Pioneer Rocketry

University of Wisconsin - Platteville

# Design Report

Wisconsin Space Grant Consortium

Collegiate Rocket Competition

2013-2014

# Contents

# Executive Summary

The 2013-2014 season marks Pioneer Rocketry's (PR) second year in the Wisconsin Space Grant Consortium's Intercollegiate Rocketry Competition. After Placing fifth overall in the 2012-2013 competition, the team has returned to put their best efforts towards the design and construction of a rocket which would best meet this year's competition parameters. The winning design this year will be determined by measures of altitude, time, and the ability to log data during flight.

The Teams' have been challenged to reach a target altitude of 3000 feet and return their rocket in the shortest time possible back to the launch pad. Additionally, a post-flight analysis of the rocket's data logging systems will be performed to determine in-flight velocity. Time and altitude will both calculate into flight performance, while data logging ability will factor into the overall team score. To accomplish these tasks, PR has broken into four main sections whose responsibilities include the airframe, electronics, simulations, and construction.

By popular vote, the competition rocket was titled *Pioneer-1*, and stands much taller than last years' rocket, *Still Dreaming,* at a full six feet. This, coupled with a four inch diameter body-tube allowed for the installation of both an extended avionics bay (AV-bay) and an innovative weight-adjustment system which will be used to quickly calibrate the stability margin and target altitude of Pioneer-1 come launch day. The extended avionics bay allows room for three data loggers, one GPS system, and one Raspberry Pi ® microcomputer, which will be used to record video from an onboard camera. The design process was influenced heavily by heuristics, and simulations through OpenRocket ©. Construction included the use of fiberglass reinforcement of the lower airframe and marine-grade epoxy for bonding the rocket sections and joints. Pioneer-1 will be launched using a CTI J-357 motor, whose max thrust of 150 lbf will be optimal for achieving the target altitude bracket.

Over the past seven months, Pioneer Rocketry has made significant investments into both the growth of its organization and the development of skills necessary to design and construct high powered rockets. In early Spring of 2014, two additional PR members received their level one HPR certifications on resources provided through our group. Emphasis was wade on team development, and elections were held to fill the newly drawn eight executive positions. Under these positions it is hoped that we may be able to expand and diversify our member base, and lend credit to aerospace applications as part of an undergraduate college curriculum. We are looking forward to the competition launch this coming spring of 2014, and the challenges that it brings.

Ad Astra.

