Flight Readiness Review Report

Windward Community College – University of Hawaii 2009 - 2010

I. Summary of FRR report

Team Summary

- University of Hawai'i – Windward Campus
- Hale 'Imiloa
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  Kane'ohe Hawai'i 96744
- Dr. Joseph Ciotti (Principle Investigator)
  Dr. Jacob Hudson (Team Official)
  Helen Rapozo (IT Specialist)
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  Joleen Iwaniec
  Todd Esposito
  Patrick Lancaster
  Jasmine Maru

Launch Vehicle Summary

- Rocket Name: Leo Hano
- Leo Hano is 86 inches in length and 4 inches in diameter
- The rocket is designed to accept an Aerotech K560W 75-mm motor
- The rocket is designed to have a dual deployment recovery system incorporating a 36-inch drogue chute deployed at apogee, and a 96-inch main chute to be deployed at 500' altitude.
- Rail Size: 10/10 rail with a length of 12 feet

Payload Summary

Payload will consist of three individual units. Unit 1 will sample air temperature at a rate of 1 sample/second. Unit 2 will measure acceleration at 1 sample/second. Unit 3 will measure acceleration at 2~5 events/second. The dimensions of each unit will be 177.8mm in length, 42mm in diameter, and weigh no more than 141.75 grams. All units will be housed in the payload carrier which will be housed in the payload bay. All units will be independently powered and will be able to endure the 1 hour pad stay time without consequence.

II) Changes made since CDR

Changes made to vehicle criteria

1) Booster forward bulk head additionally secured with 6 wood screws
2) Payload bulkhead additionally secured with 3 wood screws
   These additional screws were to reinforce bulk head attachment to body tube.
3) Payload bay increased in length to 20 inches.
   Increase in length is to accommodate future ease of payload manipulation. Total Payload section length is now 20 inches.
4) The design for the nosecone has changed. We have removed the centering ring and replaced it with a ½ inch thick Birchwood solid

bulkhead, offset the electronics mounting board, added a bigger electronics mounting board, and have used a shearing pin assembly to hold the bulkhead in place. All of this was done to accommodate the size the GPS flight unit.

Changes made to Payload criteria

It was originally planned to have one unit called Mynah Bird 2 to measure air temperature, air pressure and acceleration and store it all in an EEPROM during a rocket flight that would be retrieved after the flight is over. .However due to time constraints and availability of launching days it would be best to use three independent but smaller electronic packages instead. These packages can be flown on smaller rockets during the monthly launches that we have at Windward Community College.

Changes made to Activity Plan

1) Launch test date delayed from March 7 to March 14.
2) Hawaii team will bring their launch system to Alabama.

III) Vehicle Criteria

Testing and Design of Vehicle

In order to continue its efforts at promulgating interests in science, technology, engineering, and mathematics, Windward Community College's (WCC) Center for Aerospace Education (CAE) wanted to acquire a re-usable rocket to perform diagnostic testing for several of our education outreach projects: A Rocket Launch for International Student Satellites (ARLISS), testing for the National CanSat competition, various High School Science Fair experiments, and as the hands-on component for a course on Rocketry that is to be integrated into the University of Hawai'i curriculum. The rocket would be designed to carry a non-specific payload, of limited weight and size, to an altitude of 1 mile (5280'), and then return safely to its launchers. The targeted altitude can change with the incorporation of our drag-shoe system and different engine selection. It will also have the ability to maintain the payload through entire flight or to eject its payload at apogee. These options depend on the needs of the outreach program that it is being used for.

With outreach being the main focus of WCC's USLI rocket, our vehicle must be able to successfully carry different payloads for various outreach projects. These payloads must meet all of our dimensional and weight limitations, to guarantee the safety of the rocket, payload, and observers.

Several design constraints are considered with this thought paramount. Since projects are to be canvassed from interested high school students or participating colleges, the payloads are somewhat unspecific. It was thought that a payload weight limit of 1 kg would allow some latitude for the high school students, was twice the weight limit allowed by the National CanSat competition, and more than enough for the past electronic payload testing that has previously been performed for the ARLISS program. Along with this was the understanding that volume constraints must also be outlined; whereas we will be pushing the

National CanSat competition, we did not want this to be the only option for interested students. A cylindrical volume, having a diameter of 3.75 inches, and length of 10 inches, was optimal for our purposes. If the payload weighs less than 1kg, to reach the desired altitude, extra mass can be added, a different motor can be selected, the drag-shoe system can be used, or any combination of the 3. Any changes made will be thoroughly tested using our simulation software (RockSim) and our 3/8-scale prototype to ensure that all safety requirements are still maintained throughout the rocket's flight.

