NORTHWEST INDIAN COLLEGE
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# 2011-2012

# Northwest Indian College Space Center
# Team SkyWalkers
# USLI Post Launch Assessment Report


Northwest Indian College Space Center
Xwlemi Elh>Tal>Nexw Squl

# Contents

**Northwest Indian College Space Center – Team SkyWalkers**
**Post Launch Assessment Report**

# I) Team Summary

### *Team Name*

Team SkyWalkers
Project Skybolt
Northwest Indian College, 2522 Kwina Road, Bellingham, Washington, 98226,

# II) Launch Vehicle Summary

### *Dimensions (without/with motor)*

| | | | |
|---|---|---|---|
| Length | 112.625 in | Diameter | 4.025 in |
| Weight | 19.2/23.67 lbs | Fin Span | 12.025 in |
| Center of Gravity | 63.424 in | Center of Pressure | 76.287 in |
| Static Stability | 3.2/1.91 | | |

### *Motor Choice*

Cesaroni Technology Inc L640

### *Altitude Reached*

4,830 feet

### *Flight Performance*

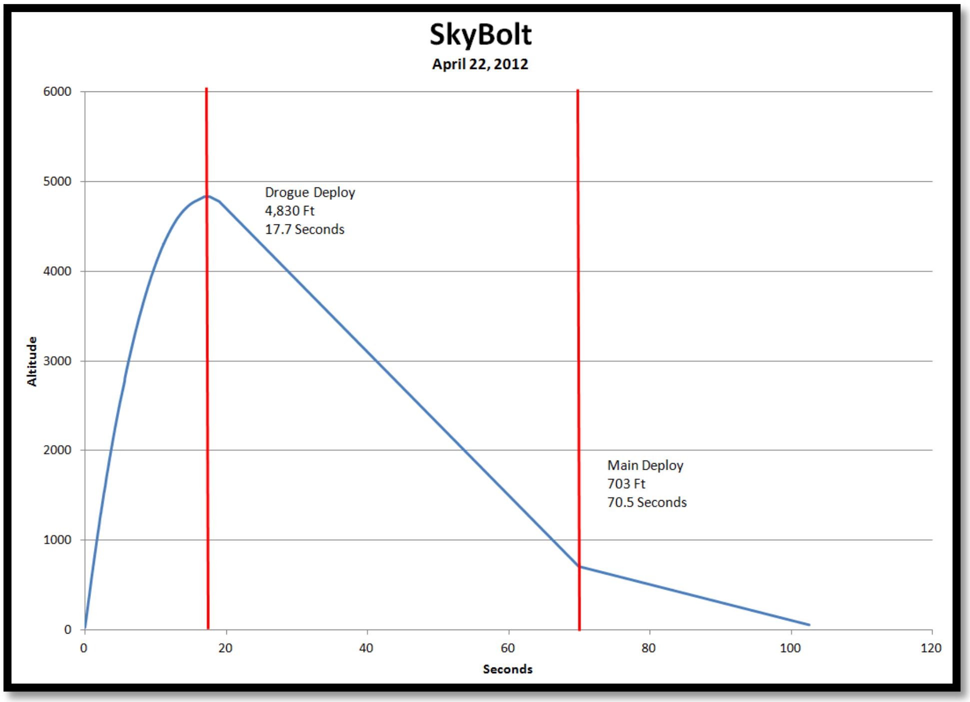
Sky Bolt passed the Flight Hardware and Safety Check on Wednesday, April 18, 2012 with only one item on its punch list, to make certain that the nosecone retaining screws were in place. Needless to say, we were very pleased with our responses to the NAR officials and the soundness of our rocket's design and construction.

Our rocket launched, flew, deployed its drogue and main parachutes, and landed as designed. The rocket landed slightly more than 0.8 miles from the launch pad. We could not adjust the launch rail angle into the wind to adjust for the wind; and we had to angle the launch rail away from the wind to avoid flying over the observers. Both of these factors contributed to the rocket landing further than our calculated drift chart.

According to the collected weather data collection from our Kestral portable weather station, the winds were blowing 10-15 mph with gusts to 20 mph. After our rocket landed, the wind picked up the main parachute and dragged the rocket an additional 0.5 miles from its landing spot.


*GPS Tack, Launch, Touch Down and Recovery*

The official read our marked altimeter for an altitude of 4,830 feet; unfortunately somewhat short of the 5,280 foot target. Both of our PerfectFlite Stratologgers performed as designed. We've included Altimeter #1's data as #2 is within 2 feet of being identical.



### *Recovery System*

Our rocket is equipped with a redundant recovery system consisting of two PerfectFlite StratoLogger altimeters that are electrically independent of each other. The recovery harnesses are 20 feet and 30 feet long for the drogue and main respectively. They will maintain the connections between ebay and the aft airframe and the ebay and the forward airframe. The primary altimeter ejected the drogue at apogee and the secondary altimeter detonated the ejection charge 1 second after apogee. The primary altimeter ejected the main parachute at 703 feet and secondary altimeter fired the backup charge at 650 feet. Landing was calculated to have a maximum kinetic energy of 56 ft-lbf.

## III) Payload Summary

### *SMD Project*

The objective of the atmospheric project is to collect data and learn to analyze that data and report it in a meaningful way. We worked with the Native Environmental Science students and the math instructor to analyze the data. We wanted to advance our developing skills in sensor data collection, micro-controller programming, and systems integration with this project.

This payload is significant because it will capture data about the atmosphere, and this data can be analyzed and perhaps used by students in the Native Environmental program of study when we do our own launches on the Lummi Nation Reservation.

The scientific payload measured temperature, humidity, pressure, ultra-violet radiation, and solar irradiance and took photos oriented with the sky to the picture's top. The experiments' objectives were to measure the changes in a column of air described by the apogee and the range at touchdown. Our column was 4,380 feet high by 3,168 feet wide. Appendix I has detailed weather information from our ground-level Kestrel portable weather station.