Pioneer Rocketry

## 2013-2014 Timeline

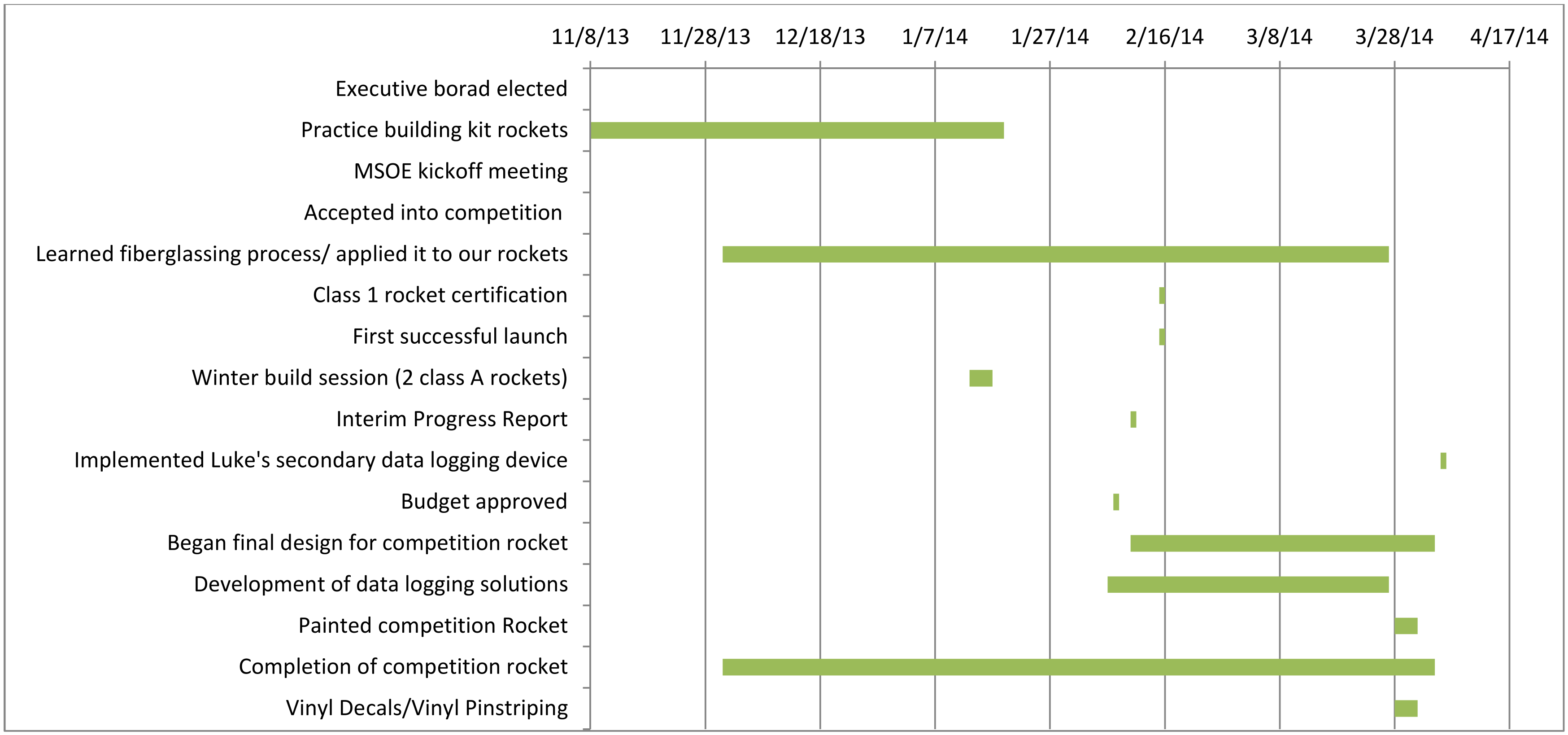



*Table 1: Gant Chart outlining timeline for work during 2013 – 2014 Competition*

# Design Features of Rocket

1. **Nosecone**

The nose cone selected for Pioneer-1 is a 16.75 inch polypropylene nosecone from Public Missiles. The shape of the nosecone is a tangent ogive, which is formed when a circle arc tangent to the body tube is revolved around the axis of t the rocket. The tangent ogive nosecone was selected because it offers good stability and drag characteristics. We have a lot of experience using tangent ogive nosecones as the previous competition rocket has used similar designs.

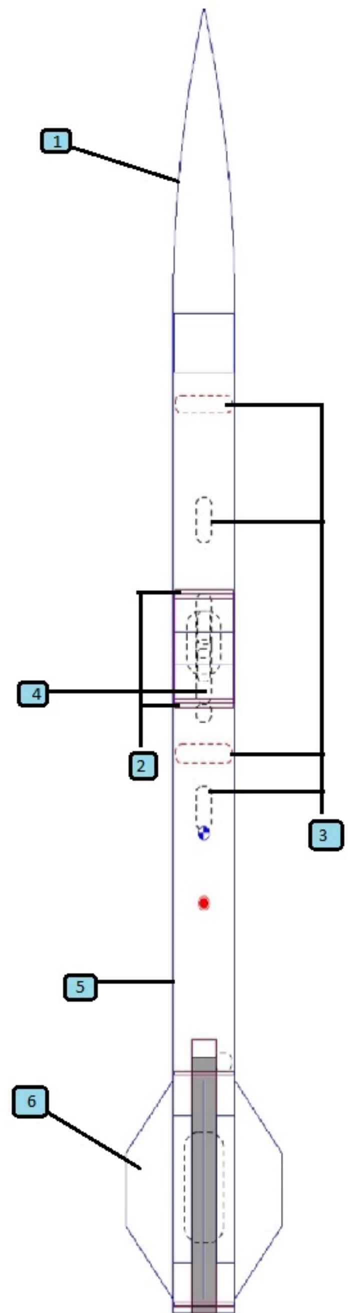



*Figure 1: Labeled Design of Rocket view corresponding section for more information.*

2. **Control & Stability Systems**

Last year's rocket had interchangeable tubefins that would be attached to the payload section of the rocket to increase drag and lower the apogee. For this year's rocket it was decided not to control altitude using drag but rather have a system of interchangeable weights. Using an interchangeable weighting system the weight of the rocket can be varied to control its flight. These weights will be attached to either the top or bottom of the avionics bay bulkhead. Through the process of selecting a certain weight and location, both the center of gravity and overall weight of the rocket can be varied to control the flight of the rocket. More information of the weighting system can be found below.

## 3. **Recovery Systems**

Per the competition parameters, Pioner-1 operates on a dual deploy parachute system including one drogue chute and one main. Commonly, HPR parachutes are made from a single cut of ripstop nylon which when filled open into a parabolic shape. A notable feature of our parachutes are that they are completely hemispherical, and also employ spill holes in their centers. “Squidding” is a term used for when a parachute fails to inflate fully, and instead ripples as the rocket falls. Though more expensive, hemispherical chutes should allow for a comparable descent rate relative to a parabolic chute, and reduce the chance of squidding. This is achieved by eliminating slack cloth, and allowing “through the chute” airflow by means of the central spill holes.

The drogue chute is to fire at apogee, and is housed in booster section of the rocket. Safe recovery of HP rockets mandates certain decent rates for each stage of parachute deployment in order to mitigate shock load while airborne, and impact trauma at landing. The drogue chute should descend the rocket at approximately 55-60 feet per second (fps). Under both drogue and main chutes, the descent rate should slow to around 20 fps. Proper parachute sizing is depends primarily on dead weight after motor burnout (6.7 lbs). Through this, along with experience from prior launches, the parachute sizes were determined.

The shock cord which tethers the rocket after parachute deployment is made from a tubular nylon material with break strength of approximately 3100 lbs.

## 4. **Avionics Bay**

The AV Bay is composed of a nine inch paper coupler tube and two birch plywood bulkheads. Housed inside is an acrylic sled which the electronics systems are mounted to. Besides housing the electronics, the AV Bay also holds the first stage and booster sections of the rocket together during descent, and is riveted to the first stage. Refer to the section on electronics titled Avionics Bay for further information on the data logging, video, recovery, and deployment systems.

## 5. **Airframe**

By using the J-357 motor, the rocket is expected to overshoot the target altitude by 256 ft. To add as much weight as possible prior to the addition of weighted rings, it was decided to make the rocket as large as possible by designing it to be just under the maximum length of six feet. For the airframe material, Quantum Tubing (QT) was selected from Public Missiles. QT is a proprietary material similar in makeup to PVC. Quantum tubing offers several preferable qualities that were felt to be ideal for the competition; mainly it's resistance to water damage relatively high fatigue and impact strength. Moisture resistance was especially important given the amount of water surrounding the competition launch zone.