Determination of the motor that is going to be used in USLI was more problematic. It was thought that we should initially over-power the rocket to carry a heavy payload to a height greater than 1 mile. By suitably deploying aero-brakes, open throughout the flight, and extra mass, it was thought that we could attain the right height. It was this in mind, as well as some simple kinematics, that led us to our initial choice of the L1400 motor. After further consideration, coupled with the arrival of our flight simulation (RockSim) routine, we concluded that this was inherently un-safe. The flight simulation showed that the amount of mass that would have to be added to the rocket using an L1400 motor was too much to guarantee a safe recovery. Further flight simulations showed that we would get a better flight profile using a K560 motor, which implied a 75-mm diameter motor mount. The 75/2560 casing, required for a K560 motor, which required the motor mount length to be at least 11 inches. A 20-inch length was chosen for convenience, and offers some latitude in future choice of motor, should the need arise.

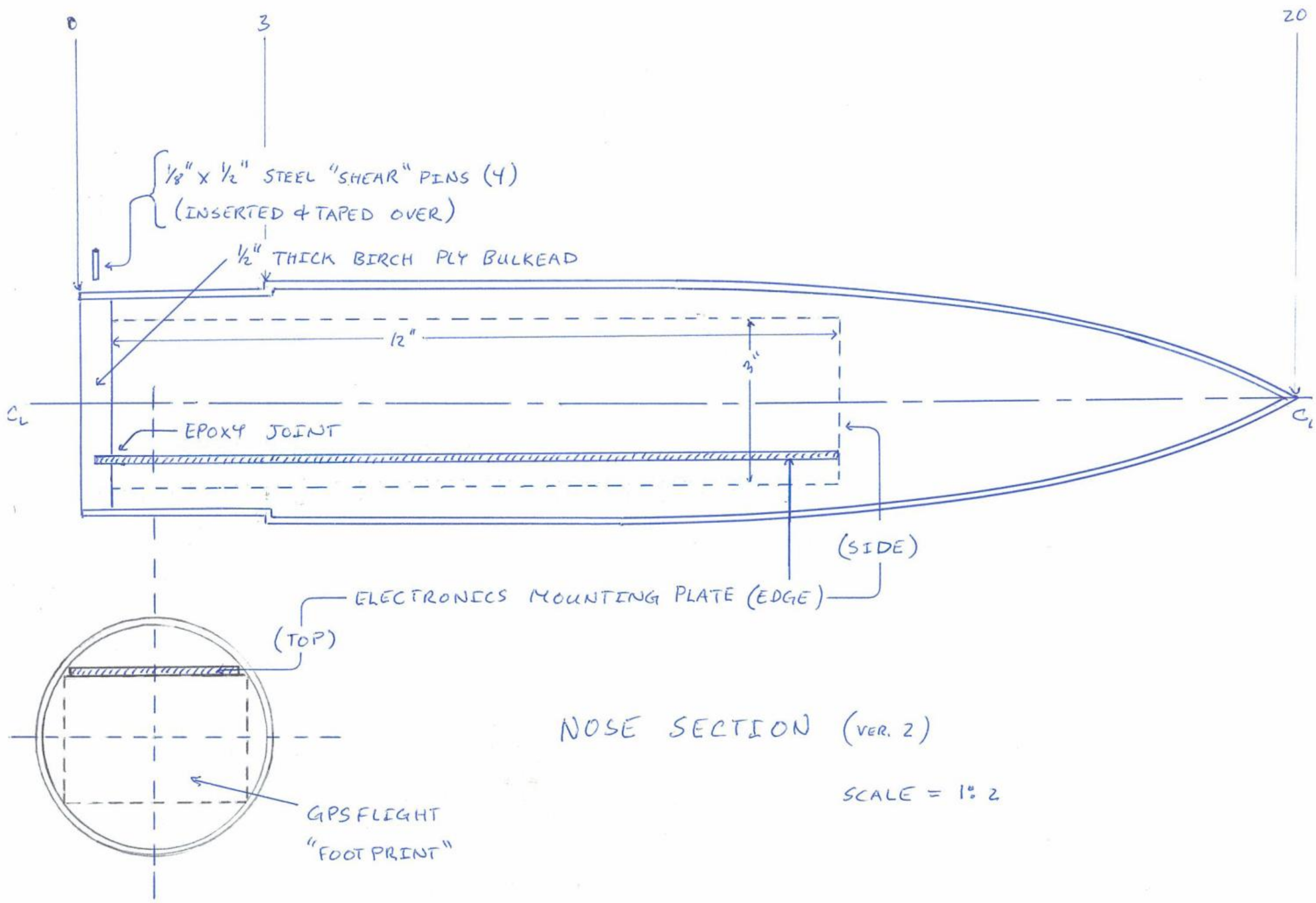
The overall length of the rocket was determined not so much by the payload, but rather by the dual deployment recovery system. Rocket design started with the nose cone, standard ogive 1:4.25, yields a nose cone length of 17 inches. The choice of this type of nose cone was dictated by the fact that this shape is commercially available. This is where the data acquisition electronics, monitoring the rocket flight profile and status of the payload, will be located. The payload section of the rocket is 19 inches in length; 4 inches as the nose cone shoulder, 10 inches as the payload section, and 5 inches is half the coupler length. Below the payload section of the rocket is the avionics section, chosen to be 18 inches in length; 7 inches to accommodate 5 inches of coupler and stowage of the drogue chute, 6 inches for the avionics electronics, and 5 inches to accommodate the coupler. The avionics electronics consists of 2 G-Wiz HCX flight controllers, and a PerfectFlight MAWDs as a redundant back-up system. The Booster section is 30 inches in length, of which the motor mount takes up the lower 20 inches. The upper 10 inches accommodates 5 inches of coupler, and act as the main chute stowage area. It goes without saying that this section will hold the three fins, and the drag-shoe assembly. This yields an overall length of 84 inches (7 feet).

