist of an overall team lead who will act as the integrations lead (OL), a mechanical systems lead (ML), a thermal systems lead (TL), and an instrument lead (IL). Each lead will be responsible for one or more student team support members (Figure 1). The students are recruited from the UAH Space Hardware Club and have prior experiences dealing with high altitude ballooning. Bob Hawkins, the club president, will use this experiment as a vehicle for research concerning his Master's Thesis. There will be two UAH faculty advisors and one NASA/MSFC advisor available for student consulting and guidance throughout the project. Advisor and student name/contact information is given following this section.

The OL primary responsibility is to oversee the ML, TL, and IL through engineering support and logistics management. These duties include integration management between each of the three divisions and integration of the instrument onto HASP. This person will effectively be the go-between to assure compatibility between groups and compatibility with HASP. The OL will also oversee the 24-hour mock testing at UAH of the final integrated instrument in its HASP before integration in LSU.

The primary responsibilities of the ML, TL, IL, and support teams are to design, purchase, fabricate, and test the necessary components to complete their associated goals;

> The goals of the ***Mechanical Systems Team*** include designing a proper mounting bracket to the HASP mounting plate(s), fabrication of appropriate detector housings and load analysis for the NSBF structural requirements. Depending on the housing design and HASP space availability, different instrument configurations will be explored. This group will aid in the final testing to evaluate the performance of their proposed design.
>
> Goals for the ***Thermal Systems Team*** include designing a thermal system appropriate for the chosen detector and electronic packages. This team will determine possible thermostat requirements for autonomous temperature control and perform temperature and pressure tests. Facilities at UAH for testing include a cold box (using liquid Nitrogen) and a thermal vacuum chamber.
>
> The ***Instrument Systems Team*** will be responsible for choosing appropriate instrumentation, discerning the proper power allowance for the imager, sorting out the telemetry and data storage needs, correlating the imager into an autonomous working system with proper wiring for the chosen configuration. Tests to determine detector operation in an ambient environment will be done. This team will also be in charge of post analysis on data from the flight. However, post analysis will not be restricted to team members from this team only.

The HASP integration in July will require at least two students and one advisor. Ideally we would like for the OL, ML, and IL students and at least one advisor to travel to LSU for integration. Flight operations in Fort Sumner, NM will require at least one student and one advisor for a final instrument check.

Student Team Members
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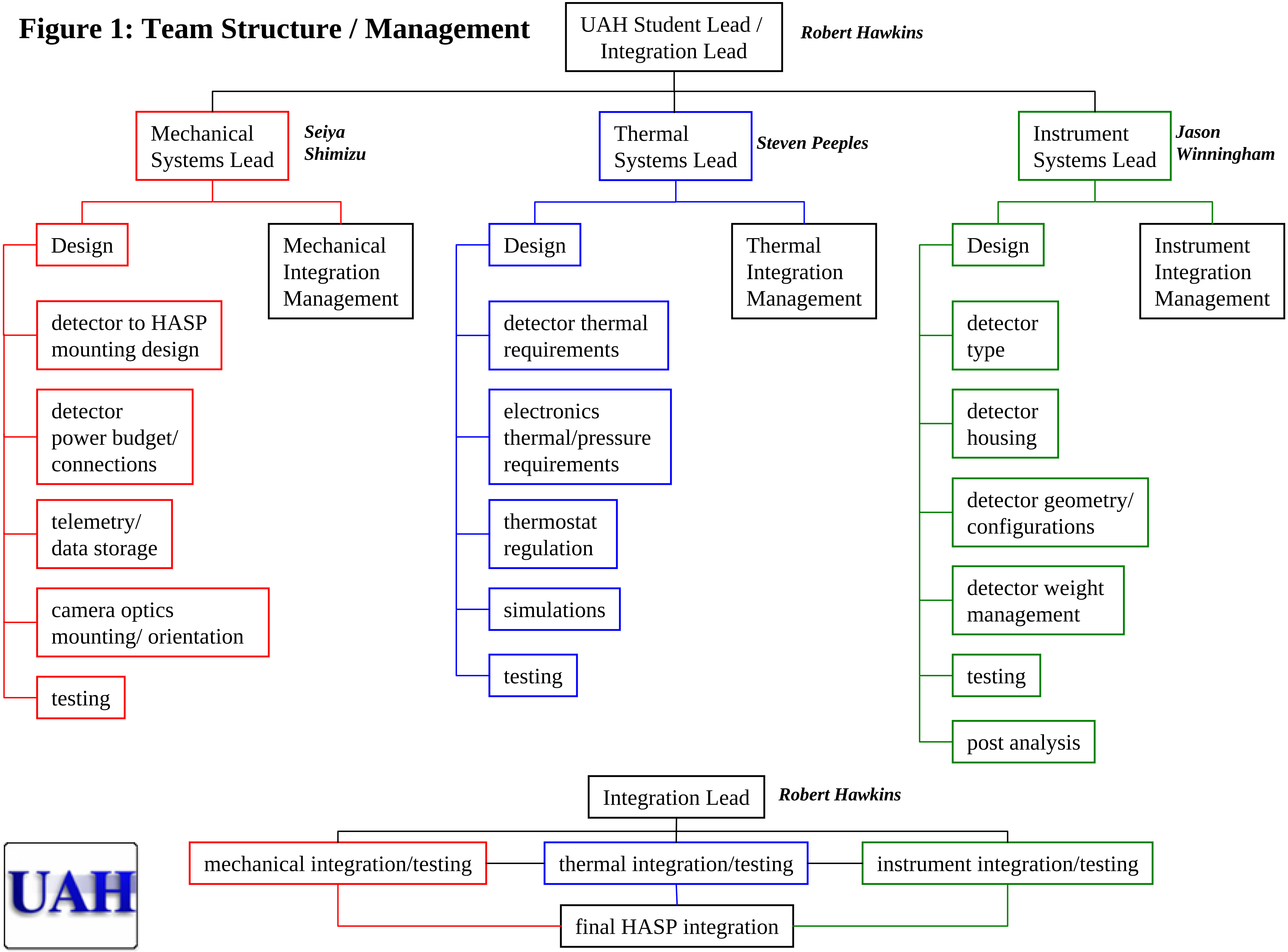
Figure 1: Team Structure / Management