## 6. **Fins**

Pioneer-1 was designed to incorporate the use of four fins with a symmetrical trapezoidal planar shape. The planar shape was adopted to reduce the possibility of damaging fins upon impact. Additionally, the symmetrical planar shape helps with ease of assembly. Initial design simulations of three finned rockets showed that to achieve the desired CG the span of each fin would be such that damage upon impact would be too great a possibility. To reduce the fin span and maintain the designed center of pressure (CP) the number of fins used was increased to four. The fins are designed as symmetrical trapezoids with a chord of 12 inches and a span of 3 inches. They are made of .125in aircraft grade birch plywood and are attached to both the motor tube and body tube. The connections between fins and the body tube are reinforced with thickened epoxy fillets and six ounce fiberglass. This fin selection gives a dry stability caliber of two and a wet caliber of one. It is hoped that having this minimal stability caliber will help reduce the effects of weather cocking.

## Weighting System

In order to adjust the estimated altitude of the rocket, it is equipped with a system to adjust its overall weight and CG. This is accomplished using specially designed plates which attach to either end of the avionics bay using the extended ends of the threaded rods which hold the ends of the avionics bay in place. The design of the weights is mostly circular with a large central hole, two smaller holes, and two square cut outs on opposite sides. The central hole, accommodates the eye hook connecting the avionics bay to the parachute cord, the plate itself is affixed to the rocket using the two small holes and the two square cut outs accommodate the electrical connections between the aviation electronics and the parachute ejection charges, two of these cutouts are used to balance the plate and make it less sensitive to the orientation of its installation. Plates with different weights are produced using a common shape but with various thicknesses. The plates were cut precisely by two team members under the supervision of an instructor using a CNC water jet table owned and operated by UW Platteville. In addition to the weight plates which attach to the avionics bay, varying amounts of washers are attached to the back end of the nose cone to fine tune the CG without significantly increasing the overall weight of the rocket. This design was agreed upon as the easiest to produce, work with, and adjust during the competition by a team of five to six group members.

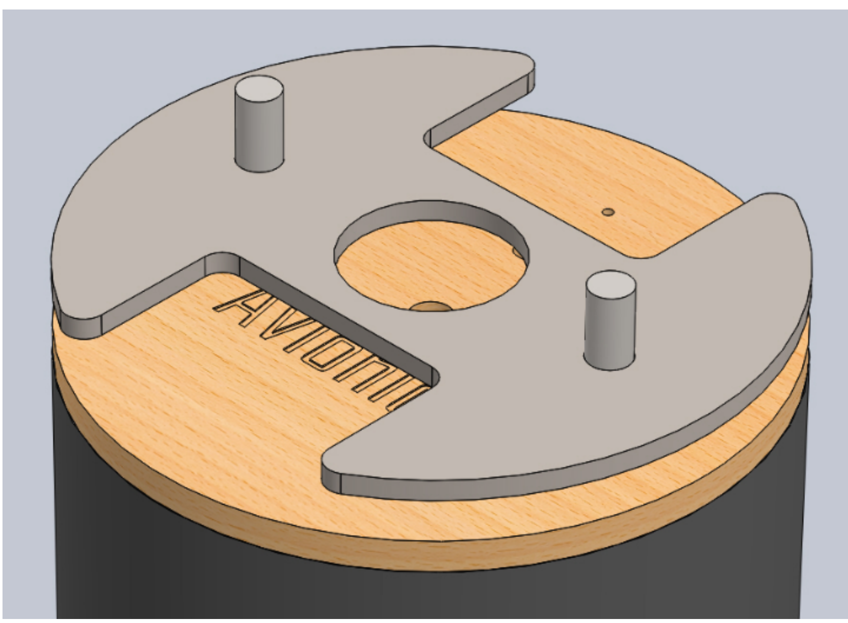


*Figure 2: Example of weight plate attached to top of avionics bay from Solid Works*

# Avionics Bay

## Introduction

The avionics bay on Pioneer-1 will house four systems of the teams own design, as well as the measurement system provided by the Wisconsin Space Grant Consortium for the Intercollegiate Rocketry Competition. The team decided to use the Raven III, Big Red Bee 900MHz, a Raspberry Pi, and a system of team's own design built around the Freescale Freedom development board. A Raven III, which is the same device used by Space Grant to take their own measurements of our flight performance, will be our primary means of recording flight as well. This device will also be used to deploy both of our parachutes. The team adopted the Raven III as compared to other systems such as the Adept, which was used in previous years competition rocket. The system was chosen for its ease of use and customizability. The Big Red Bee is a GPS coordinate transmitter designed for being used to track and locate rockets.

## Secondary Velocity Measurement

Our second method of data logging is a custom solution built around the microcontroller FRDM-KL25Z, a development board by Freescale. Last year the team used Flight Trac, a custom built data logger designed and constructed by team member Weston Woolcock; this year instead of refining that system the team felt that it would be advantageous to migrate to the freedom platform. The Freedom platform was chosen because of multiple advantageous qualities. The board has an effective 48 Mega Hertz 32-bit ARM Cortex-M0+ processor, which is capable of running on a very low amount of power. This quality will help to reduce the amount of batteries we will need to fit in to our avionics bay. The board also has an Arduino compatible pin layout which allows developers to utilize the large amount of hardware for the Arduino platform. Due to the Arduino compatible layout it can be integrated into the Mbed platform which like arduino allows access to a wealth code created by an active community of developers as well as a browser based development environment. Finally team member Luke Sackash already had experience with this board. In order to collect data, an electronic barometer will be used get air pressure which will then be used to calculate altitude to with only 0.4

meters rms of noise. The Altitude will be recorded with a time stamp one each data point so that velocity and acceleration can then be calculated for Pioneer-1's flight.

## GPS Positioning

The Big Red Bee sends the rockets GPS coordinates over a 900Mhz radio signal to a handheld radio device that is stationed at the launch site. Members of Pioneer Rocketry have developed software to interpret these coordinates over SPI and log them so that later a flight path can be reconstructed. The software developed also converts the coordinates received into a more user friendly format, allowing the team to briskly locate and retrieve the rocket. In preliminary flights the GPS proved extremely useful allowing for recovery of a rocket that would have otherwise been lost forever in the enchanted forest.