Basic weather conditions between 7:45 am and 10:00 am were:

| | |
|---|---|
| Temperature: | 44° increasing to 52° |
| Wind: | 8-14 mph |
| Wind Direction | Mostly Northerly |
| Humidity | 93% falling to 67% |
| Cloud Cover | Mostly cloudy to clear |

### *Power Management System Project*

The power management system was designed to prevent the vehicle from flying higher than 5,280 feet, the target altitude. Data was collected using a numerical simulation that factored in various variables and then plotted the data using the motor burn characteristics of the CTI L640. The variables were:

Rocket Mass (empty)
Motor Case mass
Propellant mass

Diameter, rocket
Impulse, motor (N-sec)
Thrust (Newtons)
Air Density (kg/m^3)
Drag Coefficient
Time Increment
Mass Decrement (propellant burned)
Gravitational Constant
Area, (widest part)
Air Brake Area
Burn Time
Air Brake Deploy Time
Drag Coefficient after brakes deployed

The motor information included key burn times associated with mass loss and thrust; this data was gathered from the motor's thrust curve.

## *SMD Payload Data*

### Experimental Design

The SMD criteria required us to transmit the data live to our ground station. Data retrieval took place during descent, while on the ground for 10 minutes. All of the sensors fed data to an AED RDAS-Tiny expansion board and was then transmitted through a 900 MHz transmitter to a receiver connected to a laptop. Appendix IV shows the instrument block diagram, the data flow, and a picture of the instrument package.

We used a microcontroller to control the sensors and to parse the data for transmitting. A datalogger did on-board data storage as a backup. We had a second microcontroller, power supply and data logger acting as backup to providing system redundancy. A totally catastrophic failure is the only reason that we wouldn't be able to collect meaningful data.

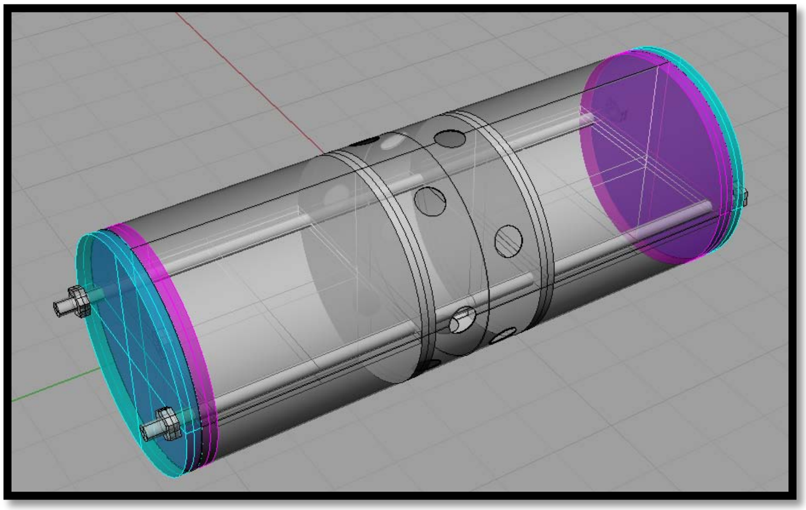
The microcontroller is the Arduino Uno. The Arduino Uno is tasked with controlling the sensors and collecting data from all of the sensors and sending the data to the Adafruit Data Logger and then to the 900 MHz transmitter. The Adafruit Data Logger stored the data on an SD card, which is easily accessible after landing.

The software used for the payload was developed using the Arduino Development Environment. The Arduino software also tagged all of the data and video with time data. In doing this, all sensor data can be related to other data taken at the same time. The sensor data was saved as a comma delimited text file for easy parsing.

## Payload Instrument Container

The UV and IR, humidity, and temperature sensors were located on a horizontal bulkhead that maintained a near vertical orientation during descent.
Circular vents allowed atmospheric equilibrium for the barometric pressure sensor as well as allow atmospheric access for the humidity and temperature sensors. The center section's interior in the diagram below is covered aluminum duct tape to better distribute the incoming light and UV rays.

***Payload Instrument Container***



## Baseline Data

We evaluated our atmospheric sensor modules by comparing the sensor results with standard scientific measuring tools such as laboratory quality thermometers, barometers, and hygrometers.

The instruments were mounted in the payload instrument container. Baseline data was collected prior to flight both on the ground and in test flight #3. The data and resulting charts are in Appendix II and Appendix III. Our instrument recorded a sample once a second.

***Instrumentation Precision, Repeatability and Data Recovery***

| Instrument | Sensor | Capability |
|---|---|---|
| AED Electronics | Temp | Temperature measurement: -40 to 85 deg C, resolution 0.22 deg C (-40 to +185 deg F, resolution 0.39 deg F) |
| | 2-Axis Accelerometer | Configurable range: +/- 50g, +/- 25g, +/- 10g and +/-5g (each axis can have a different scale) |
| Barometric Pressure Sensor - BMP085 Breakout | Barometric pressure | 300-1100hPa (+9000m to -500m) |

| Measurement Items | Illuminance | Ultraviolet Light |
|---|---|---|
| Measurement Range | 0 to 130,000 lx | 0 to 30 mW/cm² |
| Measurement Resolution | Minimum: 0.01 lx | Minimum: 0.001 mW/cm² |
| Measuring Accuracy | 10 to 100,000 lx: ±5% (At 25°C 50%RH) | 0.1 to 30 mW/cm²: ±5% (At 25°C 50%RH) *1 |
| Relative Spectral Response | Approximated to the CIE standard response function V ( ë ) | 260 to 400 nm |
| **Measurement Items** | **Temperature** | **Humidity** |
| Measurement Range | 0 to 55°C | 10 to 95%RH |
| Measurement Resolution | 0.1°C | 1%RH |
| Measuring Accuracy | Avg. ±0.3°C | ±5% (At 25°C 50%RH) |
| Sensor Response Time | About 7 minutes (90%) | |
| Humidity Hysteresis | - | ±1%RH (30 to 90%RH) |

## Illuminance

The solar irradiance unit determines how much available sunlight there is at a location. The silicon pyranometer is based on a PIC16F88-I/P microcontroller. Its probe will be mounted in the probe section of the science payload bay. The irradiance range it from 0 to 1520 watts per meter squared ($W/m^2$). The resolution is 0.001 $W/cm^2$. Readings are taken every second. Data collection will start when the vehicle is on the launch rail prior to arming the altimeters.

## UV

The TR-74Ui will measure Ultraviolet Radiation with one of its probes. Its probe will be mounted in the probe section of the science payload bay. The UV range is from 0 to 30 milliwatts per square centimeter ($mW/cm^2$). The recording level is one reading per second. Data collection will start when the vehicle is on the launch rail prior to arming the altimeters.

## Temperature

The TR-74Ui will measure the temperature with one of it probes. Its probe will be mounted in the probe section of the science payload bay. Data collection will start when the vehicle is on the launch rail prior to arming the altimeters.