Payload Specifications

Values in Table 2 are given for the complete configuration of an individual module.

Table 2: Instrument Specifications

Parameter	Single Module
Weight	10 kg
Mounting Footprint	see figure
Height	30 cm
Power	72 W (2.5A)
Telemetry Rate	4800 bps
Uplink	None

Thermal Control

The instruments to be flown will require coarse control of temperature to insure that they are within their operating range. We propose to achieve this through a combination of insulation and onboard heaters. In our previous balloon flight experience on DSTB and HASP 06, the heaters were turned on at launch and the package was well insulated. The temperature history of both experiments showed that the temperature stayed within acceptable limits throughout the flight. There are some significant changes in the proposed payload that will require some changes in the thermal management approach. The increased size of the payload and mass will require more insulation and thermal control due to the thermal sensitivity of the imager. These differences will require that we carefully size the heater for the extremes in temperature experienced during assent and decent, and that we be able to control the heaters automatically to avoid both a too low and a too high temperature. We were able to avoid the use of heater controls in the DSTB experiments because of the thick insulation and the high thermal mass allowed the use of rather modest heaters that could be left “on” for the duration of the experiment. We utilized mechanical temperature controllers for HASP 06 that worked exceptionably well.

Power and Grounding

We plan to use dc-to-dc converters to power all instruments at voltages specified from the supplied 28V. The solid-state converters are readily available and provide safe and efficient power management at small converter mass and size. The heaters (simple resistive heaters) are the potentially largest power requirements for the system and the size can be controlled by careful thermal design.

The importance of a safe grounding plan is recognized for the safety of personnel and the minimum interference (EMI) to all experiments flying on HASP. We were able to avoid ground loop problems in the DSTB and the HASP 06 experiments with the use of the dc-to-dc converters and careful attention to grounding straps and shielded cables for communication between the controller and instruments. Further attention is needed however in that our DSTB data showed periods of EMI which could likely be eliminated by additional shielding and testing under strong EMI conditions, though HASP 06 showed minimal problems.

Structure

Our modules will be designed to attach flush with the mounting plate and with appropriate constraints to ensure the vertical and horizontal shock parameters. Our instruments will be designed and tested for these parameters. An additional level of security is given in that the instruments are fully contained within the module.

Figure 2: UAH IR Experiment Configuration

Our instruments will be housed within one of the larger payload slots. Any of the four available positions are capable of fulfilling our requirements. Shown below is just one option for positioning. Our team is open to other options if they fit the needs of the HASP gondola.