## Raspberry Pi and Video

The final piece of hardware included is a Raspberry Pi and its camera board to capture and store in-flight video. The raspberry pi runs off of a custom built voltage regulated power supply. An SD card is loaded up with a Debian Linux distribution tailored specifically for the raspberry pi. After kernel-space is loaded, the camera module will begin to capture video. The captured video is then stored in the file system as it is recorded. For next year's build there are hopes to take further advantage of the processing power the Pi for more advanced inflight data logging as well as exploring other possible uses.

## Anticipated Performance

Pioneer Rocketry's airframe designs depend heavily on the collection of empirical data However Following the current competition timeline it became impractical to construct and test the competition rocket prior to launch day. Because of this, PR has utilized simulation programs to help with design. The simulation program used was Open Rocket. This was the first time PR had used this program, and for this reason, we conducted three test flights over the past few months to verify the software's accuracy. We tested a several different construction techniques and rocket designs, and referenced our flight data to the results given in Open Rocket. Data was taken for altitude, decent velocities, and acceleration. The important points of the test launches are highlighted bellow along with the expected results for the competition rocket.

There were a total of three test flights used to verify simulation results, two 38 mm Hi-tech rocket and one Torrent rocket. For the 38mm Hi-tech rocket with the H120 & H152 motors, simulations were run in Open rocket and the simulation data recorded. These rockets were then launched on Saturday, February 22nd, 2014 at Richard Bong State Recreation Area, and data was collected from those launches. The data from the Torrent rocket launch was deemed unusable due to launch issues. The predicted data was then compared to the actual launch data. The summary of the comparison is that the actual data was considerably close to the predicted data. Actual apogee was in both cases within a few hundred feet of predicted, proving that Open Rocket is a viable simulation program to use in the design of a rocket.

**Rocket** Hi-Tech H-45, 38 mm

| Predicted Data | | | | | | Actual Flight Data | | |
|---|---|---|---|---|---|---|---|---|
| Motor | Stability (Cal) | Apogee (ft) | Time to Apogee (s) | Flight Time (s) | | Apogee (ft) | Time to Apogee (s) | Flight Time (s) |
| Cesaroni H120 | 1.72 | 3333 | 11.8 | 177 | | 3168 | 26.5 | 111 |
| Cesaroni H152BS | 1.7 | 3363 | 11.6 | 174 | | 3441 | 12.5 | 171 |

*Table 2: Predicted Data compared to actual data of two test flights of both Hi-Tech rockets*

**Projected Flight Performance**

A rocket must perform under strict parameters and is best built with experience and extensive testing as opposed to simulation. This said, we have extensively tested two practice rockets prior to construction of the Pioneer-1. Our design process can be seen through the figure below:

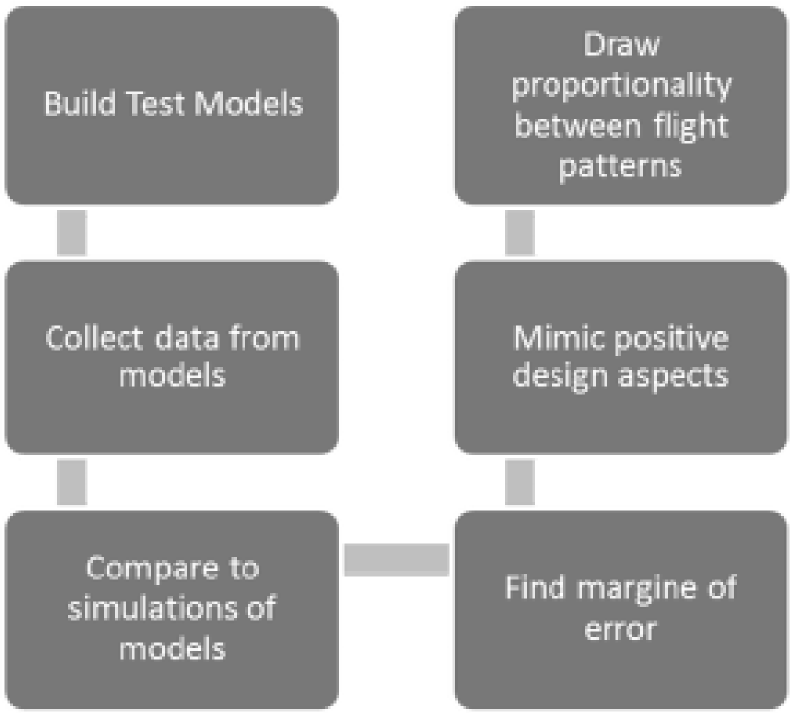



*Table 2: Design Flow Chart*

The Hi-Tech and 2013's DX-3 –the rockets which came close to reaching the simulated height were chosen as the models for our process. By evaluating the known values of projected and actual flight data from the Hi-Tech and Pervious year launches, while looking forward at the projected data from the Pioneer-1, the following equation was developed. Given the anticipated weather conditions for April 5th (as of 3/28/2014) Pioneer-1 was fitted and situated in the simulator to push maximum altitude. Added to the equations, an anticipated maximum altitude of 3256 feet is expected provided no wind and a vertical launch. To help us achieve the 3000 feet target accurately a weighting system was developed as explained above to help plan for changes in weather conditions. Estimates of peak acceleration from Open Rocket are generally low in comparison to our recorded values from launches at about 13.2 G. We anticipate a peak acceleration of 34 G with an average acceleration of 26 G – Values much more closely related to our recorded data from previous years. Below is a graph showing the expected acceleration when compared to time from the simulation program Open Rocket and a graph showing the peak acceleration of a previous launch of the Super DX-3 rocket collected from a Raven altimeter.

