HASP Student Payload Application for 2009

Payload Title: University of Maryland Advanced Balloon Communications Experiment 2 (UMD-ABC-2)		
Payload Class: (circle one) Small Large	Institution: University of Maryland, College Park	Submit Date: 1/03/09

Project Abstract

Radio communications are a critical component of the dozens of sounding balloon flights launched by universities and Space Grants each year. In general, these communications are limited to tracking and a few commands such as triggering cutdowns, but, as HASP has continually demonstrated, the ability to downlink science data and upload commands to the experiments greatly adds to the science and engagement of students. The focus of this experiment is to bring some form of the HASP capabilities aforementioned to sounding balloon flights.

This is a continuation of the UMD/ABC experiment flown last year on the 2008 HASP flight. That flight successfully tested many of the hardware components, subsystems and techniques that will be used in this year's experiment. The focus of this second flight is to improve on and expand the experiment based on last year's results, and to move from testing system capability to optimizing system functionality.

The UMD/ABC-2 experiment will further refine the original experiment and collect data on the performance of ISM communication links for university balloon flights and the performance of COTS GPS receivers on extended flights. Additionally, this expanded experiment will test payload to payload communications and the performance of the computer flown last year for intensive operations such as digital image capture and live downlink.

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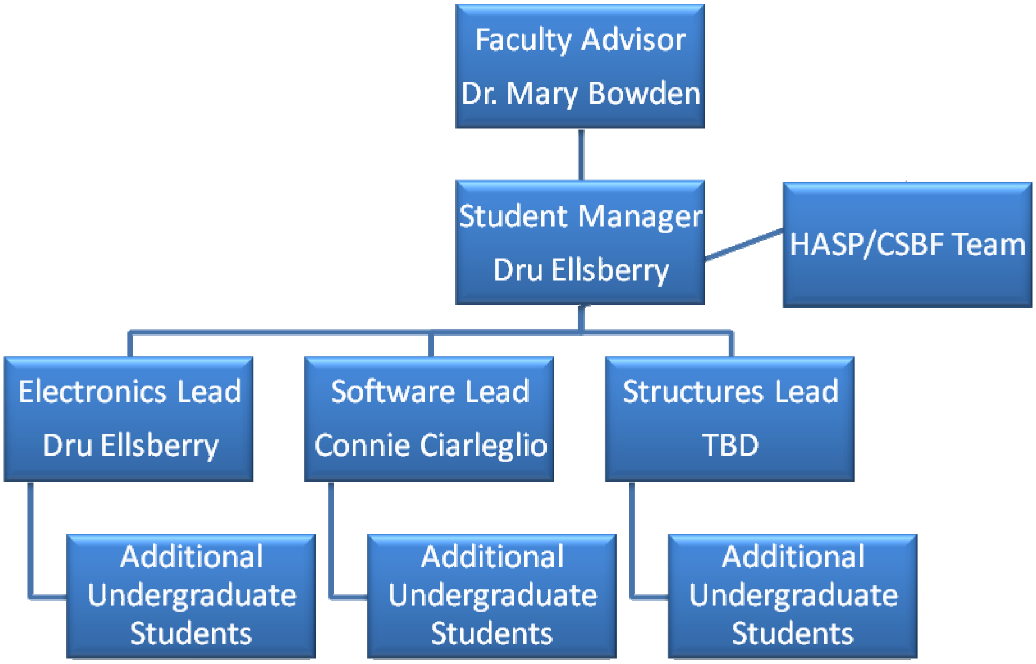

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Overview

The objective of this experiment is to test a balloon communications and control system that functions in a similar capacity to the HASP gondola and mini-SIP, but with a weight and cost much more in line with the sounding balloon flights carried out by universities and Space Grants. The system is based around a short range 2.4 GHz link between payloads* and a long range 900 MHz (ISM) link from the balloon to the ground.

The proposed payload is the second phase of the original UMD-ABC payload flown on the HASP 2008 flight. It is intended to take the development phase testing done on the last flight and "beta test" a fully functional design. Flying on HASP will provide a stable testing environment and provide roughly 10 times the flight time of a traditional sounding balloon flight. This flight time, especially at altitude, will help test the system and work out issues that otherwise may not arise in any single sounding flight.