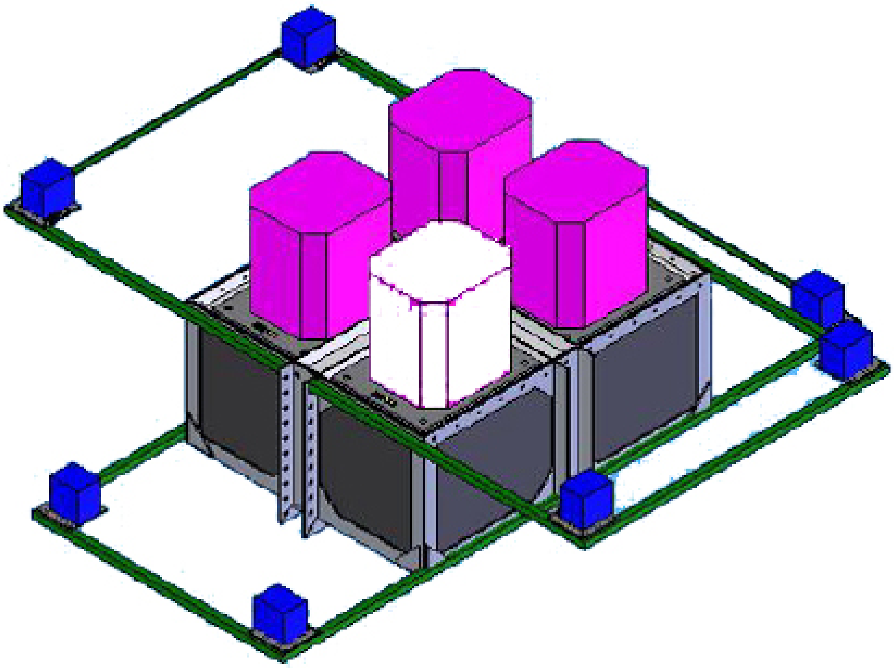
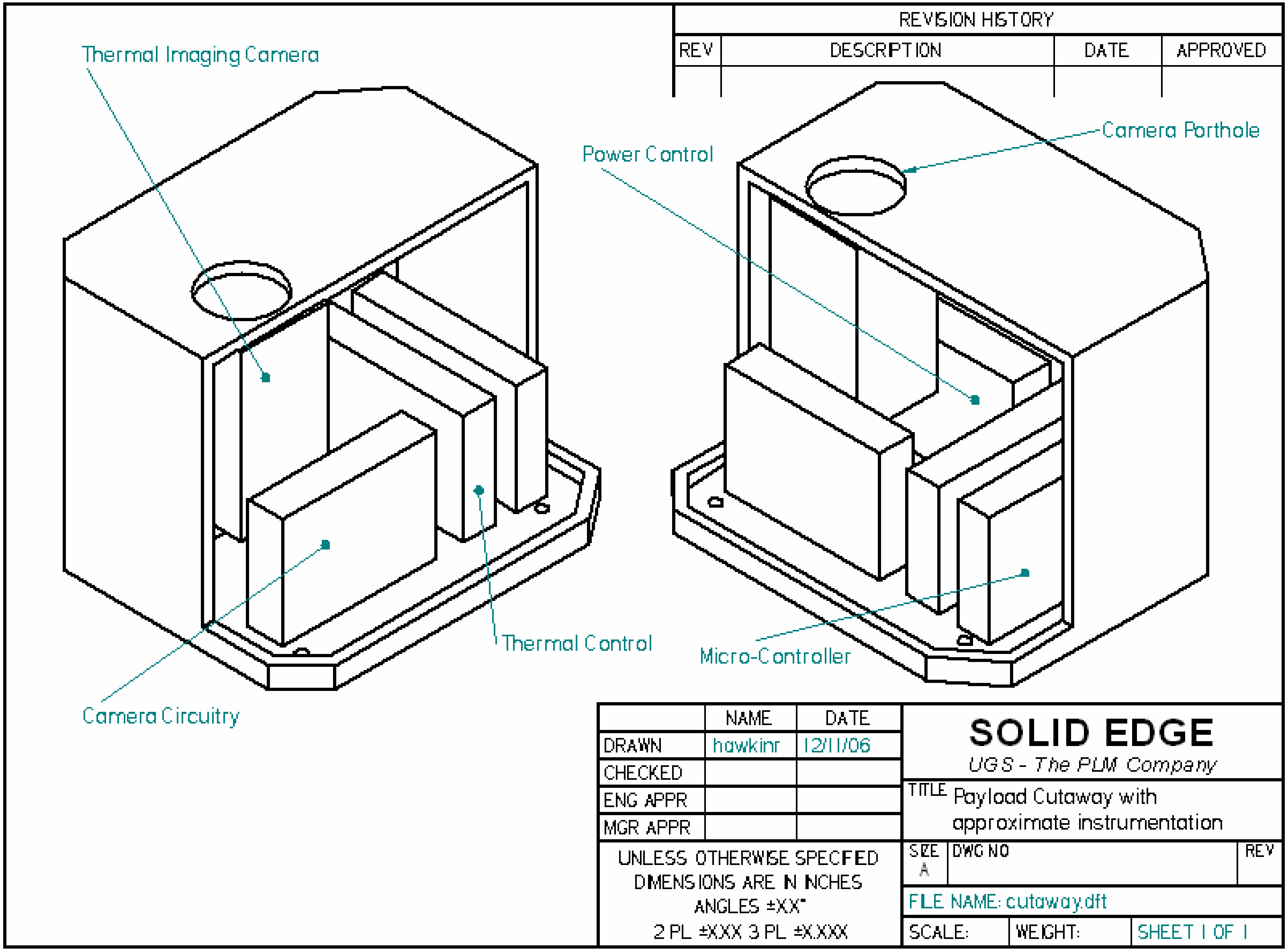


Figure 3: Individual IR sensor housing and components



REVISION HISTORY

REV	DESCRIPTION	DATE	APPROVED

	NAME	DATE
DRAWN	hawkinr	12/11/06
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE Payload Cutaway with
approximate instrumentation

SIZE	DWG NO	REV
A		

FILE NAME: cutaway.dft

SCALE: WEIGHT: SHEET 1 OF 1

Figure 4: External IR sensor housing and footprint