## Humidity

The TR-74Ui will measure the relative humidity with one of it probes. Its probe will be mounted in the probe section of the science payload bay. Data collection will start when the vehicle is on the launch rail prior to arming the altimeters.

### Barometric Pressure

The barometric pressure will be logged and transmitted with the BMP 085 barometric pressure sensor. The sample rate is 4 times per second and it takes 13.5 milliseconds to conversion time for pressure.

## *Data Analysis*

After landing, the vehicle was dragged for more than 15 minutes at speeds up to 3 mph for a total distance of 3,298 feet. The dragging started within seven minutes of touch down.

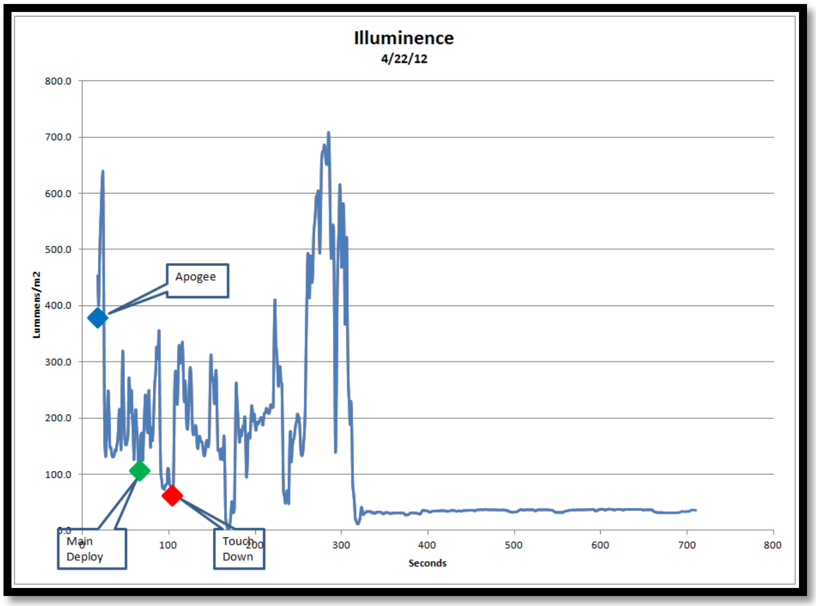
The flight profile used for the data analysis is as follows:

Launch: 9:51:37
Apogee: 9:51:54
Landing: 9:52:57
End of Data Collection: 10:02:57

Data for analysis is from 9:51:54 CDT to 10:02:57 CDT. The data was received at our ground station. Some of the data is suspect because of the instruments being dragged behind small knolls and into ground depressions.

Regardless of the intent and mechanics designed to keep the sensors oriented in the same position throughout the measurement period, motion from a non-stationary body has not been entirely eliminated. Swaying at the end of the recovery harness most likely affected the data during the data collection period.

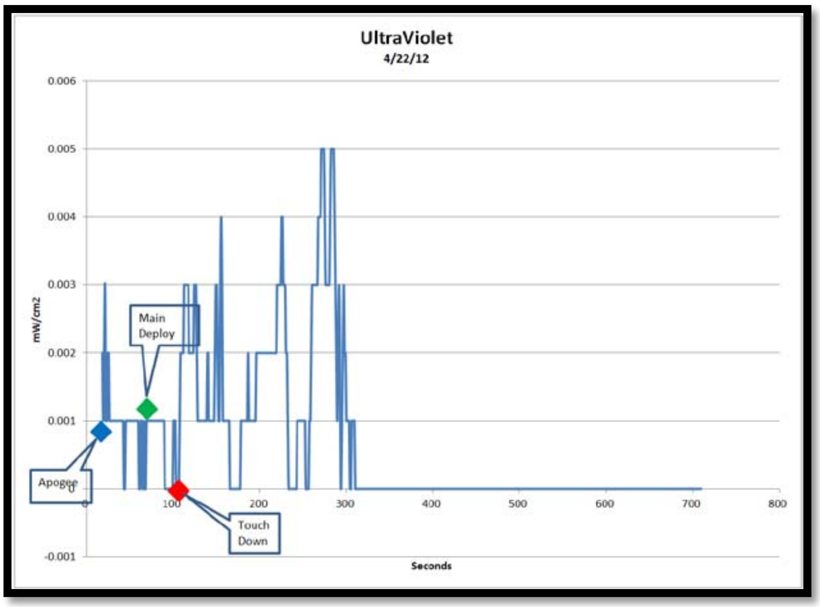
### Illuminance Analysis




*Data collected from apogee to 10 minutes after touch down*

The first big rise in the chart is 9 seconds after apogee. We surmise that the rocket passing through its arc at apogee oriented the sensors more directly at the sun. After drogue deployment the data became more rhythmical, probably due to the swaying while under the drogue parachute followed by swaying while under the main parachute. The remaining oscillations are most likely due to the rocket being dragged through the field at Bragg's Farm. The flat line is interesting. Speculation is that for this period of time the rocket was lying in the shade (temperature analysis negates this) or perhaps one or more of the parachutes covered the sensor ports.

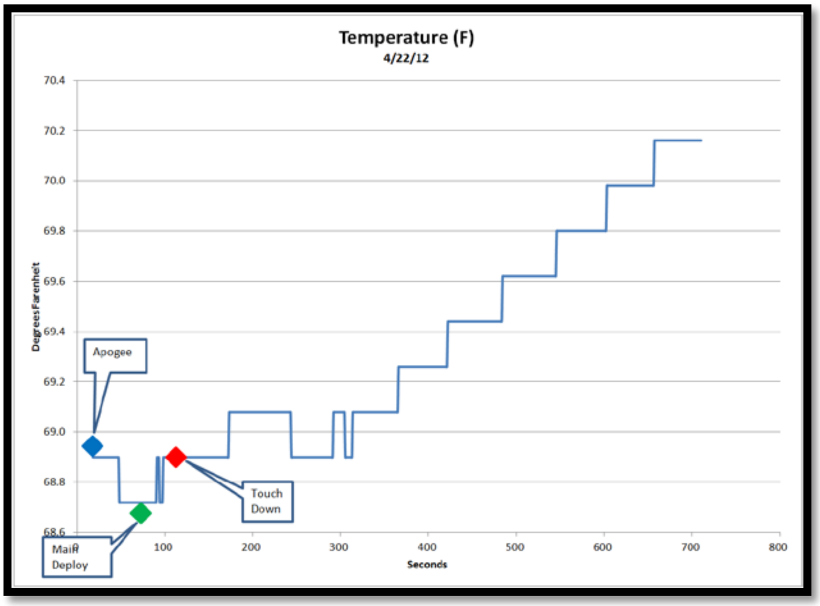
## UV Analysis




*Data collected from apogee to 10 minutes after touch down*

This data pattern follows the Illuminance data pattern because both sensors rely on sunlight impinging upon them.

