Preliminary Report

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Where we are now

According to our initial timeline, by March 12th we needed to have the tasks shown below completed. Additionally, we added more deadlines for ourselves during this time span (*italicized*).

1. Procure materials
2. *Create the box for the payload*
3. Prototype circuit board using breadboard
4. Hack camera and test the hack
5. Test out GPS with InstaMapper
6. *Learn about the RC Logger and SPOT and what has to be done to use them*
7. Test components to see if they work at low temperatures
8. Put electronics in the container with holes for the sensors and apertures.
9. *Determine our launch site*
10. *Contact weather-ballooners for advice*

In this report, we will outline where were are on each one of these tasks.

1. Procure Materials

The materials that we had to acquire are: a weather balloon, helium, Canon PowerShot camera, cell phone, Spot GPS, RC Logger with environmental module, sensors, parachute, lithium batteries, and foot warmers.

Item	Have Item?
Weather Balloon	Yes*
Helium	Yes
Canon PowerShot Camera	Yes
Spot GPS	Yes**
RC Logger with Environmental Module	Yes
Sensors	Yes
Parachute	No***
Lithium Batteries	Yes

Foot Warmers	Yes

* **Weather Balloon:** We have ordered a weather balloon that fits our specifications. However, we are waiting for the company to get back to us with an ETA for the balloon. We wrote to them on Friday and asked and they replied that the balloons come from Japan, and as Japan was hit with a disaster, they will let us know as soon as they know when the balloon will arrive. However, in addition to buying this weather balloon, we have received a weather balloon from the Human Powered Vehicles Team, which we plan to use in all our testing up until the final launch.

** **Spot GPS:** We have this, but it has a bug that makes it unusable right now. Drew Bennett is working on it.

*** **Parachute:** We ordered the parachute 8 days ago and it is on its way. It should arrive within a week.

As of right now, we have all the materials we need to proceed up until the final launch, where we will need the SPOT GPS and parachute and would prefer to use the weather balloon we ordered, as the weather balloon the HPV donated has been sitting in a shipping container for a year and is of “sketchy quality” (in the words of HPV’s team leader).

