HASP Student Payload Application for 2018

Payload Title: **HAAT-TRIC**			
Institution: University of Maryland			
Payload Class (Enter SMALL, or LARGE): SMALL			Submit Date: February 16, 2018

Project Abstract:

The University of Maryland HASP team proposes to upgrade the two system experiment HAAT-TRIC that was flown on the 2017 HASP Flight. HAAT will continue its previous objective of characterizing upper-stratospheric turbulence, data which can then be used to aid in the prediction of boundary layer transition for hypersonic vehicles. The two thin-film probes used last year will be replaced with a suite of PCB microphones, which will allow for the measurement of pressure disturbances, as opposed to temperature and velocity fluctuations. TRIC will siphon off this data and log it to a separate module which will drop halfway through the flight into a net secured onto the pallet. TRIC will demonstrate data acquisition, logging, and in-flight termination which are all key technologies that would be necessary if TRIC were to actually become a functional data drop module.

The UMD HASP Team includes one graduate student and about a dozen undergrads. The team also includes two faculty advisors, one for overseeing the science objectives and another for her expertise in directing the Maryland Space Grant Balloon Payload Program for 14 years, launching over 70 sounding balloon flights, a sounding rocket flight, and supporting 6 previous HASP payloads.

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HAAT-TRIC

UMD HASP 2018 Flight Proposal

Reapplication - February 2018

UMD Nearspace Program
University of Maryland College Park
Department of Aerospace Engineering
Space Systems Laboratory
Hypersonic Aerodynamics and Propulsion Lab

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Contents

1 Abstract

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2 Terminology

UMD: University of Maryland (College Park)
BPP: Balloon Payload Program
CAT: Clear Air Turbulence
DRS: Data Relay System
HAB: High Altitude Balloon
HAPL: High-speed Aerodynamics and Propulsion Lab
HASP: High Altitude Student Platform
HAAT-TRIC: High Altitude Atmospheric Turbulence - Triggered Release Information Carrier
FISH: Fluctuations In Stratosphere by Hot-film
MARS: Mechanically Actuated Release System
MCU: Microcontroller Unit
ADC: Analog Digital Converter

3 Project Overview

3.1 Background and Scientific Objectives

Hypersonic vehicles are being developed for flight at altitudes above 100 kft (i.e., mid to upper stratosphere), where they encounter extreme aero-thermal-acoustic environments which strongly affect the boundary layer flow over the vehicle. Specifically, free-stream disturbances can cause laminar to turbulent transition of the boundary layer, which brings with it greatly enhanced thermal and mechanical loads. Robust vehicle design therefore requires accurate prediction techniques regarding the onset of transition. However, state-of-the-art transition prediction methodologies require knowledge of the magnitude and length-scales of the free-stream disturbances. Preliminary balloon-based measurements have shown a strong influence of CAT (Clear Air Turbulence) on disturbance levels; nevertheless, in contrast to the well-studied troposphere, CAT in the mid and upper stratosphere remains inadequately characterized. Thus, despite the availability of advanced numerical tools, it is currently impossible to predict with any certainty the onset of boundary layer transition on hypersonic vehicles in atmospheric flight.

The flow disturbances present in the atmosphere can be decomposed into acoustic, vortical and entropy components. Last year's HASP campaign measured the vortical and entropy components, leaving only the acoustic (pressure) flow disturbances left to be examined. The scientific objective for The High Altitude Atmospheric Turbulence (HAAT) subsystem of the proposed HASP experiment is thus to measure the random fluctuations in pressure that occur in the upper stratosphere. This data will be analyzed to determine the magnitude and frequency content of these acoustic disturbances, which are the characteristics needed for predicting how disturbances will affect a hypersonic boundary layer. A successful flight of the HAAT subsystem will yield a general characterization of the acoustic (pressure) fluctuations at the float altitude of a typical HASP flight, which may then serve as input to flow physics models for higher-fidelity transition prediction.

HAAT is coupled with a simulated data drop payload called TRIC which will explore the possibility of releasing a physical payload that has data stored on it from a scientific balloon. Some scientific balloon flights can last for months at a time and gather data at higher rates than is possible to downlink to the ground over radios, making the acquisition of data before the flight is terminated very difficult. TRIC is designed to siphon off data from HAAT and log it to a separate module that will drop when given a discrete command from the ground. There will be a backup serial command that can be used to trigger the drop of the drop module. For this flight, TRIC will be dropped into a net that is securely fastened to the upper half of the payload, and by extension, the HASP gondola. This years's experiment will focus on fixing data acquisition problems experienced last year.

Using droppable data modules such as TRIC, significant amounts of data can be retrieved part way through a long-duration flight for a relatively inexpensive cost. With this released information, researchers can assess early data from their experiments and, if necessary, make adjustments to their scientific instrumentation for the remainder of their flight. This concept was initially implemented with a UMD / HASP payload called StratoPigeon; and discussions with High Altitude Balloon (HAB) scientists at UMD and Goddard Space Flight Center have indicated that there is renewed interest in this capability. Unlike StratoPigeon, however, the primary objective of the HAAT-TRIC payload is to gather scientific data, and the engineering goal of demonstrating a data-drop module capability is secondary.

3.2 HAAT

3.2.1 Sensors

The goals for this HASP 2018 design differ from those of our 2017 payload only in terms of the physical quantity being measured. The 2017 version of HAAT yielded a wealth of temperature and velocity measurements, so the decision was made to now measure pressure fluctuations. Due to the differences in how these quatities can be measured, we have had to switch our instrumentation over to a suite of high-sensitivity microphones.

There was some consideration for incorporating the mini-CVA and thin film probes used last year with the microphone suite in order to simultaneously measure pressure, temperature and velocity. However, the addition of two more data channels would have significantly cut down the potential duration of data collection. Additionally, we determined that it was unlikely we would be able to significantly improve the quality of the temperature and velocity data over what was acquired in the HASP 2017 flight.

In total, three PCB microphones will be implemented with varying levels of sensitivity: one 378A06 microphone (sensitivity 12.6 mV/Pa; frequency range, +/-2 dB, 3 to 32, 000 Hz), one 378B02 microphone (sensitivity 50 mV/Pa; frequency range, +/-2 dB, 4 to 20, 000 Hz) and one 378A04 (sensitivity 450 mV/Pa;

frequency range, +/-2 dB, 10 to 16, 000 Hz). It is evident from these specifications that the 378A04 is by far the most sensitive of these microphones and is capable of measuring much smaller fluctuations that the other two microphones. However, it is still useful to have all three microphones included so that we might correlate the signals and improve confidence in the fidelity of the measurements.