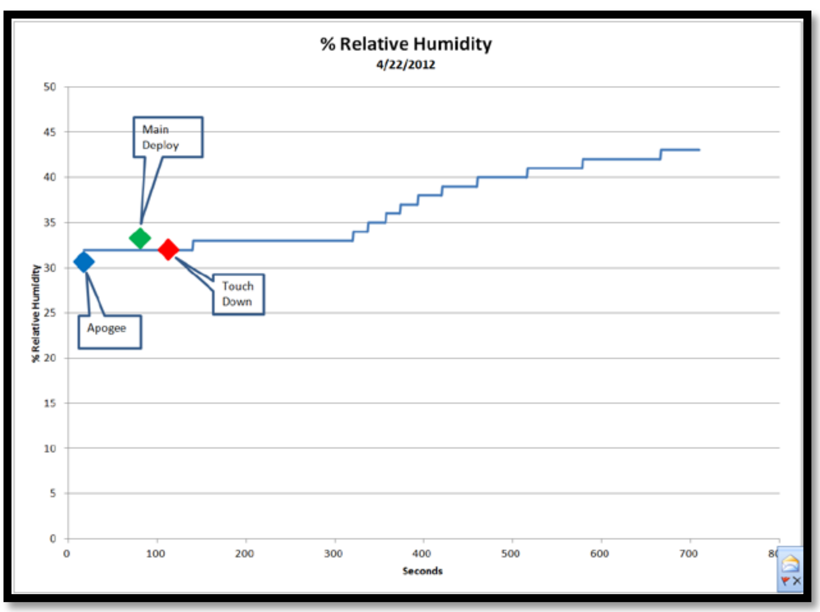
## Temperature Analysis




*Data collected from apogee to 10 minutes after touch down*

The Temperature data shows a similar pattern to the Illuminence and the UV data between apogee and touchdown. There is a dip and then after touch down the data starts increasing. The major difference is that the temperature keeps rising after the touchdown point. This supports the theory that one or more of the parachutes covered the sensor ports allowing the interior temperature to rise rapidly as result of the sun hitting the rocket in the bare field.

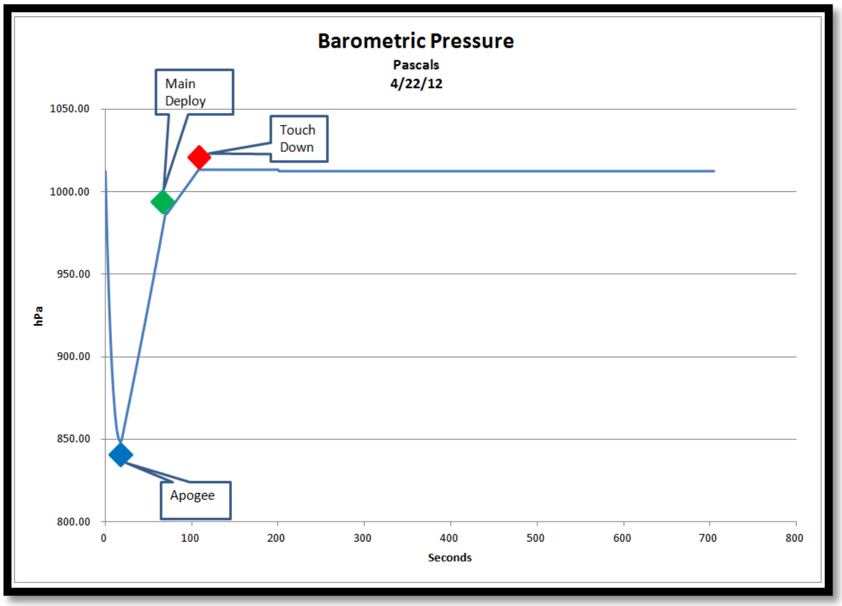
## Humidity Analysis




*Data collected from apogee to 10 minutes after touch down*

The Humidity data follows a similar pattern as the other data. Again, the rise in humidity suggests heated air entrapment with something similar to the parachutes.

### Barometric Pressure Analysis




*Data collected from apogee to 10 minutes after touch down*

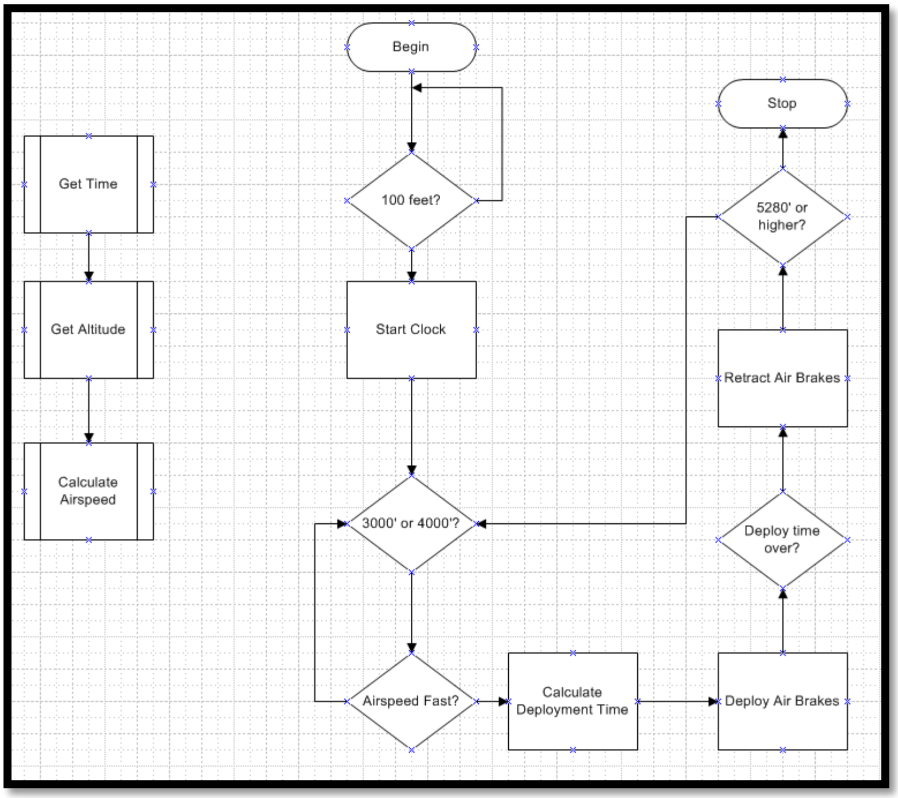
The barometric data is nearly the inverse of the altimeter data. There is a slight increase in pressure at the 70 and 200 second marks. This roughly corresponds to the changing pressure that we noted from our weather ground station.