*The 2.4 GHz communications will not be tested on the HASP flight to prevent interference with the CSBF S-Band communications. To insure this and to reduce power, the 2.4 GHz radio will be physically removed from the payload.

Thermal

Based on the TV and flight performance of the original UMD-ABC payload, which shares many of the same major components, the UMD-ABC-2 payload will be passively cooled and generates enough heat internally to keep the components operational through all phases of flight. When possible, industrial rated components will be used to keep this operational range as wide as possible. The exterior of the payload will be covered in "Balloon Tape" to minimize the solar heating during the flight.

The major components will either have an internal temperature sensor or an external sensor located nearby, primarily used for diagnostics and monitoring during the TV testing.

Structure

The structure for this year's payload will consist of a commercial extruded aluminum housing that our circuit board will be designed to fit inside. This will reduce the amount of time and effort going into the structures work and provide a more robust design. The standard extruded aluminum housing is sufficient for the experiment being conducted as all the major components are integrated onto a single printed circuit board. The final decision on a specific housing will be made after the prototype boards are fully designed and the exact volume needed is known.

Power System

The power system (an updated version of the one used last year) is based on PTN78000 modules from TI, which contain all the components aside from 2 capacitors and a resistor. There will be two independent DC-DC converters based on the same module as last year. The main power converter will convert the 30v input to 3.3v to be used by the majority of the electronics onboard. The second unit will be used for the radio and the Gumstix processor, which run off of 5v. Aside from independent 3.3v and 5v rails, the only other change will be a move to solid polymer electrolytic capacitors that should prove more reliable over a wider temperature range.

Microcontrollers

The original UMD-ABC flight test demonstrated some shortcomings of running the lower level code with the higher level code on the Linux operating system. To improve reliability and performance, there will be two microprocessors used on the UMD-ABC-2 payload.

The low level processor will be a Z80 derivative with 5 serial ports. This processor will handle all the basic commands and control functions such as GPS position, the communications testing, payload housekeeping messages, and hardware interfacing. All data collected and all transmissions will be logged to a microSD card for later use. An Ethernet connection will be used for communication with the upper level processor and a simple port forwarding scheme will allow the upper level processor access to the same data such as commands, GPS position, and data from the radio. This processor will run C/C++ code on a uC/OS-II real time operating system that should eliminate some of the complications of the Linux operating system used last year.

The high level processor will be a Gumstix embedded computer similar to the one used in 2008. The Gumstix computer runs an embedded version of Linux 2.6 and functions similar to a PC/104 stack with daughterboards, but with a form factor close to a stick of chewing gum. This module, with a full operating system and USB makes it ideal for processing images and other high level operations. For the HASP 2009 flight, the Gumstix computer will primarily be used to capture video using a USB webcam and send the images to the ground over the 900 MHz data link.

Sensors

The payload will carry a commercial GPS receiver and continue the secondary experiment that (unintentionally) came out of last year's flight data. This experiment will assess the performance of a commercial GPS unit for high altitude flights and measure how much performance is lost compared to much more expensive professional or aerospace receivers. The unit tested in 2009 will be an internal GPS receiver with an external antenna that will either be mounted on top of the main payload or on the fiberglass beam next to it (as was done in 2008).

A camera will be used for still photography and possible slow frame rate video. This will be a commercial webcam that will interface over USB to the high level Gumstix processor and be mounted externally. The images (and possibly full video) will be processed and stored on a microSD memory card and a subset will be processed and sent to the ground. One of the main goals of this year's flight is to characterize and develop a solution that solves the problem of sending digital images over a lossy communications link.

Telemetry

While large amounts of date will be processed and transmitted by the payload, the data will be handled by the internal storage and communications system. We do plan on using the 1200 baud link for a downlink of a limited portion of our in flight data. Two analog lines will also be used. One analog line will be used to track the internal payload temperature and another will be used to track the 3.3v power bus. A limited number of serial commands will be used to switch the operating mode of the payload. There will be no scheduled use of serial commands, and they are expected to be used at a frequency of less than once an hour. The only discrete command will be to turn the 30v power line supplying the payload on and off and no discrete command connections to the payload are necessary.