All three of these microphones are rated to operate down to -40°C and have been flight proven several times. However, we will use our thermal chamber to verify the ability of these microphones to function under the typical HASP temperature environment.

3.2.2 Data Acquisition System (DAS)

HAAT will be designed to take pressure measurements through the three PCB microphones that will then be stored within a SLICE Micro DTS data acquisition system, shown in Figure 1. This configuration is small and lightweight, with the heat sink footprint measuring 3 in x 3 in and a system mass of 187 g. The SLICE system is extremely rugged, having been engineered to military standard MIL-STD-810E. This means that it is capable of withstanding temperatures ranging from -40 °C to 60 °C and shock loadings of up to 500 g. The DAS will be powered entirely through HASP, with a maximum current draw of 0.18A at 10V. The system has 16 GB of non-volatile flash memory for storage purposes and can sample up to 24 channels at 200 kHz. For a sampling rate of 40kHz with 3 channels, the DAS can log data for over 18.5 hours. We will be implementing serial commands to trigger data acquisition in order to maximize the amount of data collected at float.

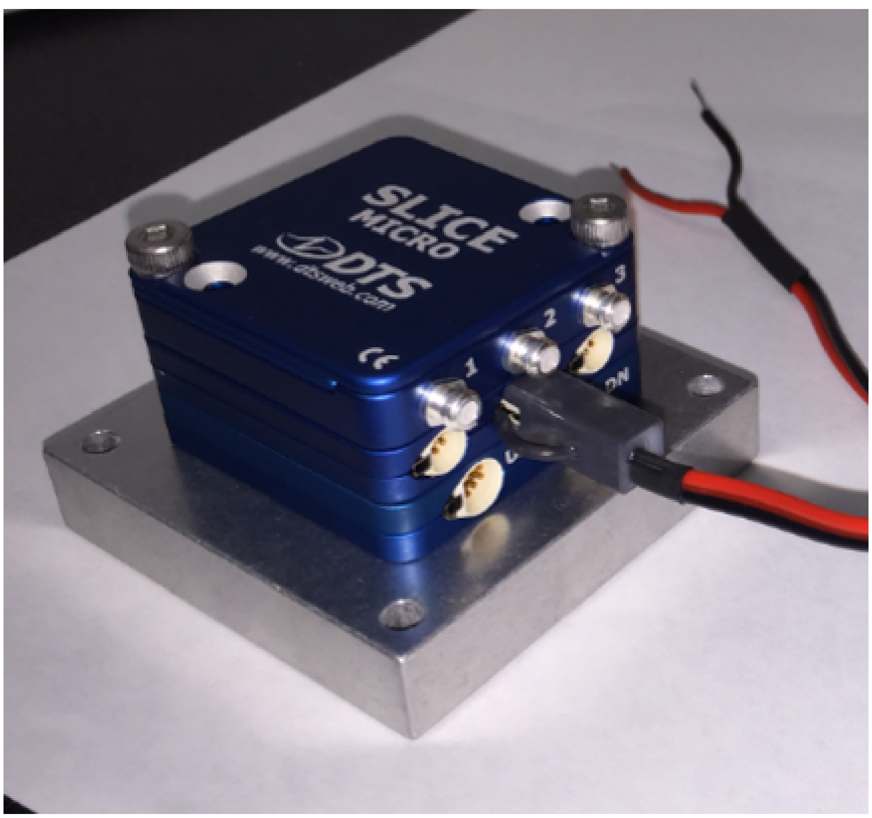


Figure 1: The Slice Micro will store data from the microphones as a part of the Data Acquisition System

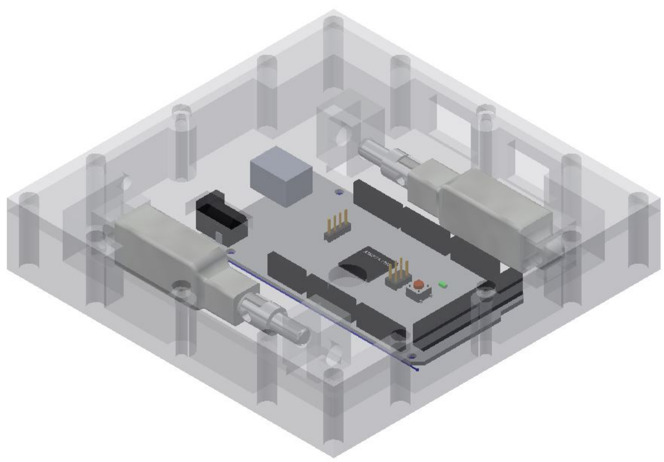
Due to the nature of the data being recorded, the data will not be downlinked via HASP. The high rate of 16-bits at 40kHz makes the link impractical to use. Instead, the Arduino unit in HAAT will be downlinking a status indication via the serial link. The DAS downlink will tell whether or not data is being recorded. The second serial downlink will be a status signal on whether or not the drop module has been dropped, and a signal about the status of the data storage on DRS.

3.3 TRIC

3.3.1 Mechanical Drop System

The release system on TRIC consists of two 10 mm stroke actuators wired to a micro-controller to move forward to lock the drop module in place, and move in reverse to drop the module. The actuators use quarter inch aluminum pins to hold U bolt mounting brackets on the drop module. To command the release of the drop module, a serial command will be sent to the on board micro-controller. Figure 2 shows the Arduino microcontroller between the two actuators.

Figure 2: Inside view of the mechanical drop system



3.3.2 Drop Module

The Drop Module contains the DRS, a custom modular data relay device. It will be powered from an onboard 3 cell LiPo battery, as connections with the main payload will be terminated partway through the flight.

Throughout the flight, the drop module will be receiving data from the DRS and logging it internally. When the actuators retract, the drop module will fall into a net/basket and the DRS connection will be severed.

3.4 Internal Circuitry

3.4.1 Arduino Mega

An Arduino Mega will be located above the payload plate to aid in both interfacing with HASP, and to run the actuators for the drop. The Arduino Mega will take in status signal lines from the DRS and the DAS. These lines will tell the Arduino whether data has started to be recorded on the DAS, and whether or not the drop module has released itself into the net. These signals will be transmitted down to the ground via HASP serial capabilities. The Arduino will also be responsible for acting upon the commands sent up to the payload through the serial connection. The list of these commands can be seen in Table 1.