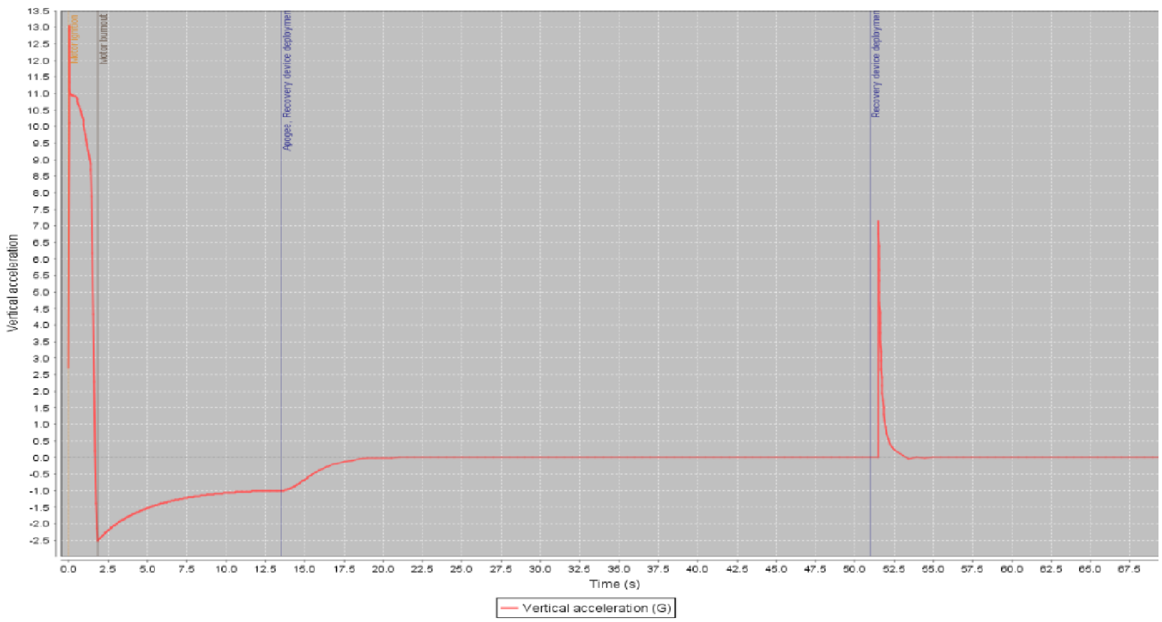



*Figure 3: Showing Anticipated Acceleration plotted against time for Pioneer-1 launch with 12 oz of added weight*

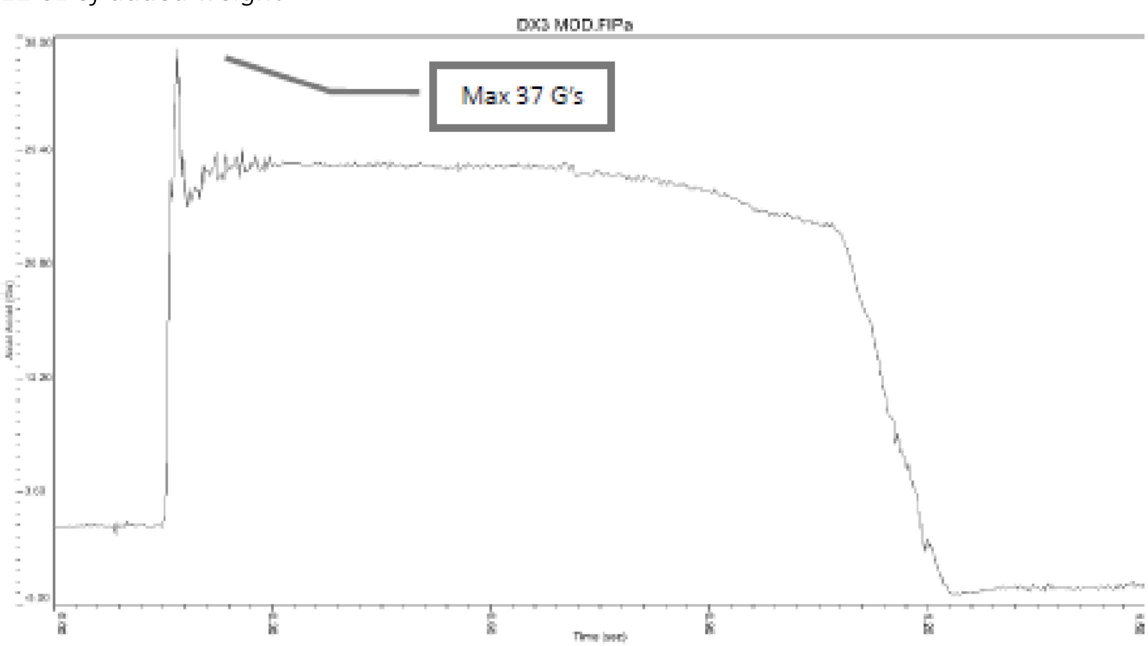



*Figure 4: Showing Acceleration Plotted against time for the modified Super DX launch – from raven altimeter*

## Pressure and Gravity Diagrams

Pioneer-1 unlike our previous SD-1 does not have the same principal of variable CG/CP, but the weight of the rocket is variable to directly affect altitude. By the insertion of weighted plates to the top of the avionics bay, the flight characteristics of the rocket can change on the fly.  Thus giving the ability to adjust the weight of the rocket to current conditions achieving the target altitude.  The positions of CG and CP are slightly affected by the weighting system but the differences are negligible.