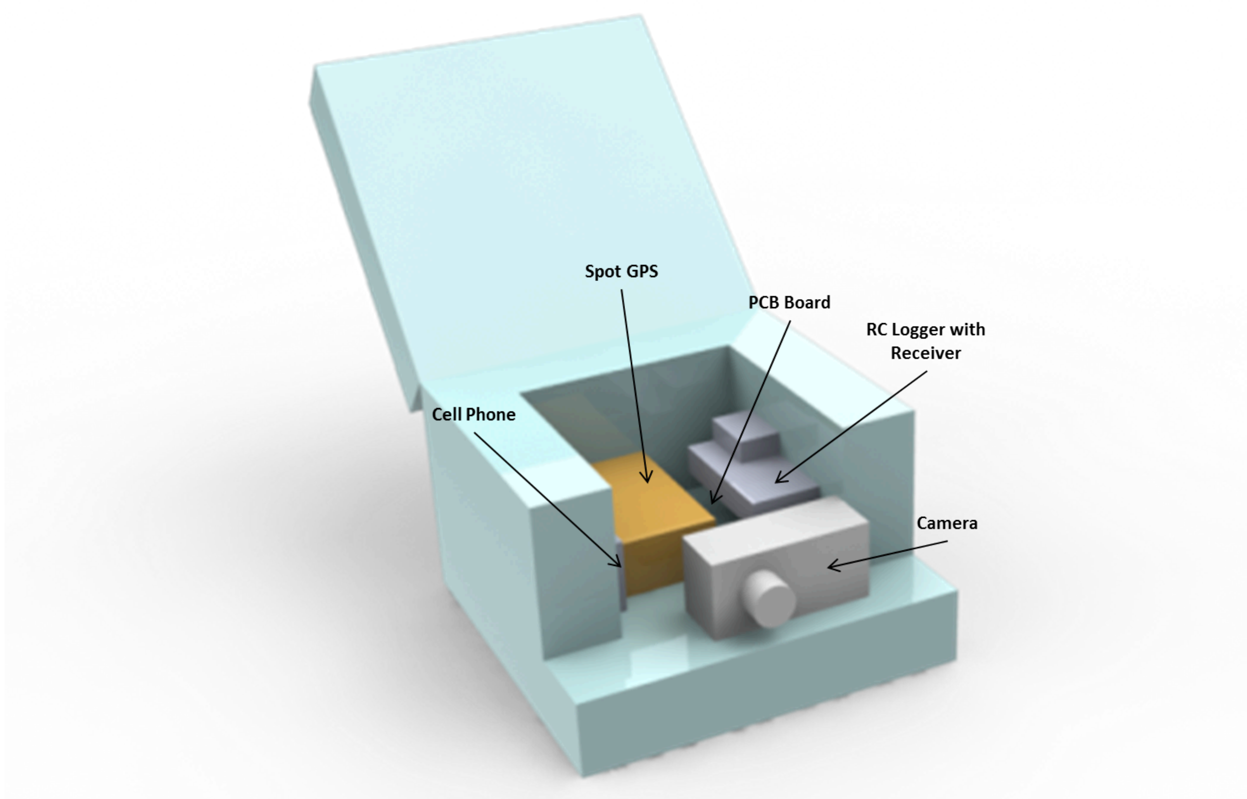
2. Create the box for the payload

We created a box to hold our payload out of blue foam and GreatStuff expanding foam. We decided to use GreatStuff foam instead of super glue or hot glue because, at high altitudes, we did not want the air bubbles sealed into the hard glue to pop and cause cracks in the glue. Additionally, we stitched the top cover on with wire and duct taped the important joints. As well, we plan to duct tape the box shut with duct tape before we launch.

Two pictures of the box are shown below. The box shown below is the second iteration of our design. The first box was heavier, as it had much more GreatStuff foam.

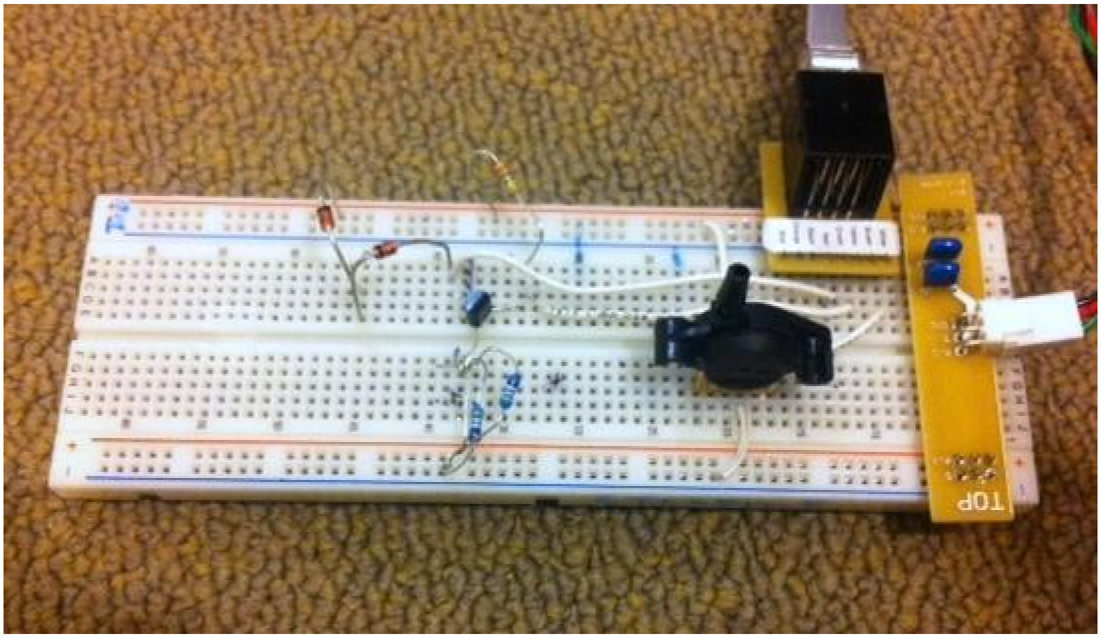
 

Additionally, to figure out how all the components would fit into the box, we made a SolidWorks model of the box with all the components inside. (In the model, one of the side walls is suppressed so that the components can be seen.)



What we have left to finish on the box is to cut the holes for the temperature and pressure sensor once we have the PCB board. We do not want to cut the holes until then because we would like to determine the exact placement of the holes by measuring the PCB board.

3. Prototype circuit board using breadboard



4. Hack camera and test the hack

We loaded the necessary software onto the camera and were able to successfully make it take one picture every 8 seconds at 1/800 of a second shutter speed, and with the screen and flash disabled to conserve battery life. We were able to combine the photos to create a time lapse video, which can be seen at http://goo.gl/AF3Vs.