3.4.2 Data Relay System

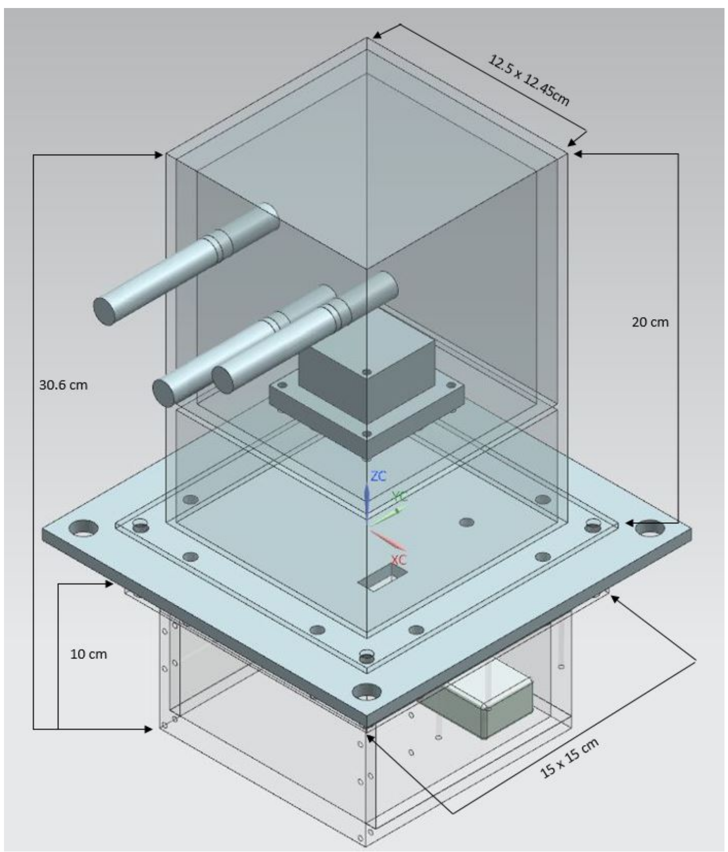
The DRS is a modular, in house PCB that will contain all of the data logging required for the drop module. In 2017, the board contained just an ADC to convert the signals, which was then sent via USB cable to the drop module, where it was separately stored. This year, to avoid buffering protocol between the serial line, the raw signal will be sent to the drop module, and converted and stored on the same DRS board. The data logging will also be redundant, containing both flash storage and an SD card.

4 Design Specifications

4.1 Structural Layout

The main structure of HAAT-TRIC will be made of 1/16 inch (0.16 cm) thick sheet aluminum and will be held together with metal brackets at the corners. All electronics will be placed on non conductive easily removable plates secured within the payload housing. The main body of the payload will be within the allowed payload space but the microphone pickups will stick out of the payload area by 2 inches (5 cm) on the side of the payload facing away from the gondola. The total height of the system will be 20 cm above the plate and 20 cm below the plate, including an extra 10 cm below TRIC for the net that will catch it when it drops.

Figure 3: CAD Rendering HAAT-TRIC



4.2 Thermal Management

As with last year, HAAT-TRIC will not have active thermal management. The housing will have a layer of insulating foam along the surface of the walls as a means of insulation. Based on the performance of the electronics on the HASP 2017 flight this configuration is expected to keep our payload within an acceptable temperature range. The expected performance of HAAT-TRIC's thermally will be verified by test. The entire system will undergo at least one thermal test, one vacuum test, and one test flight on a UMD high altitude weather balloon, and the thermal-vacuum test at CSBF integration.

The thermal chamber at UMD can go to both high and low temperatures, but for the purposes of this project will be used to test the system to a temperature of -60° C. The chamber will be held at the target temperature long enough to cold soak the hardware, and test the drop mechanism. After that has been completed the chamber will be brought back to room temperature, and the data logs examined to ensure that all equipment remained functional. This testing can and will be repeated along with hardware modifications as needed until all systems function reliably for the entire duration of the test.

The vacuum chamber can achieve pressures similar to those at 100,000 ft. It does not have thermal controls, but could still be used to identify potential issues with the electronics, which will be monitored for the duration of the testing.

HAAT-TRIC will also be tested on a minimum of one high altitude balloon flight prior to integration. These flights typically last 1.5 to 2 hours and reach a maximum altitude between 80,000 and 100,000 ft. All flight capabilities, including data collection, data duplication, and a simulated drop will be tested during ascent. Though this flight will not last long enough to cold soak the payload, it will provide a baseline assessment of flight readiness.

The closest simulation that can be achieved pre-flight will be the Thermal Vacuum test at CSBF. All systems are expected to work during this test, but if they do not there are strategies that can be implemented to address the issue. If the electronics get too cold, additional insulation and/or resistive heating would be added. Conversely, if the electronics get too warm a heat sink exposed to the environment but shielded from the sun would be used to remove heat from the payload.

4.3 HASP Interfacing

4.3.1 Structural Interface

HAAT-TRIC will be rigidly attached to the payload plate using a flange around the bottom as shown in Figure 3. Additionally, 2 inch long 1/4-20 bolts will be threaded through the corner holes, the payload plate and the housing of the mechanical drop system (these bolts are not shown in Figure 3 for clarity).

4.3.2 EDAC Interface

HAAT-TRIC will utilize the power and discrete lines of the provided EDAC connector, as seen in Figure 4. Power will be routed through a switching regulator board that will regulate the 30 V from HASP down to 5 V and 10 V lines to be used in the payload. The 10 V line will power the DAS (and thus the microphones through an excitation voltage); the 5 V line will power the Arduino Uno and actuators. It should be noted that in the Power budget (see Table 2), the peak current draw of the actuators is 185 mA from HASP at 30 V. This is the worst case current draw while dropping the payload, for which the duration will be one minute at most. The actual peak power is much closer in value to the average current draw, which will be what the actuators draw during normal operation.