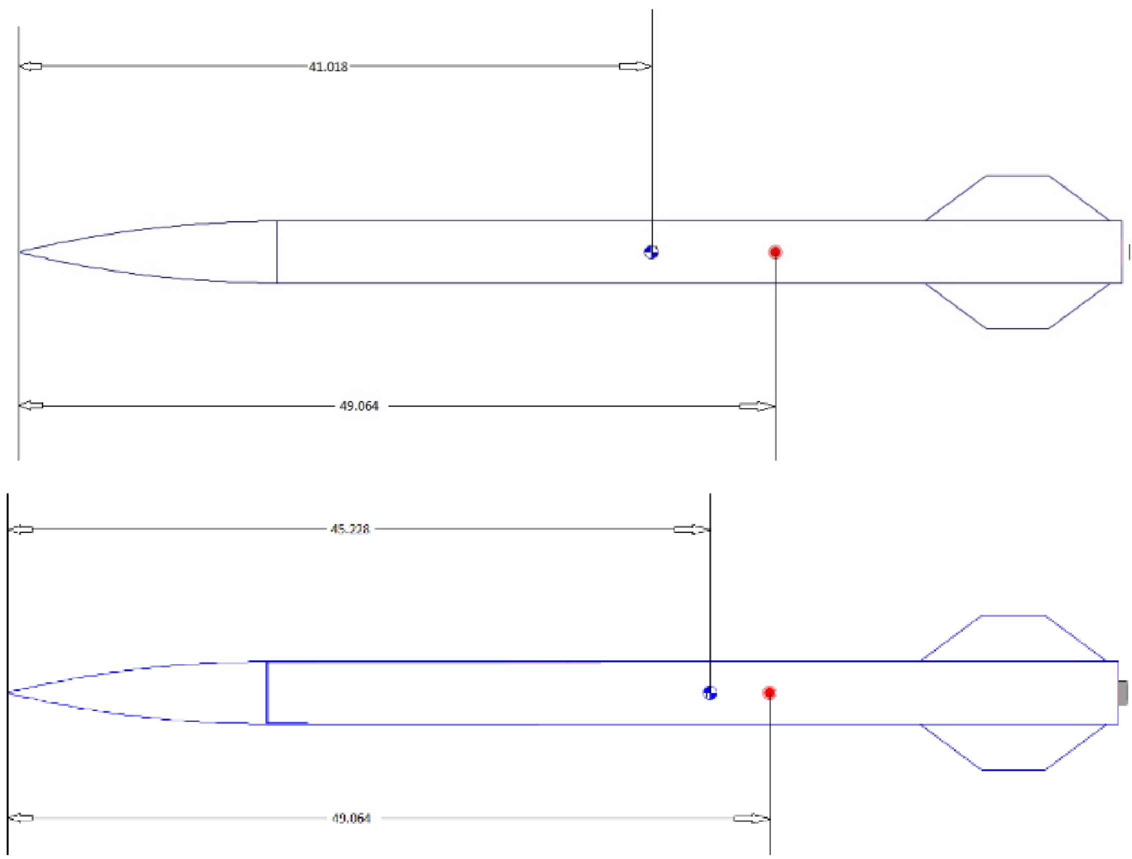



*Figure 5:   A) CP and CG measured from nosecone dry weight    B) CP and CG measured from nosecone wet weight*

## Rocket Construction

When constructing a rocket many things must be considered; most notably, the materials and fabrication methods used. Most of the teams focus was placed in the construction of the lower airframe and fins.

One distinguishing feature of the rocket is the use of four fins instead of three which allows each fin to be smaller than it otherwise would be. Four smaller fins gives the rocket the same center of pressure as three larger fins. Having four fins also increases drag without significantly altering the center of pressure. To accurately attach the fins the Tip to Tip Fin Jig from year was used (http://www.jcrocket.com/tttjig.shtml). This jig both orients the fins with either 90 or 120 degrees of separation and provides a flat, supportive surface for applying a layer of fiberglass.

This past semester, privileged use of a new laser cutter was granted to the team. This tool has provided the capability to rapidly prototype and test parts for the rocket. The laser cutter also provided the ability to make entirely custom parts that are accurately made to fit the rocket, most notably centering rings, bulkheads, fins and custom designed avionics sled. The ability to produce multiple designs proved especially beneficial when building the avionics sled. Due to the large number of electrical components used on the rocket, multiple designs had to be tested to determine the ideal layout. The laser cutter has proved very useful and we are looking forward to using to build future rockets.

The second most important rocket feature was deemed to be the body. When building 2 previous rockets, problems were encountered with the standard phenolic tubing ripping and tearing at certain points such as rivet locations and shear pin holes. To combat this a product called Quantum Tubing marketed by Public Missiles was settled upon for the body tube. This quantum tubing was resistant to the ripping and tearing that the phenolic tubing was subject to, but had its drawbacks; Quantum tubing is nearly twice the price as standard phenolic tubing. It also expands and contracts with changes in temperatures. This in mind, much consideration was needed when designing some components in hopes that on launch day they fit pending the temperature.