## *Power Management*

We wanted to branch out into an engineering type project to see what we could accomplish. As a result, we are attempting a power management system to give us more control of the rocket's flight to its altitude target.

The objective of the power management project is to see if we can put into practice ideas that involve engineering and construction skills beyond rocket construction and launching. This will develop our analytical, programming, engineering, and construction skills. Our team is composed of primarily 2-year students seeking direct transfer degrees with plans to attend a four-year university in such fields as education, humanities, science. The non-emphasis of science and math skills has been both a detriment and boon. A detriment in that nearly everything we do has to be learned from beginning levels; a boon in that we are not hamstrung by "conventional" solutions or attitudes toward the issues that we face.

An Arduino microcontroller interfaces with a BMP085 barometric pressure sensor and a real time clock to measure altitude and airspeed. There are two check points that the microcontroller's program will check; one at 3,000 feet and the second at 4,000 feet. It will be looking for a target pair of altitude and airspeed. If the air speed is low or correct for the target altitude, nothing happens, if the airspeed is high, then the microcontroller will calculate an approximate length of time to deploy the air brakes. This procedure will repeat at 4,000 feet.




*Flow Chart for Power Management System*

*Air brakes extended* *Air brakes retracted*

## Power Management Data Analysis

We don't know if the air brakes worked or not. We suspect that they didn't because of the lower than targeted altitude. Of course they could have partially worked and caused the altitude of 4,830 feet instead of the 5,280 foot target. We relied on our cameras to show the extending and retracting of the air brakes. The cameras will be addressed in the next section.

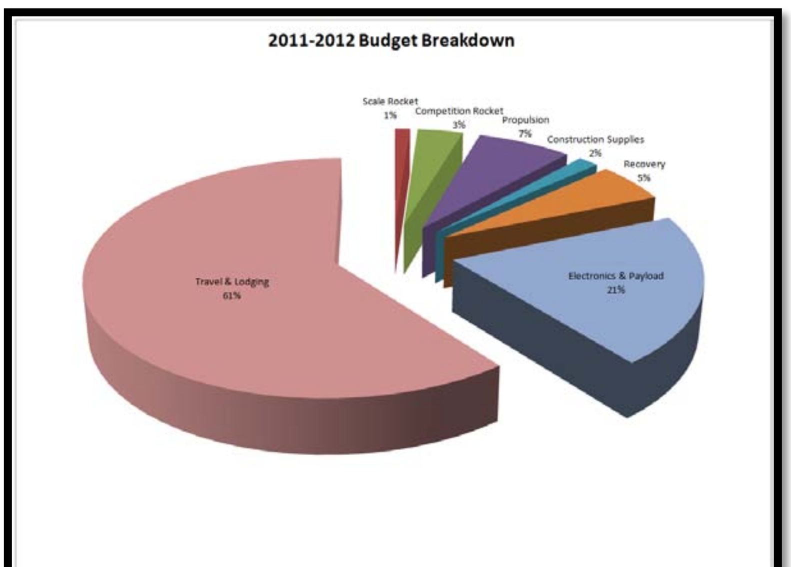
### *Photography*

A camera, 0.5 x 0.75 x 2.75 inches in size, will be mounted on the airframe near the nose cone. It will be mounted in an inverted position so that it will record with the sky at the top of the picture frame after the drogue parachute has deployed and is descending. Three additional cameras are mounted in line with the fins will ensure that at least one of them will record with the proper orientation. They will also monitor the movement of the air brakes. Each of the cameras will be powered by a battery pack that will record for at least two hours. The cameras will start recording when the altimeters are armed.

### *Photography Data Analysis*

Our cameras did not function as we had planned. Two of the thee exterior cameras lost data due to the damage suffered while being dragged across the country side. The remaining exterior camera and the horizontally placed interior camera batteries died within minutes of liftoff. The exterior camera was inadvertently activated prior to carrying the rocket to the launch pad. The interior camera was intentionally activated prior to going out to the launch pad; however, the cold weather may have shortened the battery’s storage capacity.

## IV) Budget Plan




| Budget Summary | |
|---|---|
| Scale Rocket | $144.37 |
| Competition Rocket | $439.13 |
| Propulsion | $911.97 |
| Construction Supplies | $200.00 |
| Recovery | $696.60 |
| Electronics & Payload | $2,604.95 |
| | $4,997.02 |
| | |
| Travel & Lodging | $7,700.00 |
| | |
| **Project Income** | |
| | $13,000.00 |

We stayed within budget! Travel and lodging, an enormous part of the budget!

## V) Educational Engagement

As of the report submittal, Team SkyWalkers have participated in the following educational engagement activities:

- AISES National Conference
- Windward Discovery Academy (Special Education Students)

- AISES Presentation at Northwest Indian College
- NASA's Future Forum at Museum of Flight, Seattle, WA
- Fairhaven Middle School
- Shucksen Middle School
- Bellingham High School
- Lummi HeadStart
- Lummi Nation School
- NOAA and NWIC Career Fair

Additionally, we are published near monthly in the Lummi Nation paper, "Squol Quol".

We've also been recognized by the "Tribal College Journal".

http://indiancountrytodaymedianetwork.com/2012/02/07/at-northwest-indian-college-its-rocket-science-as-students-apply-learning-to-competing-96150

And in an article in 2012 February's "Indian Country Today"

http://www.tribalcollegejournal.org/archives/7918

And we have a NASA webpage devoted to us.

http://www.nasa.gov/audience/foreducators/postsecondary/features/inexperience-stop-flying.html

Our outreach is focused on middle school aged students. However, we recognize the importance of a successful Native American science endeavor. We need to take this and reach as many people as possible. It is a vast contradiction to how many view Native Americans.

# VI) Conclusion

The overall success of the SkyWalkers is dependent upon dedication, hard work, and the excitement of doing something that few of us have previously done.