We have used G-10 fiberglass as the main tube material, with two 10-inch couplers, three ¼-inch thick plywood bulkheads, two ½-inch thick Birch wood centering rings, and three fiberglass trapezoidal fins. The un-loaded weight of our rocket is 18.5 lbs, and the pad weight is 24.56 lbs.

The flight profile that our rocket follows is the standard dual deployment routine, and has been simulated (under various launch conditions) on RockSim. The flight will begin with the boost phase. The K560 motor will produce an average thrust of 120 lbs (giving us a thrust to weight ratio of 6), with a burn time of 4.95 seconds. The maximum estimated acceleration is ~8 g's (258 ft/s/s), with an estimated maximum speed of 500 mile/hr (735 ft/s). At motor burnout, the rocket then enters its coast phase. We expect the rocket to reach apogee ~25 seconds after launch. At apogee, a 36-inch drogue chute will be deployed, yielding an initial descent speed of ~ 60 ft/s. At an altitude of 500 ft, a 96-inch main chute will be deployed, slowing the rocket descent rate to less than 20 ft/s, which we believe to be a safe descent rate.

Leo Hano rocket

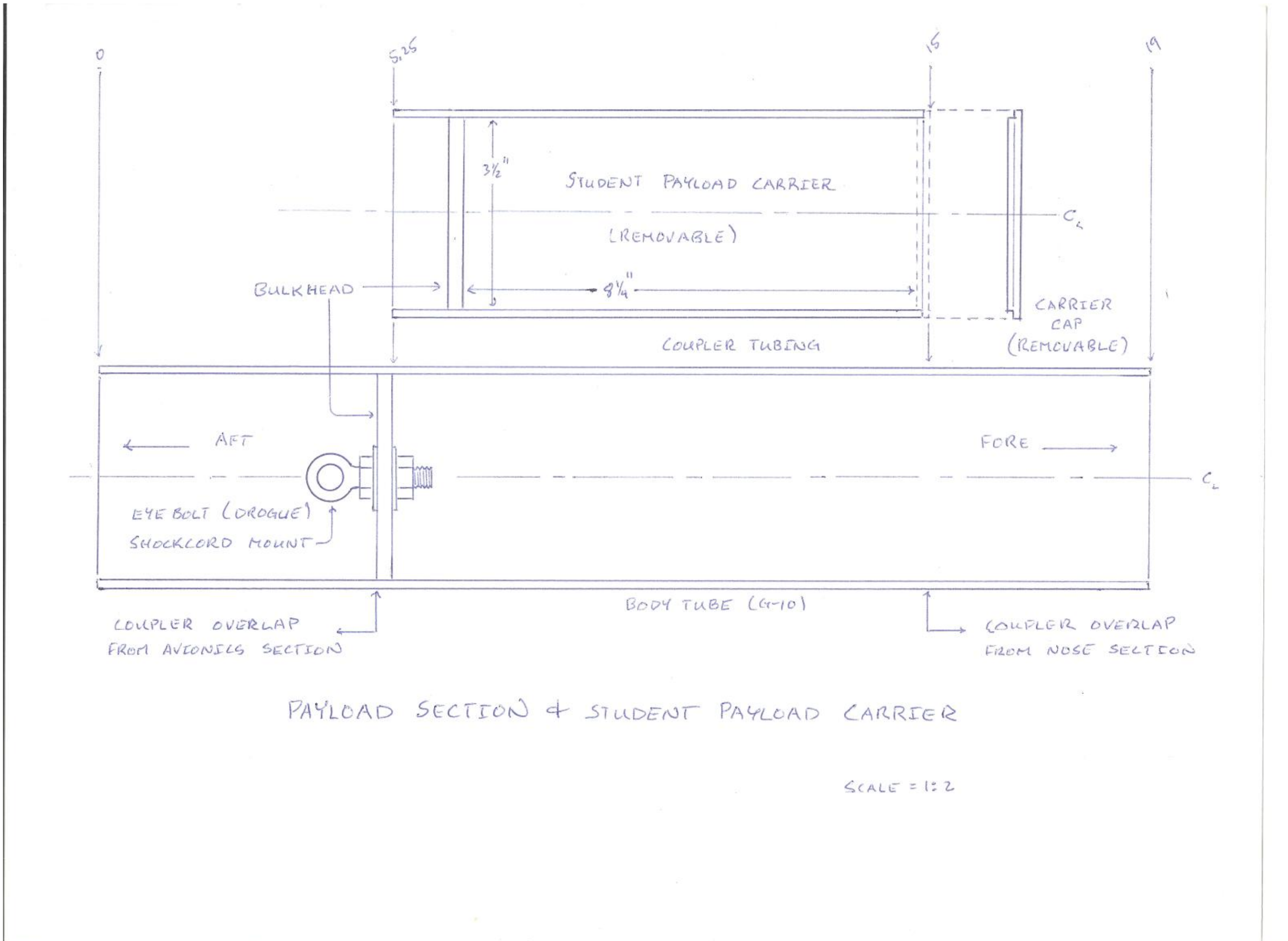
Nose Section



Nose Section

The nosecone is a standard 1:4.25 ratio ogive, having an outer diameter of 4”, a shoulder length of 3”, and made of fiberglass. The chosen GPS unit has a foot-print that is 2”X3”, and as such, our previous design would not handle easy insertion or removal. Also, we found an increase to area of the electronics mounting board to be an extra advantage. Mounting the electronics board to a ½” thick Birchwood Ply bulkhead, and using a 4 shear pin attachment proved simple. This will allow the removal, preparation, and installation of the GPS/transceiver assembly required for the public address voice-over system. It should also be noted that the shear pin assembly is an added precaution since there are no stress events that rely on the nosecone bulkhead, and that the nosecone assembly will be placed atop the student payload lid. This should supply more than enough support for the voice-over electronics.