# Additional Projects

## Launch Controller

As part of the team's efforts to be able to launch and test rockets independently, it was decided that one team members should construct a launch controller. The launch controller was constructed mostly during the Christmas break early in 2014. The outer container for the controller is a reproduced Vietnam era .50 caliber ammunition container, a metal box with a waterproof, lockable hinged lid, inside of which is plastic plate hinged at one end onto which a keyed toggle switch, two indicator lights, two momentary switches, and two banana plugs. Pop rivets were used to attach the internal metal and plastic components to the outer casing. The hinged plastic plate conceals two six volt lantern batteries rigged in series to produce twelve volts which powers the device, also concealed is a wire spool onto which is wound 115 feet of speaker wire used to keep the people setting off the rocket a safe distance from it. To operate the controller, wire is first unwound from the spool between the controller and the rocket igniter, the banana plugs are inserted in the banana jacks, the wire loop is anchored to a solid part of launch pad, and the alligator clips are connected to the motor igniter. During the process of setting up the rocket the key for the ignition switch is removed and carried with those doing the set up to prevent accidental ignition. When it is time to launch the rocket, the key is inserted into the switch and rotated so as to connect the ignition system to its power supply which is indicated by the illumination of a red light. After this both momentary switches must be depressed to send power to the igniter, power being sent to the igniter is indicated by the illumination of the second red light. Upon successful launch, the key is returned to the off position to disable the controller. Shortly after the completion of the launch controller, it was successfully used at a launch event in February, 2014 at Bong Recreational Park where two of our team members received their class I certification.

## Community Outreach

Pioneer Rocketry, in association with its parent organization the Society of Physics Students (SPS) held its annual "Phunshop" educational outreach event in the fall of 2013. The Phunshop event caters to local elementary schools and allows students a chance to see many unique and exciting physics demonstrations. The theme for this year's event was pressure, and many of the experiments involved showing how pressure differences can affect the world around us. In addition to the pressure demonstrations the students enjoyed watching the launches for both model Estes rockets and custom built rocket cars. Physics Phunshop typically caters to around 20 students each year.

## Surface Roughness of Rocket

A major problem in the performance of last year's rocket was the misinterpretation of the drag coefficient. To address this, we analyzed the surface roughness of acrylic paint using the ektakXT Profilometer. Surface roughness values were determined to be on the order of 10 nm, an order of magnitude smaller than those obtained by some sources. This disparity was likely due to the unconventional sample shape that was tested. This profilometer measures parameters like surface roughness very well for flat surfaces, but the only sample of paint we were able to obtain was from a broken rocket. The curved sections of body tube didn't allow for accurate measurement of the surface roughness. Due to time constraints, an accurate surface roughness measurement from a flat sample was not obtained.

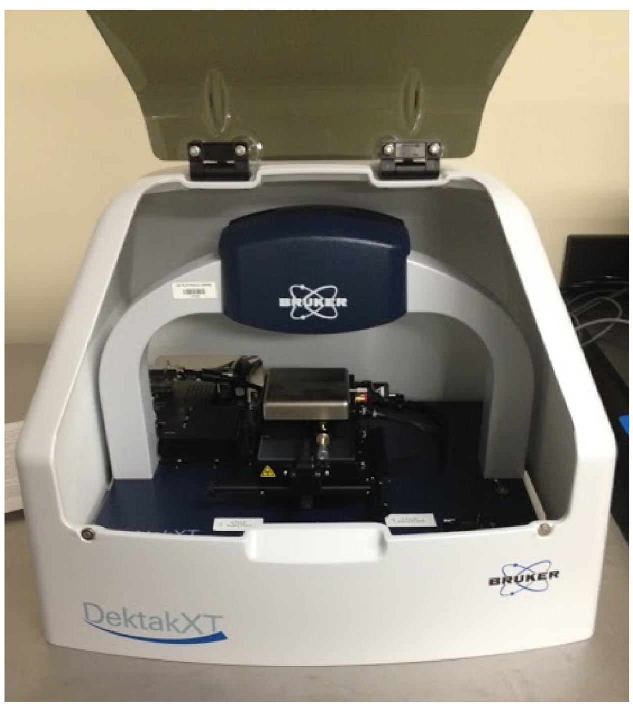



*Figure 6: Profilometer used to measure surface roughness of paint sample*

# Photographs

## Community Outreach

Demonstrations at Physics Phun Shop on October 26, 2014.

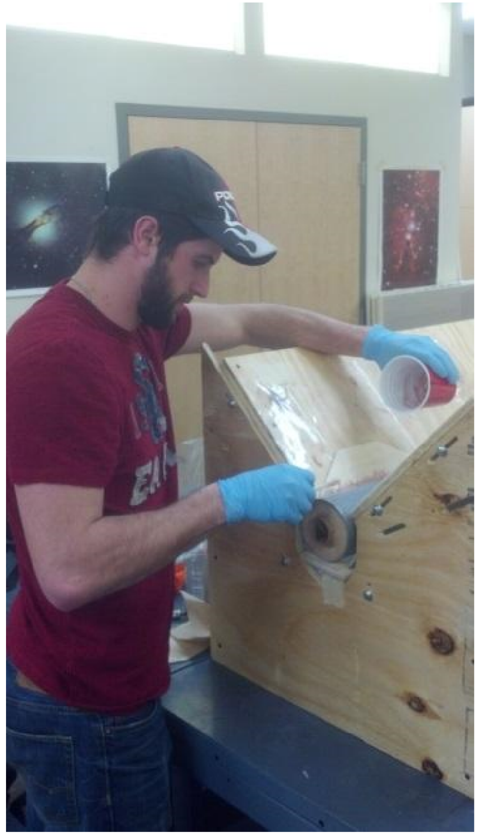
## Images of Certification Launch

The team going through the preparation for launching a rocket at the certification launch at Richard Bong Recreation Area.

A group picture of those who attended the certification launch.

**Build Sessions**

Chris and Eric laminating fiber glass on the fins.



Eric applying epoxy fillets to the rocket.


Team members holding the nearly finished Pioneer-1.

# Conclusion

The completion of Pioneer-1 brings a close to PR's second season as part of the WSGC intercollegiate rocketry competition. The challenge of designing a rocket capable of reaching the 3000 foot altitude while simultaneously logging data via a suite of onboard electronics has been met by the hard work and dedication of over twenty undergraduate engineering students. The larger airframe, extended avionics bay, additional data logging capabilities, and weight control systems integrated into Pioneer-1 are examples of our growth as a team, and our understanding in the fields of engineering and aerospace science.