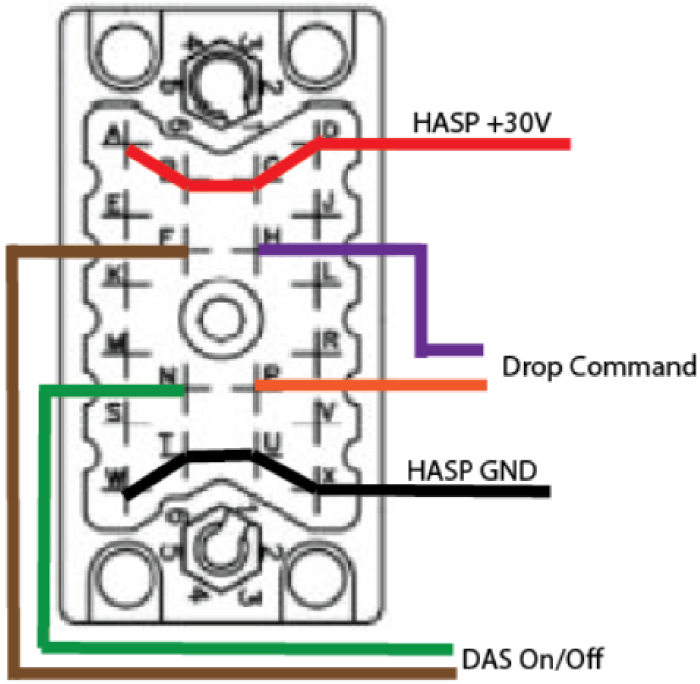


Figure 4: EDAC Connector

4.4 Payload Operation

During the HASP 2017 flight, our group encountered numerous issues due to our lack of a robust serial interface with HASP and the time dependency of the discrete commands. We could not determine the functionality of our payload until after the flight's conclusion, and we were restricted in our data acquisition time due to the lack of triggering and power cycling options. All of our electrical systems relied on mechanical switches that had to be thrown just prior to flight, which was logistically difficult. Furthermore, with no way to trigger data acquisition, the DAS had to begin logging data immediately upon startup. This meant that a significant portion of the data logged took place on the ground or during ascent.

Based on this experience, we have taken the time to become much more fluent in serial interfacing and identified a number of serial commands that we will be using the HASP serial interface to execute. One serial command will be to turn on the DAS, and secondly to turn on the data acquisition at altitude. This will allow for much more robust data acquisition and for all of the data acquired to occur at float when the data is of most interest. It will also allow for non-consecutive acquisition, meaning that we can examine how the magnitude and intermittency of stratospheric turbulence varies with the diurnal cycle.

Additionally, the release of the drop module can be triggered via the serial lines. This redundancy with the discrete lines allows the ability to trigger the drop with either method, instead of having to then hard-code the time of drop into the flight code when the discrete signaling fails.

5 Design Changes

5.1 Changes from 2017 HASP

5.1.1 Atmospheric Data Measured

Regarding boundary layer transition, we are interested in fluctuations with length scales on the order of 1 cm. This corresponds to pressure fluctuations at frequencies above 10kHz, as the appropriate scaling velocity for acoustic fluctuations is the freestream speed of sound. In order to avoid aliasing of the most interesting frequencies, the sampling rate of the DAS was increased to 40kHz for the 2018 campaign. A much lower sampling rate could be employed last year because the appropriate scaling velocity for temperature and velocity fluctuations was the relative payload velocity.

5.1.2 Structure

In the HASP 2017 Payload, most of the structural components and outside body panels that made up HAAT-TRIC were made out of PLA (Polylactic acid) or ABS (Acrylonitrile butadiene styrene) 3D printed plastic. These components displayed performance issues, and while their failure did not impede mission success, it raised concerns on their use in future flights.

During the flight, several body panels on HAAT, especially those darkly colored, deformed. The temperature of these plastic panels likely reached above the glass transition temperature, causing the material to become rubbery and flexible, without completely melting. The panels in question bulged outward, but did not deform to the point of breaking the nylon bolts holding them together. As a result, **no future outside structural body panels will be made out of 3D printed plastic**, particularly PLA, as it has a lower glass transition temperature.

The upper part of the Payload, HAAT, was affixed to the payload plate using 4 plastic brackets. These structural brackets were 3D printed out of PLA plastic with a 10% infill. ABS plastic would have been a better choice along with a higher infill setting, as this would have made a stronger part. Issues did not arise until landing. The impact was harder than expected, and all 4 of the brackets failed causing the upper half of the payload to separate from the payload plate. Only the internal electrical wires were holding the payload together, as could be seen from recovery photos. **For all future critical structural components, 3D printed plastic will not be used**, particularly low density plastics that are not intended for structural components. These corner brackets will be replaced with an aluminum flange.

5.1.3 Data Relay

The entire system for relaying probe data on the previous HASP 2017 flight consisted of many different discrete parts on both HAAT and TRIC in order to convert the analog signal to digital, splice the data, and then store the data.

The ADC on the DRS on HASP 2017 were both in the top, HAAT, portion of the payload. The data was routed into the DRS, sent to the teensy microcontroller, and then rerouted back to the DRS to be sent down to the TRIC portion of the payload for data storage. Onboard TRIC was the Raspberry Pi used for storing all of the converted data.

Our HASP 2018 redesign will consolidate all of these tasks onto a single DRS board that is located in the TRIC portion of the payload. The data lines will be sent directly from HAAT to TRIC via the same magnetic release cable, and will be routed to the DRS. The DRS will contain an onboard ADC to convert the data, as well as flash storage and an SD card to store the data. This is a much simpler system.