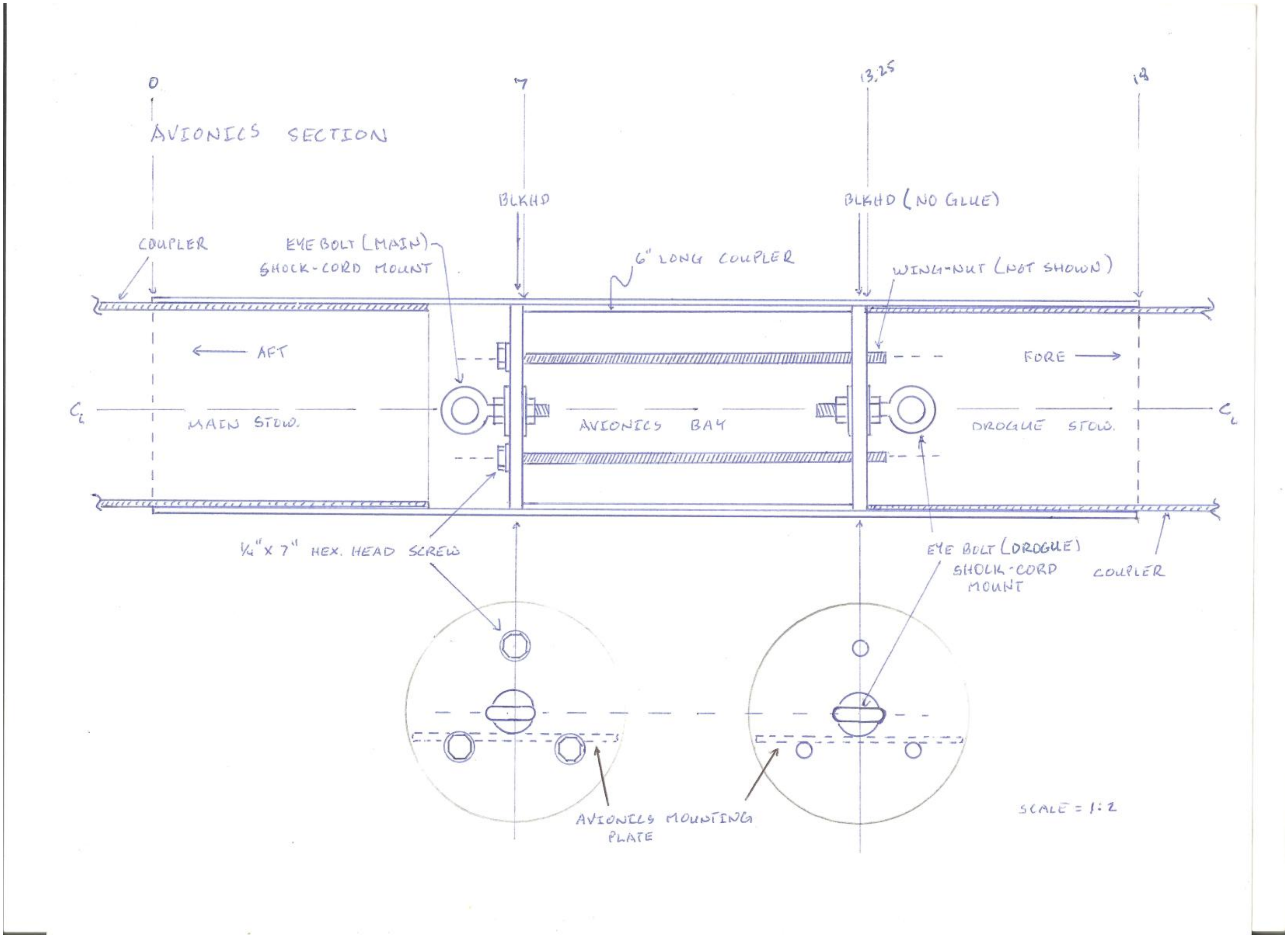
Payload Section and Student Payload Carrier



Payload Section and Student Payload Carrier

The primary purpose of this section (and indeed for the entire rocket) is to carry the student payload carrier. The carrier, with its lid, would be given to the students prior to the launch date. On the launch date, the students would return the carrier (with their experiment in it) to the rocket preparation crew, who would then integrate it into the rocket. Once the student payload carrier is inserted into this section, the nose section would then be inserted on top of the payload carrier lid, and held in place by means of 3 nylon screws (which are not shown). This section consists of a 19" long, G-10 tube, with a circular ¼" thick Birchwood ply bulkhead epoxied into it. This section is attached to the rest of the rocket by a shock cord, which is mounted to the bulkhead via an eyebolt. The shock cord is also attached to the avionics section, and is where the drogue chute would be attached.