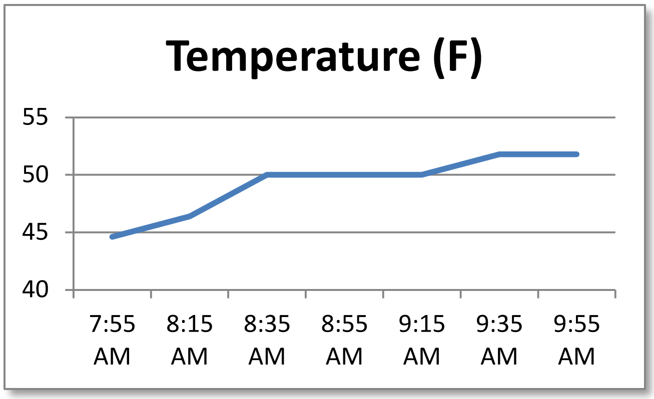
Our major reasons for doing this are to enhance the learning and knowledge of our team members. All of the team members want to be challenged and to build upon last year's team success. *(Advisor's note: several administrators and faculty members have likened the Space Center's activities to a major university's successful athletic team. This project has brought pride to both the college and the Space Center's team members.)*

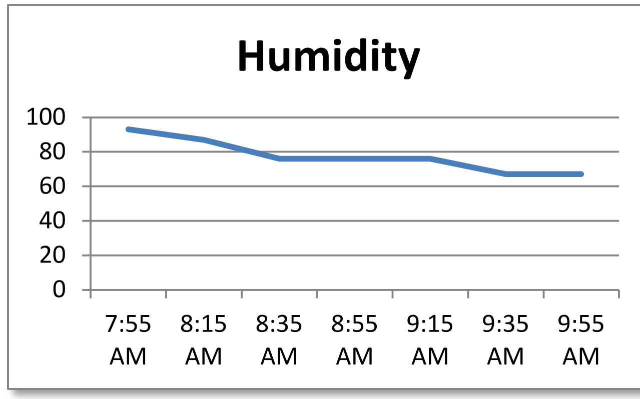
Imagination and the resultant ideas often meet challenges in the execution. This is where the USLI project and rocket program has greatly benefited NWIC students.

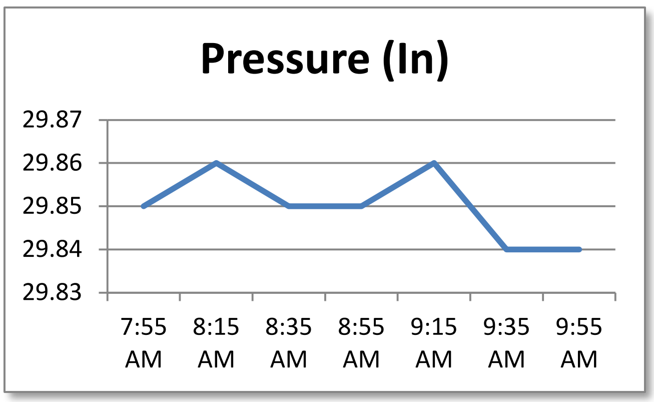
### Lessons Learned

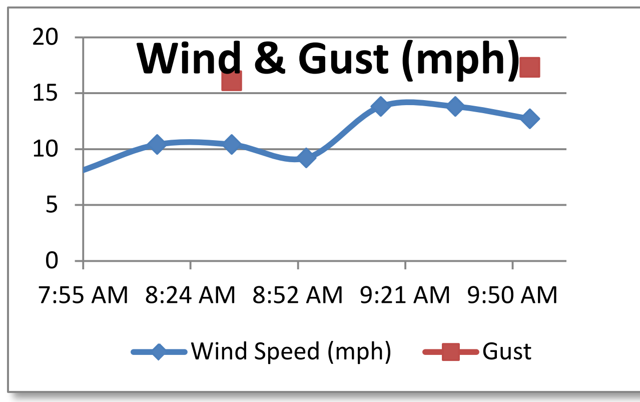
1. Better cameras – they have not performed as designed or intended at either of the USLI launches.
2. Better protection for the cameras – we did not anticipate the rocket being dragged for such a distance or time