5.1.4 Arduino Unit

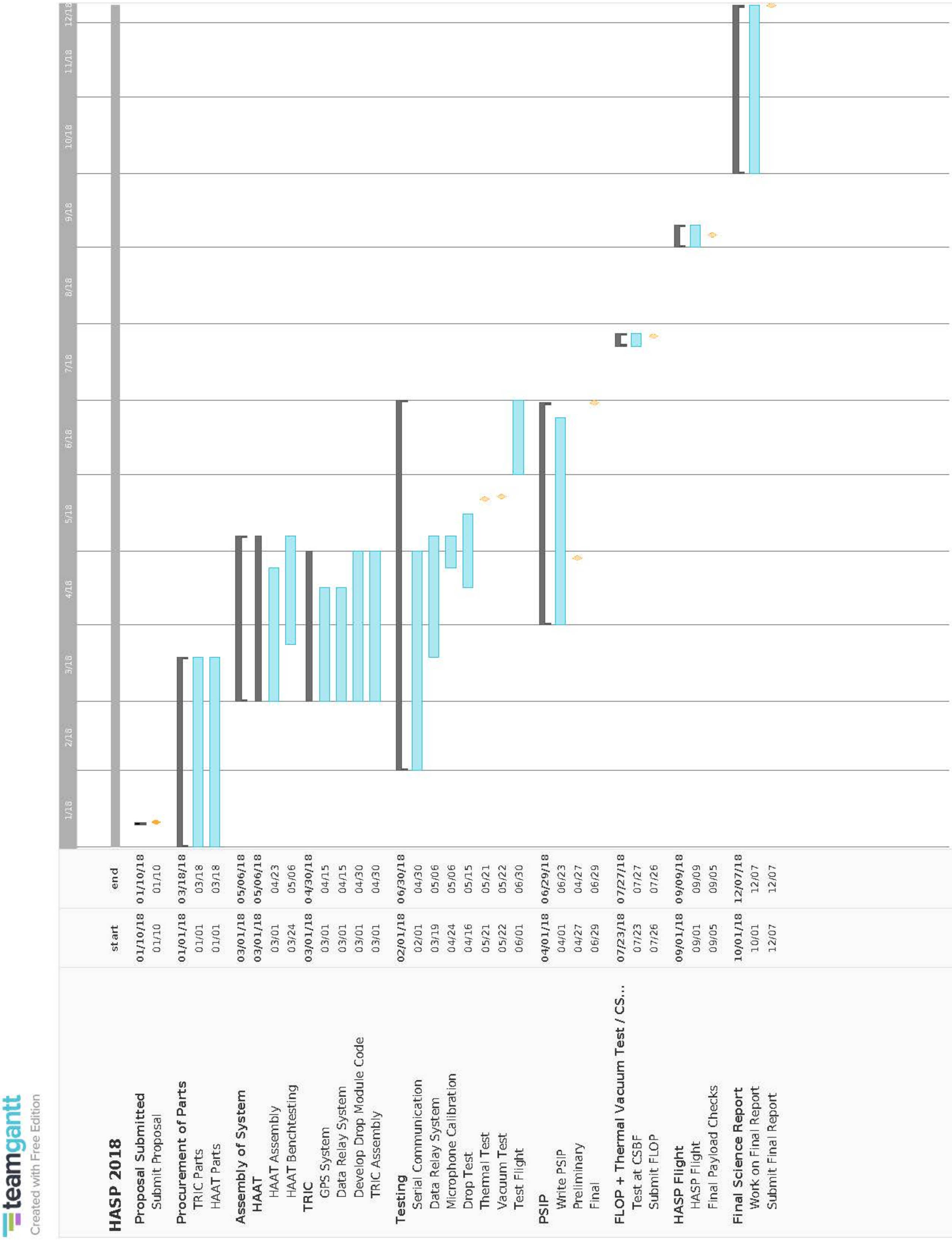
On HASP 2017, we flew a custom Arduino unit known as a Balloonduino. The Balloonduino has the same processor as an Arduino Mega, although it contains a suite of onboard sensors including an IMU, RTC, and pressure and temperature sensors. While these boards are convenient for BPP projects since they require no additional shields to create a sensor dependent payload, they vastly complicated the design of the HASP project since there was little to no use for the additional features provided by using a Balloonduino. One of the most notable issues with the Balloonduinos for the HASP project was their unreliability: all of the units brought to New Mexico for flight were unable to pick up the timer line of the discrete signal. The unit used for integration was unable to be used since the serial driver had stopped working and was unable to flash code.

For many reasons, therefore, our payload on HASP 2018 will switch to using an Arduino Mega unit to minimize design complexity. The Arduino Mega will be able to both send and receive packets to and from the HASP pallet. It has the capacity, upon receiving the signal from HASP, to start the actuators that release the drop module from the payload plate. All of these changes remove unnecessary complications and reduce possible points of failure.

5.2 Changes from Initial 2018 Proposal

In our original 2018 HASP proposal, it was intended that there be a GPS receiver onboard our payload and a radio to transmit the locational data. **We are no longer proposing to fly a GPS unit or any on-board radios.** In an effort to focus on a smaller number of subsystems, this idea has been dropped from the scope of our 2018 HASP payload.

6 Project Timeline



7 Previous Balloon Flights

7.1 HASP

7.1.1 2008 - 2009

On the 2008 and 2009 HASP flights, the UMD ABC payloads (University of Maryland Advanced Balloon Communications Experiments) tested various configurations of GPS antennas and radio downlink systems. These GPS antennas successfully communicated with a ground station throughout the flight.

7.1.2 2010 - 2012

HASP 2010 was the first flight of the UMD payload StratoPigeon, which would acquire data for a few hours before dropping. StratoPigeon received its drop command through a ground station telemetry network similar to that tested during the ABC experiments. The 2010 flight was a systems check operation to ensure full system functionality. The 2011 and 2012 flights both demonstrated successful drops, but only the 2011 drop module was successfully tracked and recovered.

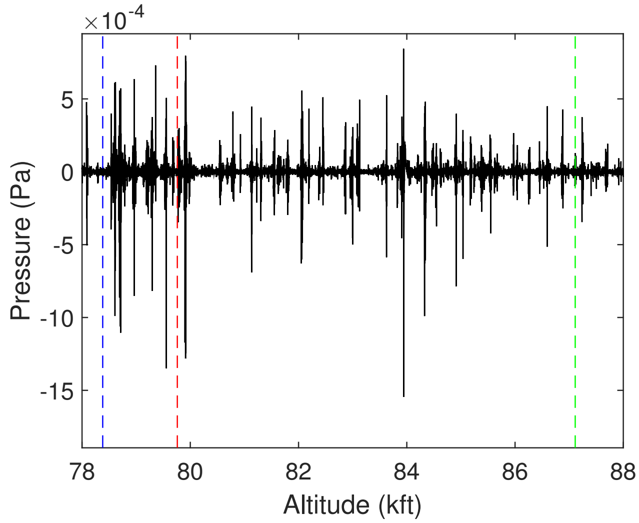
7.1.3 2017

The UMD HASP 2017 payload was a spiritual successor to StratoPigeon dubbed HAAT-TRIC. This was a partnership between the Balloon Payload Program (BPP) and the High-speed Aerodynamics and Propulsion Lab (HAPL), both research labs in the Aerospace Engineering Department at UMD. BPP provided the droppable module while HAPL supplied the scientific instrumentation. HAAT used a constant voltage anemometer coupled with thin-film probes to measure perturbations in velocity and temperature within the upper stratosphere, while TRIC contained a Raspberry Pi for data logging that was to be dropped when commanded with a HASP discrete signal. Due to hardware difficulties before flight, the drop module was dropped on a 4 hour timer instead of using the discrete command lines, and there was no serial downlink of the payload status.