Payload Characteristics Summary

Payload Mass	~2 kg
Power Draw @ 30v	<500 mA
Payload Size	Small*
Payload Dimensions	~15 cm x 15 cm
Payload Height	~5 cm
Payload Orientation	Pointed Up (Towards Sky)
Serial Commands?	Yes
Serial Telemetry?	Yes (1200 bps)
Analog Telemetry?	Yes (2 Lines)
Discrete Commands?	No (Excepting Power On/Off)

*The payload will be contained in a single box (aside from the camera and antennas) and could just as easily be mounted to one of the large pallets or inside the gondola if that would make space available for other payloads.

Timetable

- November – February: Complete PCB design and start programming
- March – April: Testing of the electronics and continue programming
- May-July: Testing of the full system at UMD
- Early August – Integration at CSBF
- Late August – Early September: Support launch of payload

Payload Integration

We expect to send 2-4 team members to CSBF in June to integrate the payload with HASP. This will consist of mounting the payload, testing the electrical and signal connections to HASP, with a special focus on making sure the discrete commands are functioning, and completing the TV test(s).

Flight Operations

We will be sending 3-6 team members to Ft. Sumner for the HASP launch in September. It is anticipated that one student member will be in Ft. Sumner for the entire flight operations period, with the majority of the team coming up at the end of the first week and staying for the launch. This should help as we try to minimize the amount of class missed and make it easier for our undergrad members to come. We will communicate with the balloon from the launch site and monitor the flight from the main HASP ground station and our own auxiliary ground station (for communications from our radio) located in the hangar. We plan on working with CSBF to mount a 900 MHz Yagi and radio (identical to 2008) next to the main dish on the antenna rotator on the hangar roof. During the flight, team members will monitor the data, and switch modes as appropriate. Unlike last year, where 100% of the coding was payload based, we anticipate ~50% of the 2009 software work to be ground based and hope to have a software solution that records, processes and displays the incoming data instead of the heavily manual task last year.

A number of hours after launch (based on the predicted rate of travel for the balloon), we plan on launching a small latex sounding balloon either from the airport. This sounding balloon will carry an expendable payload including a GPS and a 900 MHz Radio. The signal from this small balloon will be received by the UMD-ABC-2 payload on HASP and relayed to the ground. This will test the systems capabilities in terms of balloon to balloon communications and use as a signal relay for other payloads. This part of the testing is self contained and will depend on a number of factors, most notably the ability to have enough of our team members there for the actual launch and working with CSBF to insure that this would not interfere with their operations in any way. The expendable payload will be very similar, if not identical, to outreach payloads we are launching in July of 2009 and the relay function is already handled by existing software.

Palestine Launch

One of the issues we ran into in 2008 was that some of our students needed to return prior to the rescheduled launch in order not to miss too many classes. A June launch would obviously help greatly as classes would not be in session. Our experiment would not be affected by the different launch site and the shorter flight would not be an issue. Our only concern is that we have recently started sponsoring a CanSat class which a number of our undergraduate students are involved with and any integration or launch operations in early June would be difficult until after the competition is over (June 14th).