PR's member base is not small, and for this reason is modeled differently than most contenders in this year's competition. Our intent is to become more than just an isolated group of rocketeers, but rather to be an integral part of our University's selection of student organizations. It is hoped that over the coming years PR will expand its membership, build more rockets, conduct more launches, receive more HPR certifications, and lend credit to the use of aerospace applications as part of an undergraduate college curriculum. We are grateful to WSGC and Tripoli Rocketry for allowing us the opportunity to compete, and we look forward to the coming competition.

**Special Thanks to our sponsors and supporting groups**

Duane Foust (Advisor, University Staff)

Wisconsin Space Grant Consortium

University of Wisconsin – Platteville

Mark Hackler (President, NAR #558)

Todd Kemnitzer

Dedicated friends and family alike

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Thomas Welsh

Trent Cybela

# Budget

| Component | Company | Unit Price | Quantity | Shipping/ Tax Discount | Total Price | Total Price for Order |
|---|---|---|---|---|---|---|
| | | | | | | |
| Base GPS Telemetry System | BigRedBee, LLC | 398 | 1 | 11.25 | 409.25 | 409.25 |
| Quick Set Epoxy | Menards | 4.49 | 1 | N/A | 4.49 | |
| Gel Apoxy | Menards | 3.98 | 1 | 0.47 | 4.45 | 8.94 |
| Rail Buttons | Apogee Components | 3.07 | 4 | 4.36 | 16.64 | 16.64 |
| AC 250V 2A Terminals On Off Tubular Key Lock Switch (Launch Controller) | Amazon | 5.81 | 1 | 0 | 5.81 | 5.81 |
| PK2 Spst Push SW | RadioShack | 3.99 | 1 | N/A | 3.99 | |
| PK2 Banana Jacks | RadioShack | 2.99 | 1 | N/A | 2.99 | |
| PK2 Banana Plugs | RadioShack | 3.49 | 1 | N/A | 3.49 | |
| PK12 1-3/8"Clips | RadioShack | 3.99 | 1 | 0.67 | 4.66 | 15.13 |
| 50 cal Steel Ammo Box | Blain's Farm & Fleet | 9.99 | 1 | 0.55 | 10.54 | 10.54 |
| 1-1/2 "X1" Mid Butt Hinge Brass | Home Depot | 2.47 | 1 | 0.14 | 2.61 | 2.61 |
| PLTD All THRD 8-32-3Ft | Menards | 2.94 | 1 | N/A | 2.94 | |
| CAP/NUT BRS/NIKL 8-32 | Menards | 0.49 | 4 | N/A | 1.96 | |
| 6V HVY DTY RAYOVAC | Menards | 3.98 | 2 | 0.49 | 8.45 | 13.35 |
| Quantum Airframe Tube | Public Missles | 32.94 | 1 | N/A | 32.94 | |
| Motor Mount 1.5X18' Phenolic Tube | Public Missles | 5.78 | 1 | 11.08 | 16.86 | 49.8 |
| Epoxy Additive | West Marine | 13.99 | 1 | 0.77 | 14.76 | 14.76 |
| .5" Nylon, Tubular | Public Missiles | 1.99 | 5 | N/A | 9.95 | |
| PNC nosecone | Public Missles | 21.95 | 1 | N/A | 21.95 | |
| QT AV Tube | Public Missles | 16.02 | 1 | 9.16 | 25.18 | 57.08 |
| 38 mm Motor Retainer | Apogee | 31.03 | 1 | 5.36 | 36.39 | 36.39 |
| Freescale Microcontrollers | mouser | 12.95 | 1 | N/A | 12.95 | |
| 3M headers | mouser | 4.48 | 1 | N/A | 4.48 | |
| Schmart Board | mouser | 10 | 1 | N/A | 10 | |
| Headers & Wire Housings | mouser | 1.13 | 1 | 7.99 | 9.12 | 36.55 |
| Screw Rivets | DB Roberts Co. | 0.6 | 10 | 15.5 | 21.5 | 21.5 |
| 12x24 18" plywood | Red Arrow Hobbies | 12.95 | 3 | 9 | 47.85 | 47.85 |
| Phenolic Coupler | Public Missles | 18.5 | 1 | 12.1 | 30.6 | 30.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tubing | | | | | | |
| SanDisk 8GB Class 4 SD Flash Memory Card | Amazon | 6.9 | 1 | N/A | 6.9 | |
| Raspbery Pi 5MP Camera Board Module | Amazon | 31.47 | 1 | N/A | 31.47 | |
| Raspberry Pi Model B | Amazon | 38.95 | 1 | 0.38 | 39.33 | $77.70 |
| Camera Flat Ribbon Cable for the Raspberry Pi | Ebay | 5 | 2 | 7.22 | 17.22 | $17.22 |
| CTI H-120 w/ Casing | Wildman Hobbies | 30 | 1 | N/A | 30 | |
| CTI H-152 w/ Casing | Wildman Hobbies | 30 | 2 | N/A | 60 | |
| Alumnimum Spacers | Wildman Hobbies | 10 | 3 | 5 | 35 | $125.00 |
| Hi-TechH45 | LOC Precision | $76.95 | 1 | $9.45 | 86.4 | $86.40 |
| 54mm Tomach | MadCow Rocketry | $167.95 | 1 | $15.93 | 183.88 | $183.88 |
| Hotel Cost | Space Grant | $75.00 | 1 | $0.00 | 75 | $75.00 |
| Motor | Space Grant | $49.50 | 1 | $0.00 | $49.50 | $49.50 |
| | | | | | | |
| | | | | Total (Before Travel) | | 1391.5 |
| | | | | Total (With $310.98) | | 1702.48 |