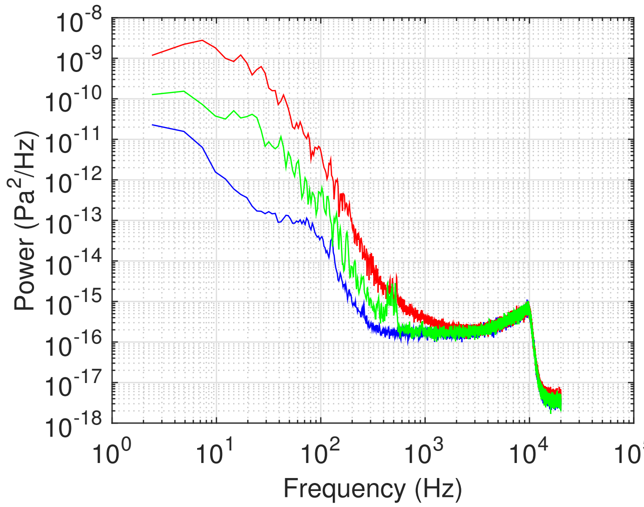
7.2 FISH

FISH (Fluctuations In Stratosphere by Hot-film) is a sensor package that has been in development over the past year and a half through an Air Force Small Business Technology Transfer Program (AF STTR) with Tao Systems Inc, a small aerodynamic sensors company in Hampton VA. The most recent balloon flight of this package on December 2nd, 2017, included a hot-wire probe for velocity measurements, a cold-film probe for temperature measurements, and three PCB microphones for acoustic measurements. These are the same microphones we are proposing to fly during the 2018 HASP campaign. Representative results from the flight are shown in Figures 5a and 5b for the most sensitive microphone flown (378A04). The time-series data has been high-pass filtered in order to accentuate the regions of relatively high fluctuations. It is also worth noting that the maximum disturbance within this altitude range is approximately 0.6 mPa. The power spectra for three 10s intervals (150 ft) are shown below, where the blue trace is for a region of relatively low disturbance, red is a high disturbance region, and green is a region of intermediate disturbance. Clearly, this microphone is capable of resolving disturbances above the noise floor until approximately 2kHz, at least in regions of large disturbances. As discussed previously, the disturbances relative to hypersonic boundary layer transition are typically at frequencies on the order of 10kHz, so this microphone is approaching the desired resolution. Currently, techniques are being considered for lowering the noise floor even further, including the procurement of a microphone with even higher sensitivity.

Figure 5: Data Collected from FISH



(a) Pressure at Altitude



(b) Power vs Frequency

7.3 DataPigeon

DataPigeon was a project, inspired by StratoPigeon, that started in the summer of 2016 until the fall when it became part of our HASP 2017 effort. DataPigeon utilized a cut-down device called MARS (Mechanically Actuated Release System) to perform a tethered drop on a balloon flight after a set time from balloon launch. A USB cable with a magnetic detachment was used to cleanly break the data line when the payload was dropped. DataPigeon flew on two flights. The first one in the late summer of 2016 was fairly successful, as the payload logged data and then dropped, severing connection with the module it was connected to. The second flight, in the early fall, was less successful due to a timing error in the code which prevented MARS from activating. The module also failed to record data throughout this second flight. DataPigeon was then combined with FISH for the 2017 HASP proposal.

7.4 MARS

The design for the release mechanism of TRIC is an adaptation of the MARS cut-down device. MARS is an actuator release mechanism used to disconnect the bottom payload from the rest of the payload string on one of our sounding balloon flights. Instead of serial commands from the main payload gondola, MARS uses XBee radio signals to communicate with the balloon's command and tracking module and with the ground. The first flight of MARS was in November 2015 and it has flown on a variety of flights since then. The MARS system has successfully dropped the intended payload on almost all of its test flights.

8 Payload Summary

In summary, HAAT-TRIC is a small class payload that will measure pressure fluctuations with an array of microphones and record it onto a robust, primary DAS and a secondary droppable module. Key information about HAAT-TRIC can be found in Table 1

Item	Units
Total Mass	4,200 g
HAAT Mass	1,400 g
TRIC Mass	1,200 g
Structure Mass	1,600 g
Average Current Draw from HASP	15.4 mA
Peak Current Draw from HASP	415 mA
Payload Size	Small
Payload Footprint	15cm x 15 cm, 5 cm additional for microphones
Payload Height	20 cm above, 20 cm below plate
Payload Orientation	Microphones pointed away from HASP Pallet
Discrete Commands	DAS On/Off (F, N) Drop Command (P, H)
Serial Downlink	1200 baud payload status
Serial Uplink	0101 Drop Payload 0202 DAS Turn On 0303 DAS Trigger
Analog Telemetry	None

Table 1: Payload Summary

A detailed Power Budget can be found in Table 2, and a Mass Budget in Table 3

Item	**Average Current (mA) at 30 V**	**Peak Current (mA) at 30 V**	**Line**
Data Relay System	84	100	Internal Batteries
Total (internal power)	**84 mA**	**100 mA**	
DAS	60	60	HASP power
Microphones	4	10	HASP power
Arduino Uno	4	5	HASP power
Actuators	5	185	HASP power
Total (from HASP)	**73 mA**	**260 mA**	

Table 2: Power Budget

Item	Mass (g)	Subsystem
Slice System	187	HAAT
PCB Microphone x 3	45	HAAT
Arduino	40	HAAT
Voltage Regulator	50	HAAT
Data Relay System	100	TRIC
Actuator (x2)	60	TRIC
Voltage Regulator	50	TRIC
3-cell Li-Po	133	TRIC
Insulation	50	Structure
HAAT Case	700	Structure
Wiring	50	Structure
TRIC Case	700	Structure
TRIC Drop Net	100	Structure

Table 3: Mass Table of Selected Components

9 Integration Procedures

Upon arrival at CSBF for HASP integration, HAAT will be bolted to the top of the payload mounting plate and the actuator mechanism box will be bolted to the bottom of the plate. After attaching the magnetic data cable, the data drop module will be attached to the bottom of this assembly by extending the two linear actuators through two U-bolts attached to the top plate of the data drop module. Once the data module is securely attached, the catch basket or net will be put in place. Testing shall include verification that the microphones are picking up data, and ensuring that both serial and discrete signaling is properly routed and working.

Upon arrival at Ft. Sumner for the HASP flight, similar testing will be done to ensure the payload is functional before flight. In addition to the previously described procedure, the drop module will need to be turned on before flight. This is outlined in Table 4.

10 Special Requests

In order to simulate the TRIC drop, we are requesting the use of space 20 cm below the payload interface plate in addition to 20 cm above the plate for HAAT. This will not add to the mass limit for the payload, but will allow for TRIC to be released from HAAT. If this request is denied, all of HAAT-TRIC will be placed above the payload plate. The data transfer system can still be tested without a physical drop, although the data transfer termination system and dropping mechanism cannot. Without the additional space below the payload plate, the drop test will be descoped from the payload objectives.

HAAT-TRIC is also requesting use of two discrete lines. The first one, as given to all payloads, is to be used for powering on and off the DAS, with a serial command as backup. This would be a redundant secondary method of ensuring that the DAS is storing data. The second set would be used as a redundant set for commanding the drop of TRIC. This would require our payload to be in a seat that has access to all four discrete commanding lines (seats 1, 2, or 5) in order to fulfill both requirements. If this request is not granted, TRIC will lose redundancy with the serial lines, but should still be able to drop.