## Appendix I – Ground Level Weather Conditions, April 22, 2012, Braggs Farm

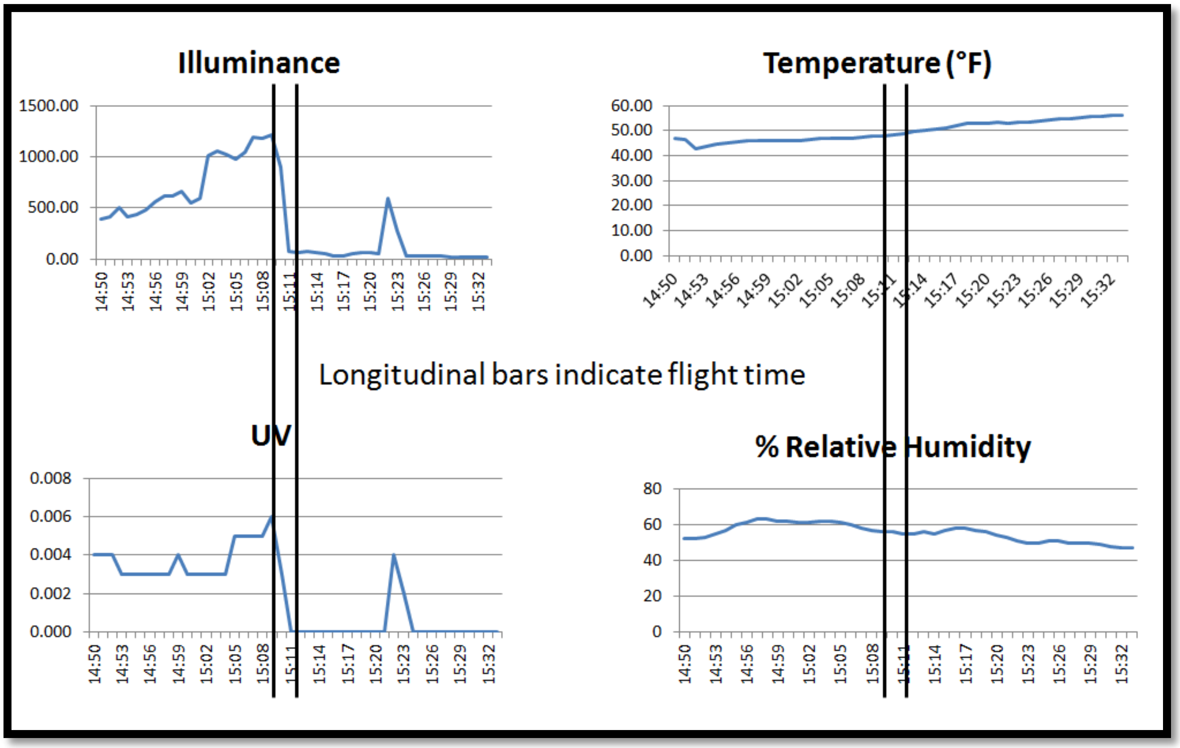


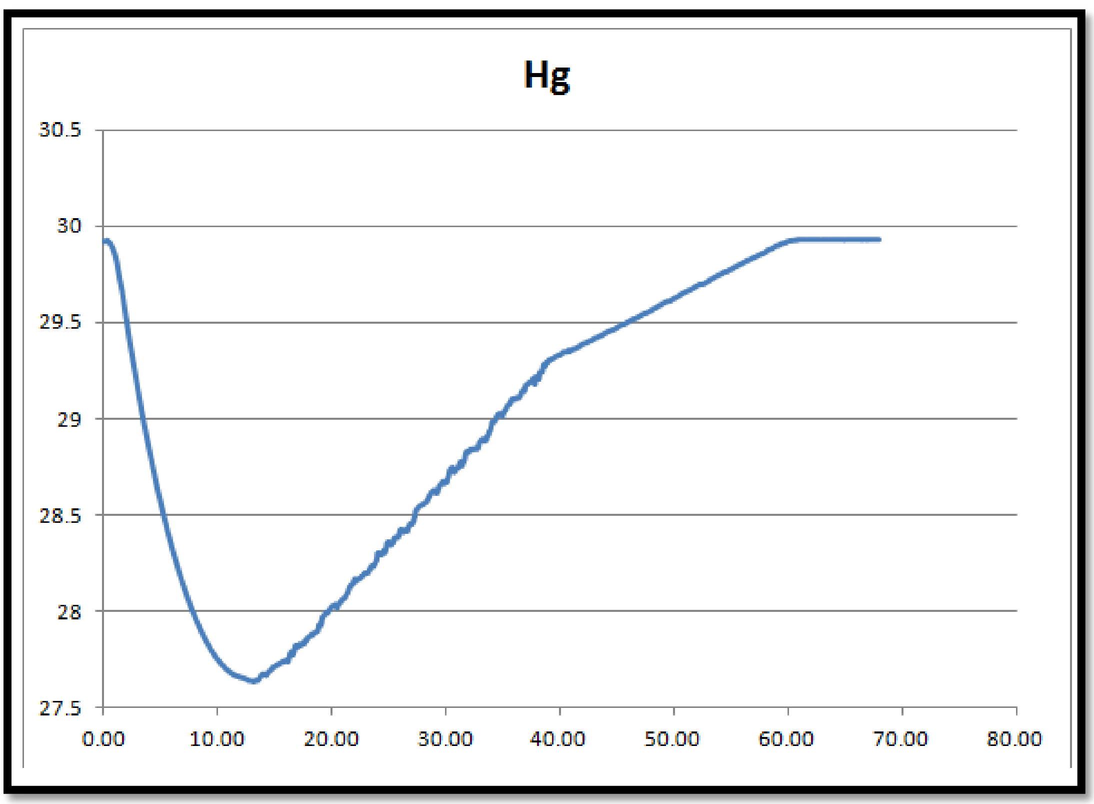



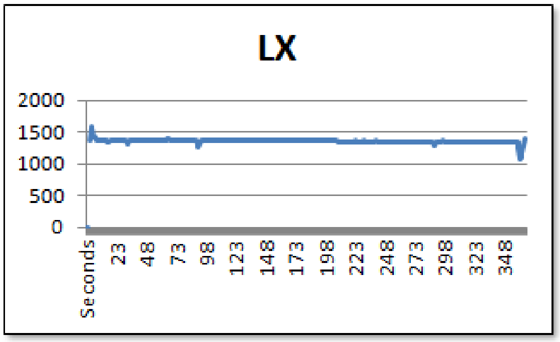
# Appendix II – Test Flight #3 Sensor Data