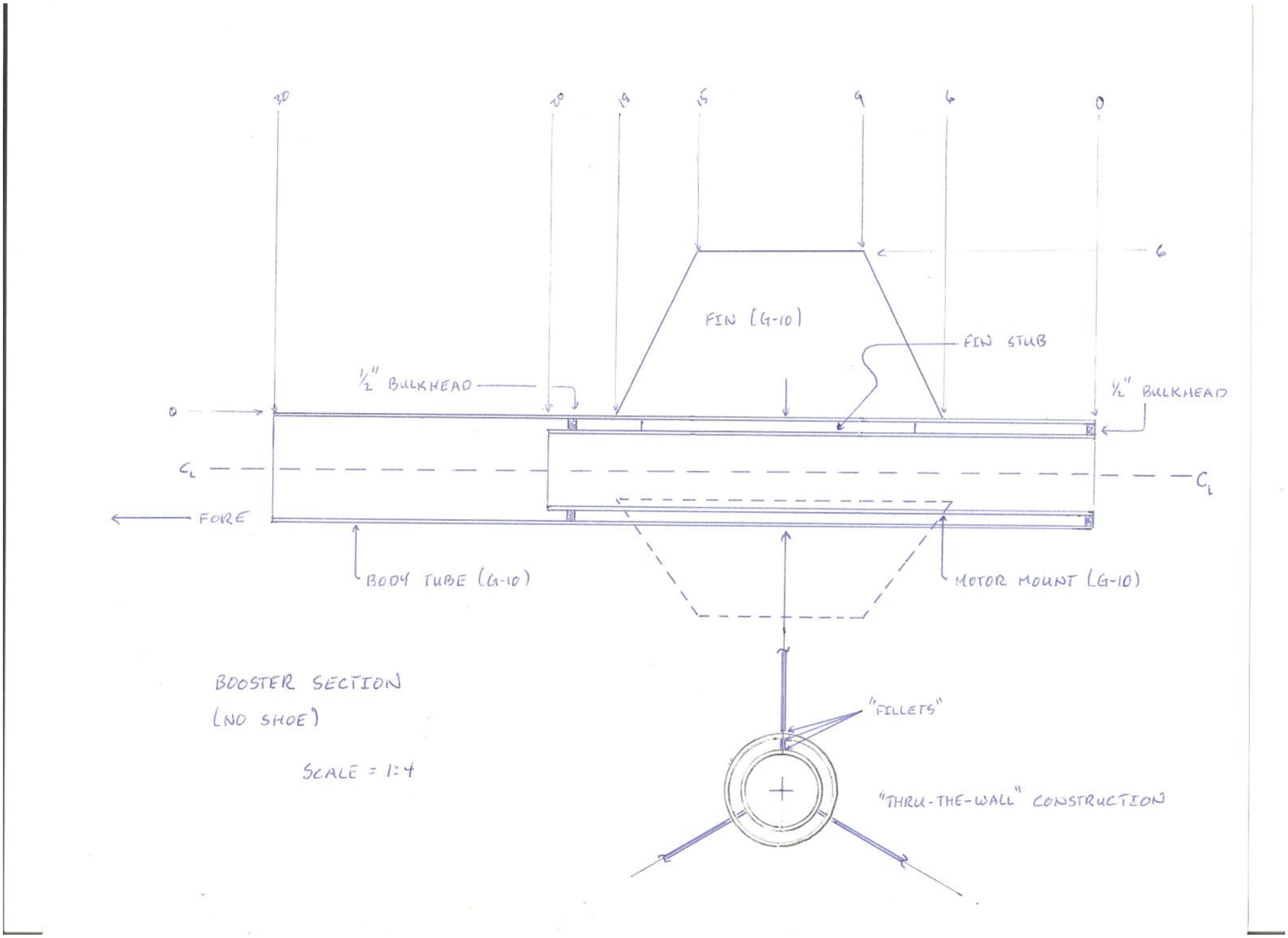
Avionics Section



Avionics Section

The main purpose of this section is to carry the on-board recovery electronics (Avionics). The center section consists of the avionics bay that will contain the necessary electronics. The bay consists of a 6” long coupler tube, epoxied into place within the body tube of the rocket. Also epoxied to the coupler tube, as well as to the body tube, is a circular plywood bulkhead having a center-mounted eyebolt. The shock cord, associated with the main chute and connecting this part of the rocket to the booster section, is attached at this eyebolt. Another circular plywood bulkhead, also with a center mounted eyebolt, is attached to the other end of the avionics bay by means of three ¼” X 7” long bolts and associated wing-nuts. This bulkhead will be removable for access to the avionics section, and is where the shock cord to payload section is attached. Both plywood bulkheads will have to have holes placed for the pyro charge wires to pass through (not shown). Also not shown is the ½" diameter hole that is to be drilled thru the body tube/ coupler into the avionics bay, for the pressure sensor to equalize with ambient.