Additionally, in order to ensure the microphones are measuring data that is uncorrupted by turbulent flow around the pallet structure, they must stick out slightly from the HAAT housing, and face away from the rest of the gondola. For this reason, we are requesting permission for our microphones to extend out of the prescribed footprint by 2 in (5 cm). Should this request be denied, we risk compromising the data acquired by the microphones and rendering it useless.

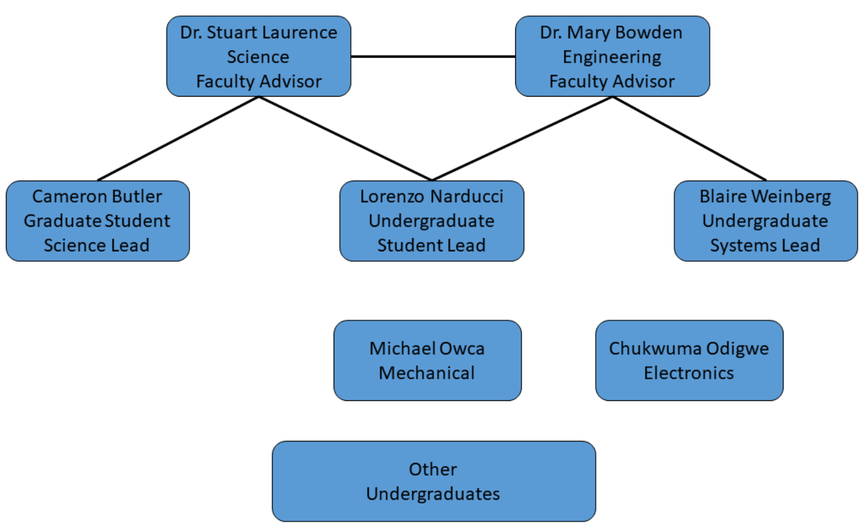
11 Preliminary Flight Operations Plan

Table 4: Preliminary Flight Plan

Time from Launch	Event Name
- 02:00:00	Turn on Drop Module
- 01:00:00	Turn on Payload
- 00:30:00	Turn on DAS
+00:00:00	Balloon launches
+02:00:00	Balloon reaches altitude
+02:01:00	Send trigger command to begin data acquisition
+08:00:00	Send command to release Drop Module
+08:00:01	Actuators begin retracting
+08:00:05	TRIC separates
+08:00:06	TRIC lands in the basket
+08:00:32	Linear Actuators stop retracting
+24:00:00	Flight Ends

12 Project Personnel

Figure 6: Team Structure



As shown in figure 6, the team is advised by two faculty advisors, Dr. Laurence, who will lead the science portion, and Dr. Bowden, who will direct the engineering portion of the payload. There are three student leads: Cameron Butler, a doctoral student in Hypersonics, who will take charge of the science instrumentation and data analysis; Blaire Weinberg, who will be directing manufacturing and assembly of structural and electronic systems; and Lorenzo Narducci, who will provide oversight of all documentation and software necessary for this project. There are also two subsystem leads: Michael Owca in charge of mechanical subsystems, and Chukwuma Odigwe in charge of electronic subsystems. Three or four other undergraduates will be assisting on the HASP project as well, in addition to some other advisors. See table 5 in the appendix below.