5. Test out GPS with InstaMapper

The GPS phone plan was activated, the InstaMapper software was installed, and we carried the phone around, successfully reporting the location back to the InstaMappter website. The tracks can be seen at http://goo.gl/xr1B8. In addition, the photos taken by the camera and the data reported by the GPS unit were combined. We geo-tagged the photos and posted them on a map so each photo appeared on the map on the location at which it was taken.

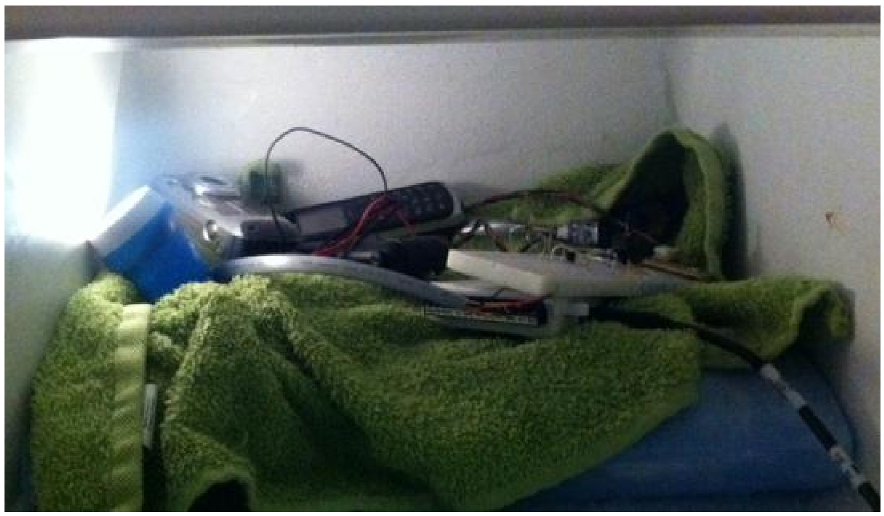
6. Learn how the RC Logger and SPOT and what has to be done to use them in our project

The RC Logger and Spot GPS finder are extraordinarily powerful. The RC Logger has an internal battery and HD camera, plus it writes to SD cards. It attaches via an I/O port to an environmental module, which contains two external and one internal temperature monitors, a pressure sensor, and a humidity sensor. The environmental module takes power from the RC logger and writes to the same SD card. The video setting on the camera is hard-wired to be capped at 1 gigabyte (or roughly 15 minutes) per video shoot, and needs to be manually triggered to start recording again. In order to continuously capture, then, we programmed the logger to take one picture per second, only capped at memory or battery limitations. A 16-gigabyte memory card, which we tested to ensure is compatible, will allow us to take pictures for several hours. The battery is lithium with 800 mAh of energy, which is likely not going to last us that long. We will augment it with an external battery provided by the robotics department.

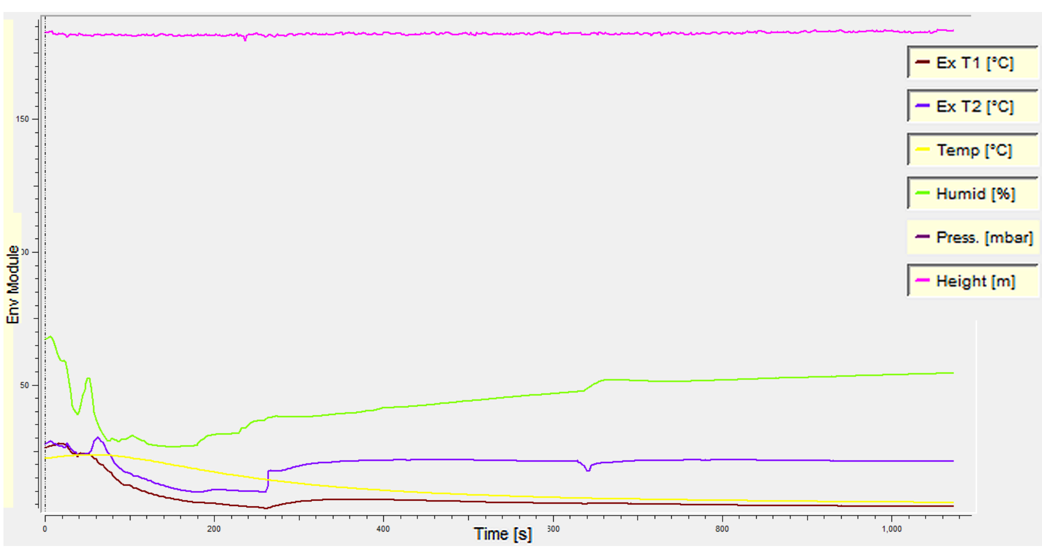
The GPS still has one flaw that makes it unusable as of yet. It is a self-powered, robust piece of engineering that can continuously send GPS coordinates to a SPOT satellite every ten minutes. It is activated on the ground by some piece of technology connected to Bluetooth, after which it continues its most recent command indefinitely. Preliminary testing shows that the signal from the satellite comes in eventually, though not necessarily reliably at every ten minutes; occasionally, a satellite is not overhead when the signal is being sent, so the data misses a beat. Since we only need a single ground data point to retrieve the payload, this is not much of an issue. A larger issue is that the GPS is wired to send a distress signal if it receives no command from Bluetooth after 24 hours. That means that, if we fail to retrieve the payload within 24 hours, helicopters and police will head to our weather balloon, incurring enormous costs. Drew Bennett, Adela Wee, and Dan Kearney are currently collaborating on a safeguard against this worst-case scenario.