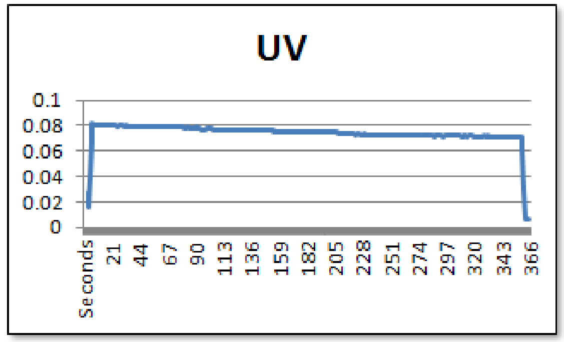


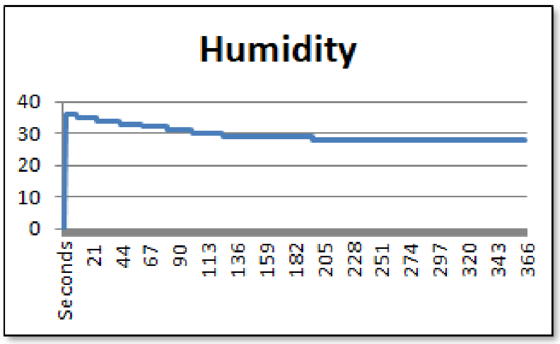



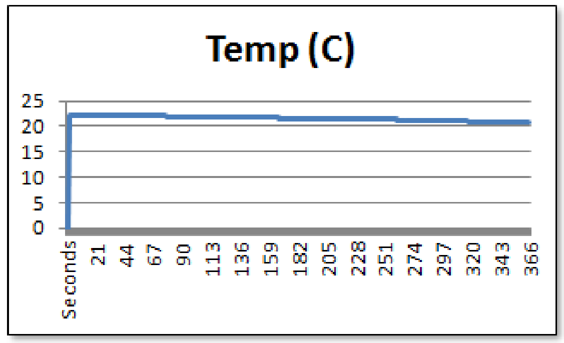

Barometric Pressure

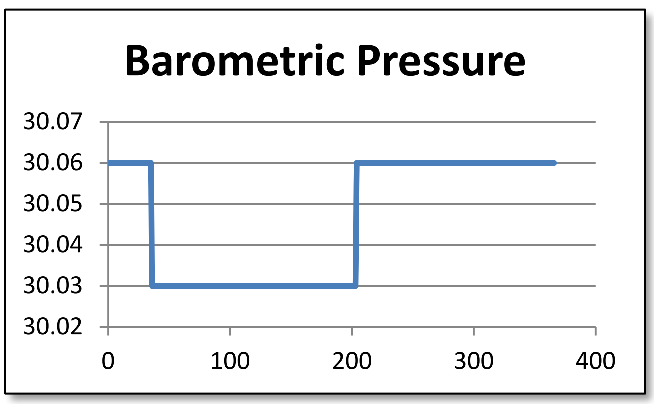
## Appendix III – Baseline Data



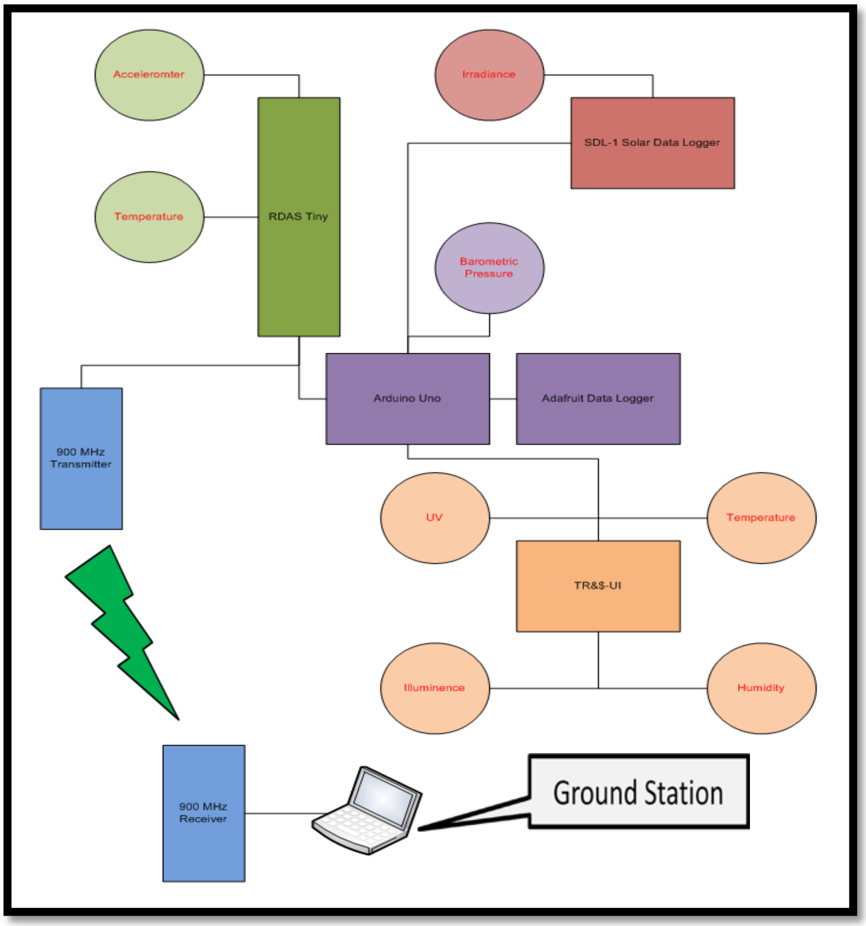



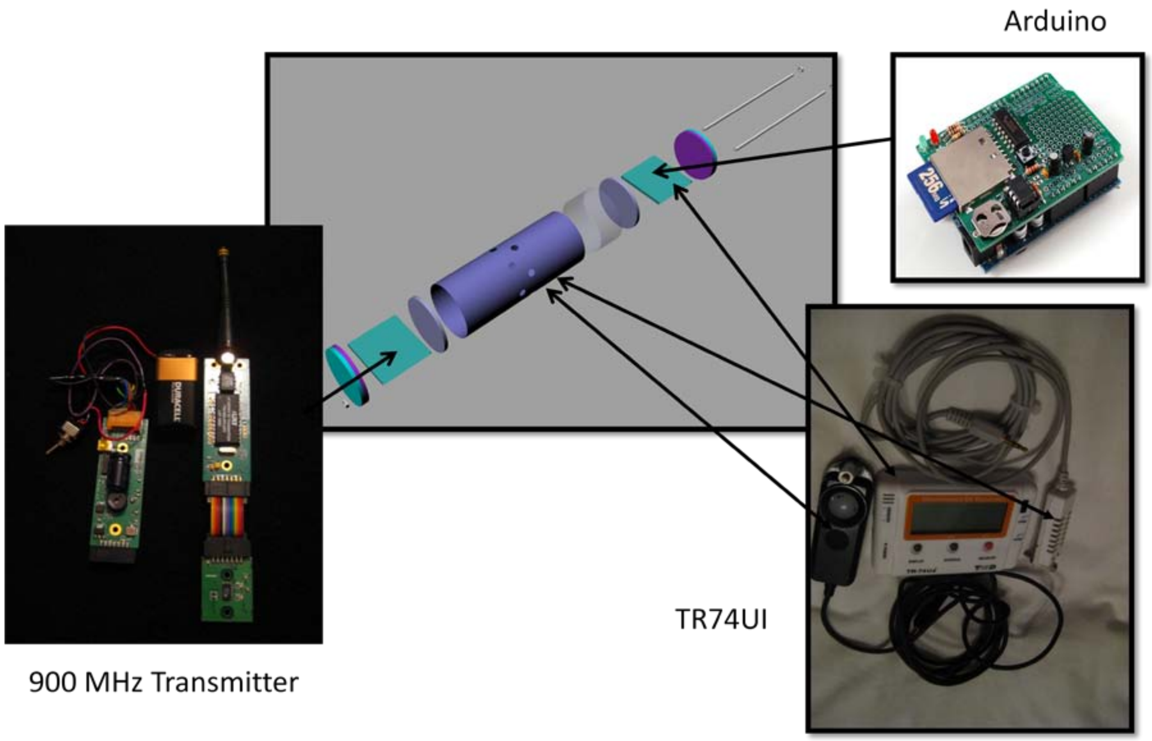



# Appendix IV – Sensor Data Flow Diagram & Locations




Arduino
TR74UI
900 MHz Transmitter