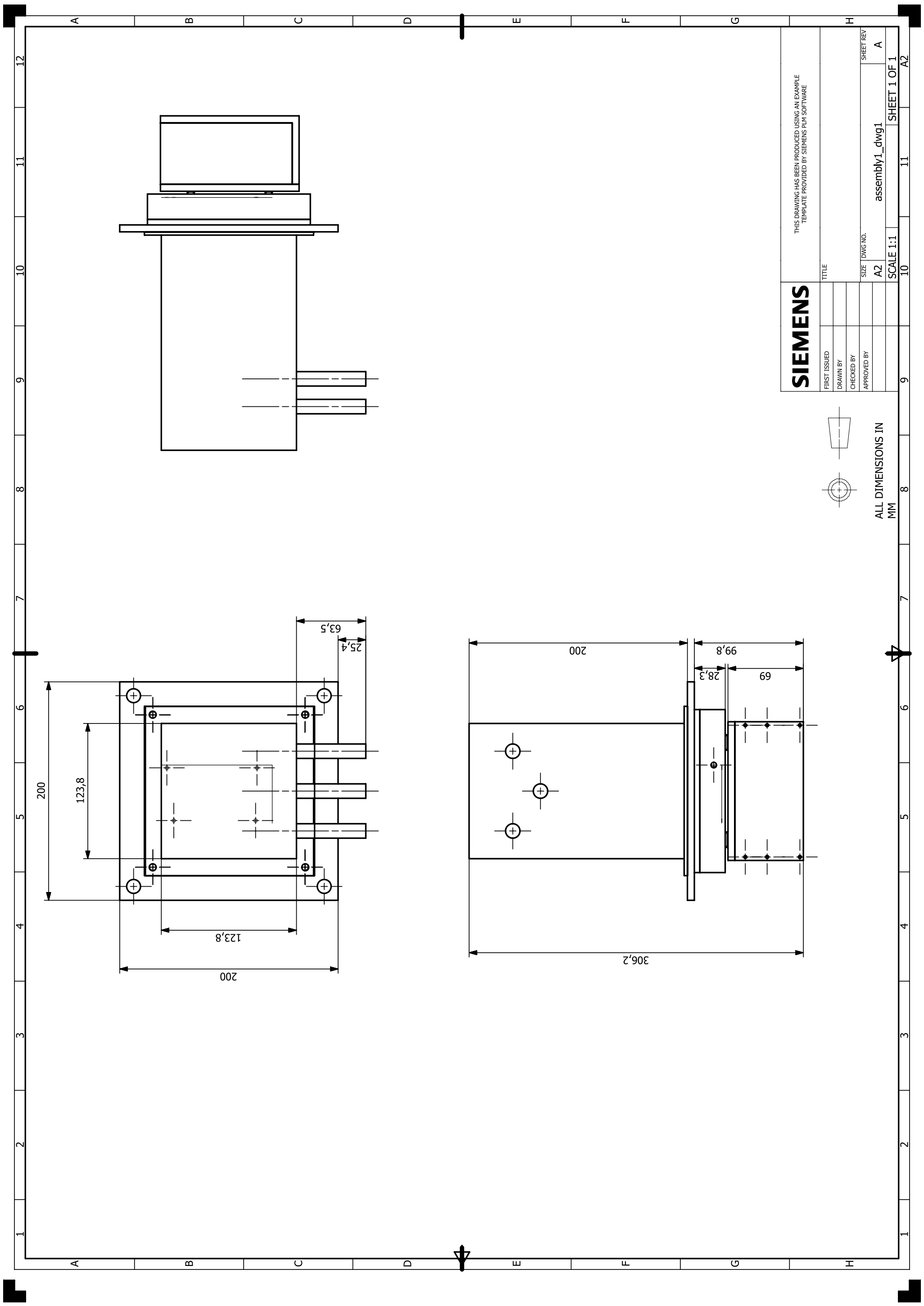
A Full Team Personnel

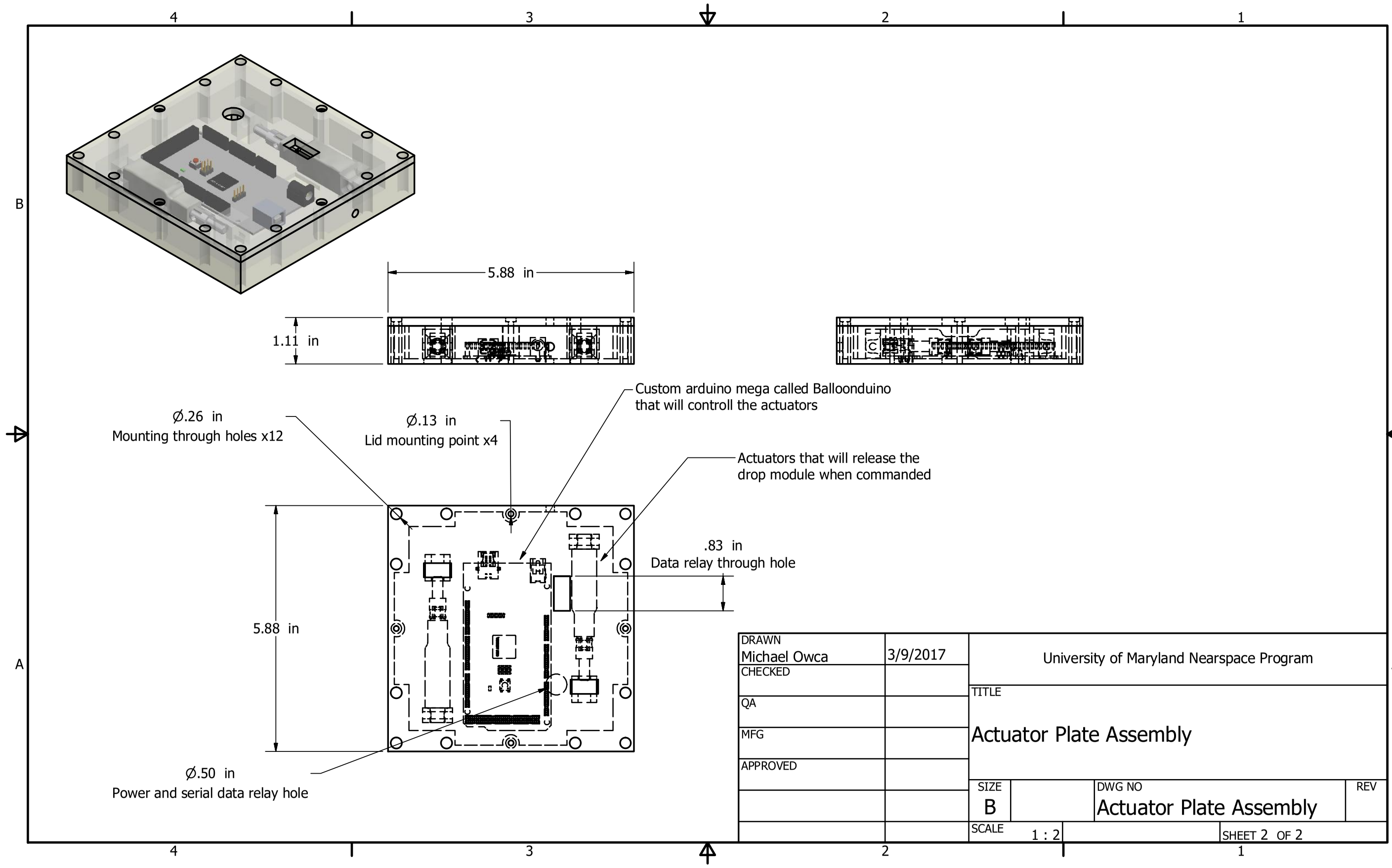
Table 5: Personnel

Name	**Start Date**	**End Date**	**Role**	**Student Status**	**Race**	**Ethnicity**	**Gender**	**Disabled**
Cameron Butler	11/15/16	Present	Graduate Science Lead	Graduate	White	Non-Hispanic	Male	No
Lorenzo Narducci	11/15/16	Present	Undergrad Student Lead	Undergrad	White	Non-Hispanic	Male	No
Blaire Weinberg	11/15/16	Present	Undergrad Systems Lead	Undergrad	White	Non-Hispanic	Female	No
Michael Owca	11/15/16	Present	Mechanical Lead	Undergrad	White	Non-Hispanic	Male	No
Michael Walker	11/15/16	Present	Integrations	Alum	White	Non-Hispanic	Male	No
Bianca Foltan	11/15/16	Present	Program Manager	Undergrad	White	Non-Hispanic	Female	No
Chukwuma Odigwe	12/21/16	Present	Electrical Lead	Undergrad	Black	Non-Hispanic	Male	No
Jessica Queen	12/1/17	Present	Mechanical	Undergrad	White	Non-Hispanic	Female	No
Olasunbo Salami	10/21/17	Present	Software	Undergrad	Black	Non-Hispanic	Female	No
Steve Lentine	12/10/17	Present	Tracking	Program Liaison	White	Non-Hispanic	Male	No

B Drawings

Figure 7: Dimensioned Drawing of Payload




5.88 in
1.11 in
Ø.26 in
Mounting through holes x12
Ø.13 in
Lid mounting point x4
Custom arduino mega called Balloonduino
that will controll the actuators
Actuators that will release the
drop module when commanded
.83 in
Data relay through hole
5.88 in
Ø.50 in
Power and serial data relay hole
DRAWN
Michael Owca
3/9/2017
CHECKED
QA
MFG
APPROVED
University of Maryland Nearspace Program
TITLE
Actuator Plate Assembly
SIZE
B
DWG NO
Actuator Plate Assembly
REV
SCALE
1 : 2
SHEET 2 OF 2