7. Test components to see if they work at low temperatures

We tested the camera, the GPS phone, and the circuitry by placing them in our dorm freezer for an hour. The temperature in the freezer was 4C. A picture of the setup in the freezer is shown below.



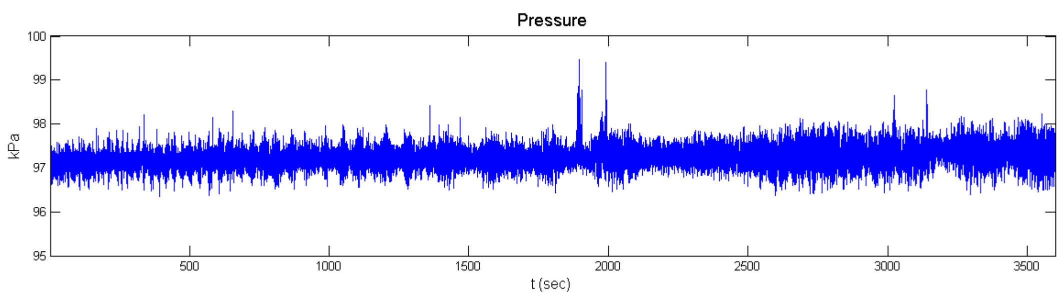
The data collected from the RC Logger during this test is shown below.

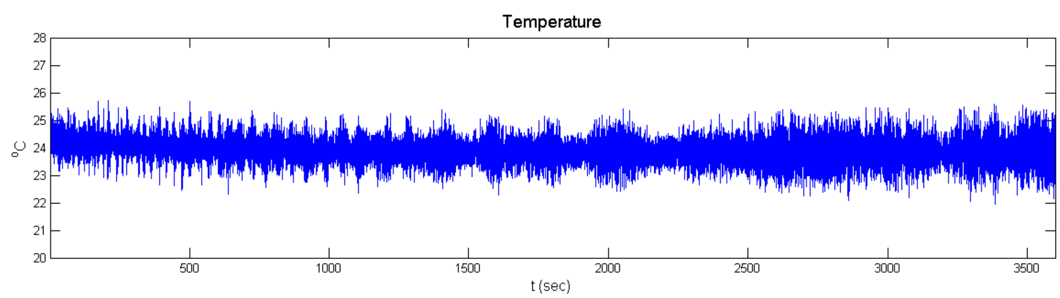


The RC logger data is predictable. There are four important measurements being taken:

temperature at two points, humidity, and pressure. Around t=0, we inserted the RC logger into a freezer. We kept one probe of the temperature sensor outside of the freezer. For the next two hundred seconds, we saw the internal temperature drop to near zero. Since the external probe was touching the freezer wall, that, too, dropped exponentially. around t=250 seconds we adjusted our measurement to prevent that cooling. At that point, the external temperature held steady at around 20 Celsius (near room temperature) and the internal temperature slowly dropped towards zero. We were surprised to see that the internal temperature did not pass below zero; we expect that heat from the other electrical components, plus the fact that the logger was near a wall in the freezer, kept the temperature above freezing. The pressure held steady, which makes sense given that nothing should change the pressure in our steady-altitude experiment. We do not care much about humidity since that sensor does not meet our goals.

The data collected by the circuit and the DAQ is shown below.