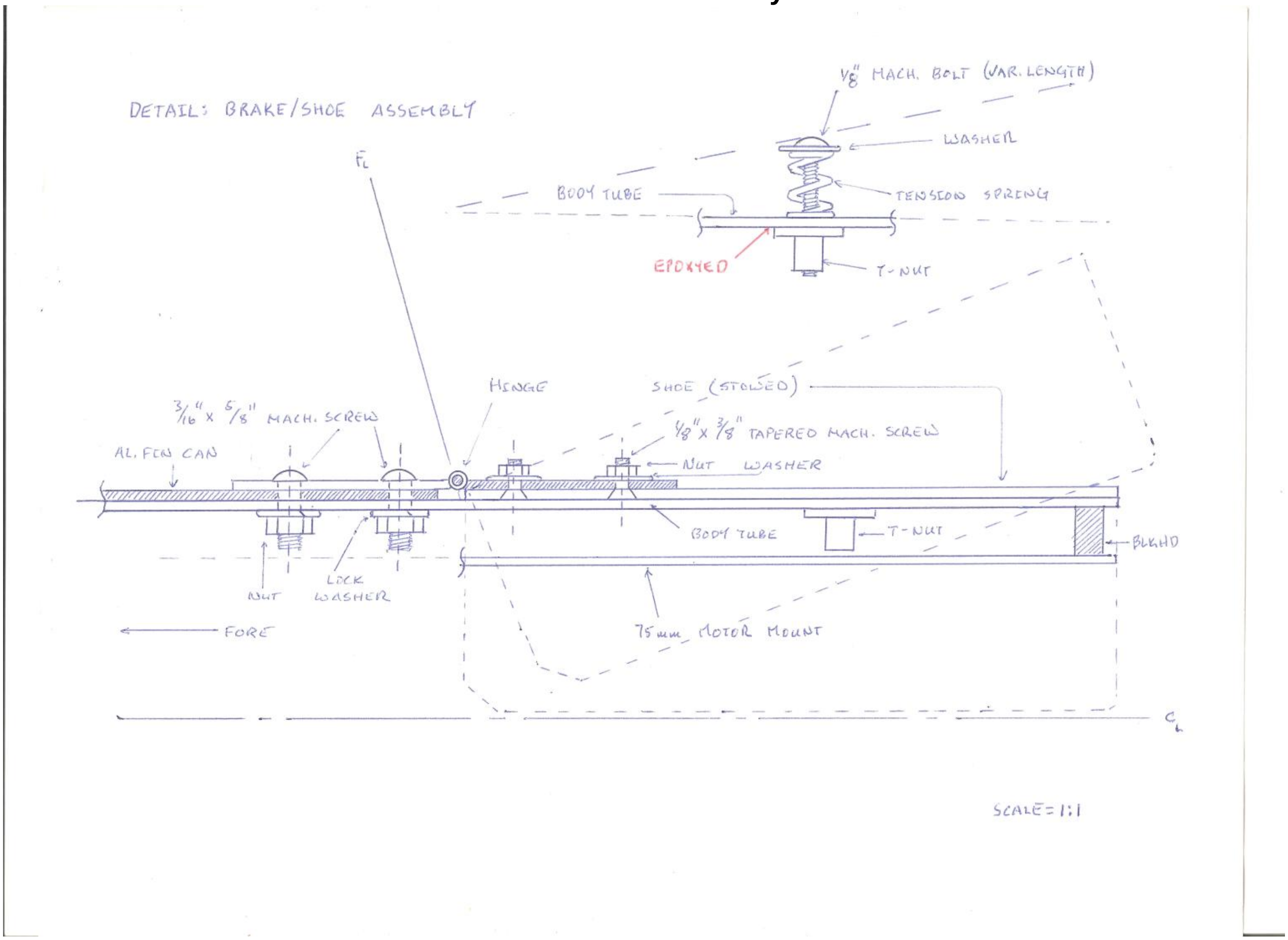
Booster Section



Booster Section

This section contains the motor, and is constructed using a thru-the-wall construction. What is not shown is the motor casing, with its threaded cap. It is at the cap where the final eyebolt is placed. This is where the shock cord joining the avionics section, and associated with the main chute, is attached.

Brake/Shoe Assembly



Detail: Brake/Shoe Assembly
This is a detail diagram of the air-brake assembly showing the mounting, and subsequent deployment of the proposed air-brake. As can be inferred, this is simple in use; a standoff screw is to be adjusted to a proper deployment angle before flight. This acts to keep a half-cylindrical shoe at a fixed angle away from the rocket body. The resulting drag will reduce the overall expected altitude of the rocket. It is expected that the deployment angle shall be less then 30°.