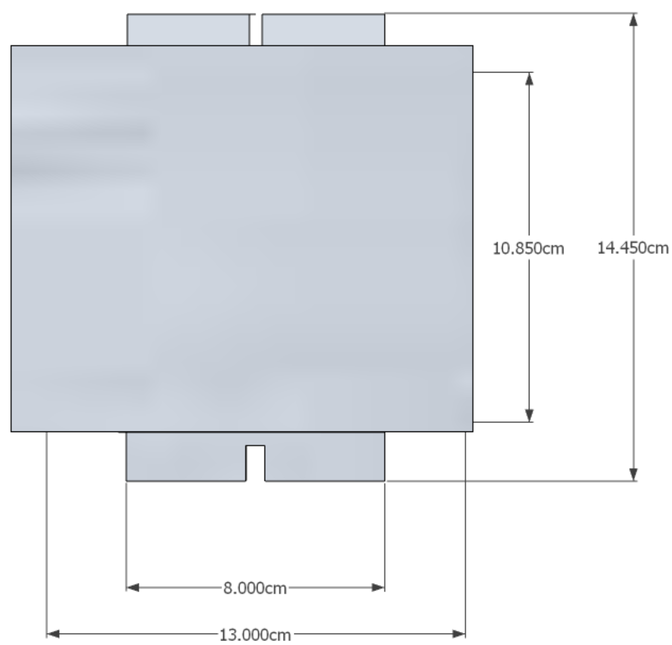
Special Requests

The 900 MHz radio will require a single antenna nearly identical to the ones flown in 2009 that can hang below the gondola. The only change from the flight units used last year will be the use of stranded coaxial cable that will be more durable and easier to hang than the solid core used earlier. We will also be using an external GPS antenna that could be located on top of our payload enclosure, but preferably on the fiberglass beam next to it if the space is available. The GPS position is not critical, but not being able to hang the 900 MHz antenna would severely disrupt the communications link when the gondola blocked line of site to the payload.

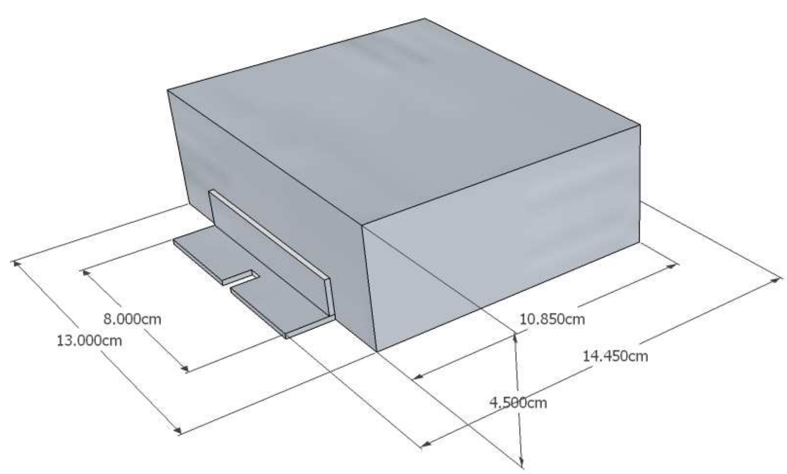
Payload Dimensions and Drawings

The UMD-ABC-2 payload will consist of little more than a single circuit board in an enclosure, the external antennas and a webcam attached to a USB port on the main payload. Also, as stated earlier, we are asking for a small payload position, but we can be positioned just about anywhere there is space. The enclosure will simply be mounted on top of the payload plate using 4 bolts and mounting flanges. Attached to this document are the dimensions of our target enclosure. Please note that we will be shortening the enclosure by ~1 inch to make it fit inside the allocated dimensions and still provide room for the SMA connectors that we will be attaching the antennas to.

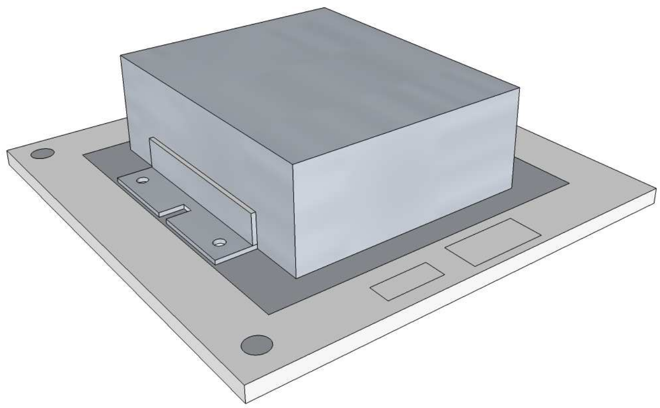
Top View



Prospective View



On Mounting Plate



Note: The screws that mount the enclosure to the payload plate will be on the outside of the mounting flanges through the holes that are shown in this view.