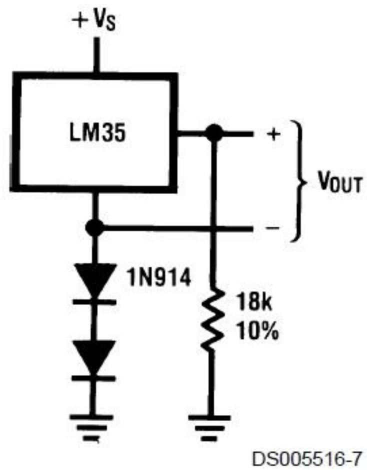


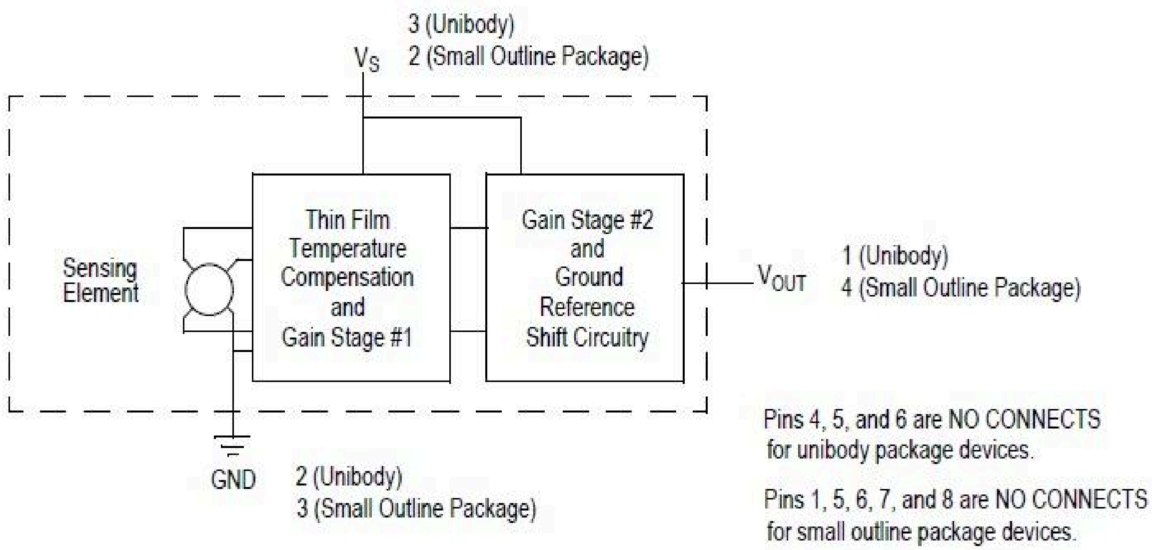


Though the circuit data seems unfiltered, this data is actually highly filtered. Both graphs display an hour of data acquisition. A steady trend in the pressure and a slight decrease in temperature is seen. The temperature data was inadequate due to a probable backwards diode.

A quick note about the circuit:

Though we had an initial circuit design, further research and refinement, along with the resolution to use an alternate power source, has led to a radically different circuit design. The pressure sensor is powered directly from a 5V rail, and its output is sent directly to the DAQ (with reference to 0V). The temperature sensor setup now includes a 250 Ohm resistor to decrease power input, two diodes to rectify the signal, and an additional resistor for grounding. In testing, the temperature sensor responded favorably to a rising temperature, but did not seem to gauge a falling temperature. This may be due to bad calibration, since the calibration settings for the current setup are unclear, or a backward diode during cold weather testing. The pressure sensor worked fantastically well, responding to even tiny fluctuations in pressure, and is well-calibrated. Both sensors responded well to cold-weather testing: the relative accuracy of both didn't seem to change drastically. Software low-pass filters were used to filter out interference in the data, as they will be used in post-processing after the weather balloon flight. This filtering greatly increased the fidelity of the data. Below are the current circuit configurations for each sensor. For reference, we're using a unibody pressure sensor.





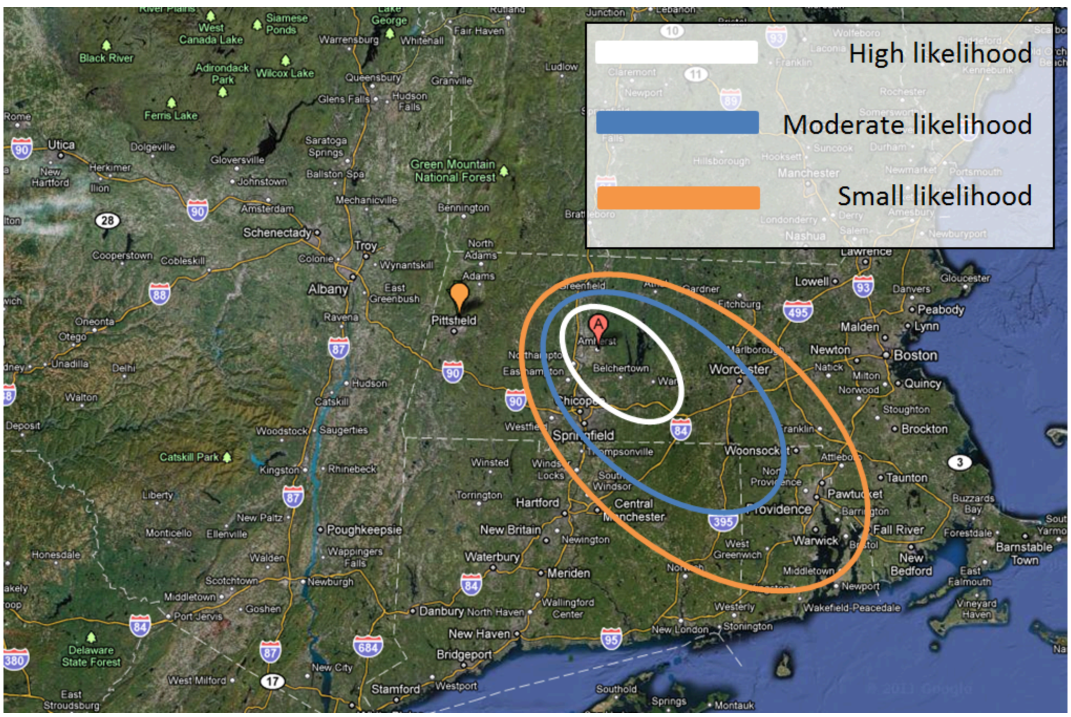
8. Put electronics in the container with holes for the sensors and apertures.

The electronics we placed in the box (minus the PCB and the SPOT) to ensure that we would have enough space.

And then holes we cut out for the camera lens and the RC Logger, ensuring that there would be no blue foam in the eyesight of either camera. (We tested that there would be no blue foam in the the camera's view by taking pictures). The camera hole, which is cone shaped so as to avoid getting blue foam in the pictures, is shown below.

9. Determining our launch site

We used the University of Wyoming balloon simulator, a deceptively simple one that takes only launch position and burst height as arguments, to determine an estimate for our balloon's touchdown point. The simulator assumes that the weather balloon has average ascent rates and parachute drag coefficients, which we are adhering to. A weakness of that simulation is that it only works for the following two days. The MIT team that we have based much of our design off of launched from Sturbridge, Massachusetts. On a windy day, the UWyoming site estimates that a Sturbridge launch will cause the balloon to land in the ocean off Nantucket. This illustrates the extreme case--that a balloon might drift one hundred miles southeast before landing. Since we want to be prepared for a windy day (and have no intention of rescuing our balloon from the ocean), we want to launch from farther inland. A reasonable place to launch from is Amherst, Massachusetts. Amherst is about 120 miles inland, and the projected trajectory will cause it to most likely land south of Worcester and north of Providence, avoiding congested airspace. The in-between is sparsely populated. Furthermore, Amherst is a town overwhelmingly populated by college students, and so there will be ample space to launch weather balloons from with minimal interference and is about 1 hour 50 minutes away from Olin by car.



This graph shows the most likely landing regions of our weather balloon. Winds tend to blow in a south-easterly direction, and we will most likely wind up around 30 miles from our launch point. On the extreme side, strong winds could pull the balloon up to 100 miles south east, or 50 miles north west.

10. Getting outside support and advice

We are sending emails to graduate students at the University of Kansas, who recently released a similar weather balloon (http://goo.gl/qAVM0). In addition, we sent an email out to the highly publicized team at MIT who made this thing popular (http://space.1337arts.com/). In addition, there is a Babson meteorology professor who is interested in the weather balloon project who we will contact soon. When we hear back from these people, hopefully they will be able to give us advice and correct us if anything we are doing seems incorrect. This will help us insure a higher chance of successfully getting our balloon to the desired height and retrieving it.

What we plan to do next

Next, we are going to attempt to fix the temperature sensor. After that, we plan to print a PCB (hopefully this week) and then conduct our tethered weather balloon test by April 16th (this Saturday). We are on schedule to launch our untethered weather balloon on the weekend of April 23rd and 24th, provided our weather balloon and parachute arrive in the next week and a half.