A simple approach to estimating the enhancement of drag force, acting on the rocket by the deployment of the air-brake can be found. Take the geometry of a deployed brake to be that of a half cylinder (of radius *r*, just slightly larger then that of the rocket, and having a length *l*) canted at an angle of *q* to that of the rocket body. By comparing the drag force utilizing a deployed brake ($FD = ½\, r\, CD\, AD\, v^2$, where $AD = p\, r^2 \{1 + (2l/r) \sin q\}$□□□to that of the un-deployed situation ($FD = ½\, r\, CD\, Ao\, v^2$, where $Ao = p\, r^2$) at the same speed, we find that the drag force is enhanced by a factor of $(1 + b \sin q)$, where $b = 6$ for our design.

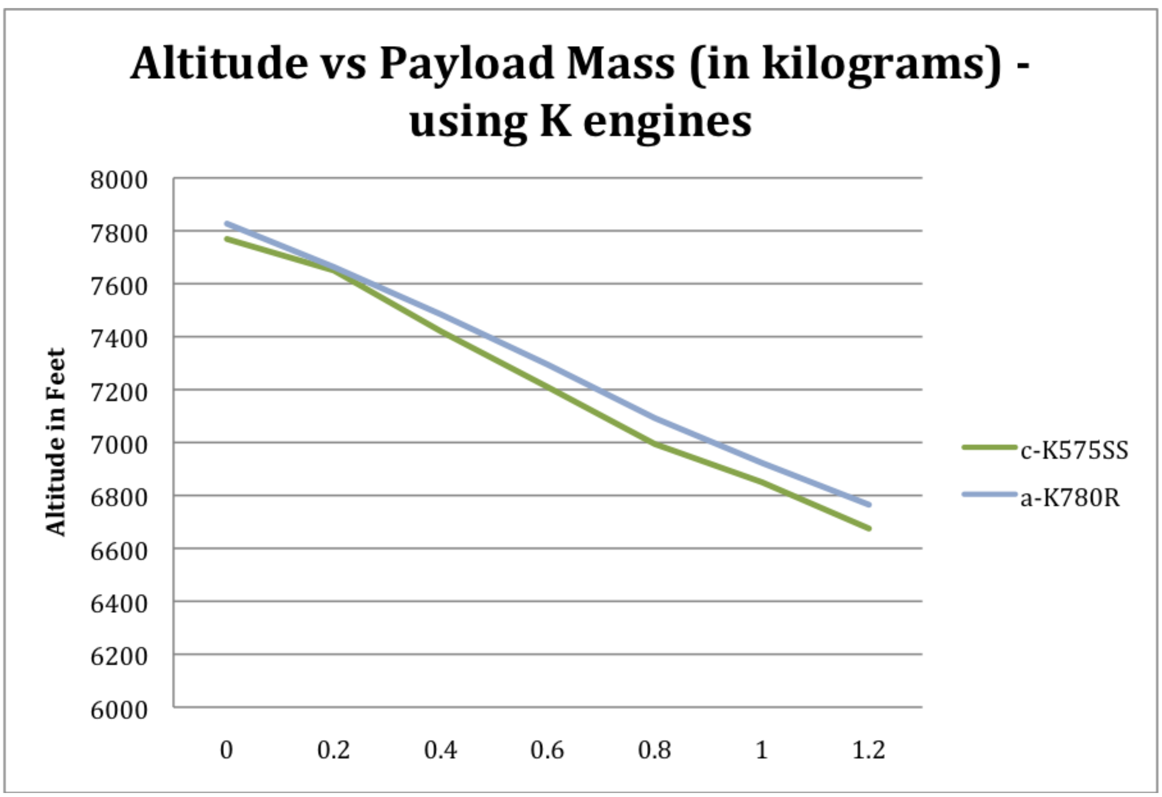
A plot of this factor versus deployment angle results in a concave down curve that is fairly linear for the first 40°. Subsequent testing, using the 3/8th scale, rocket showed a loss in altitude corresponding to ~1% for every degree of deployment. It is hoped that with a proper choice in motor, one yielding an altitude less then 30% over the height, and a judicious adjustment in deployment angle, the desired altitude of 5280 feet can be obtained.

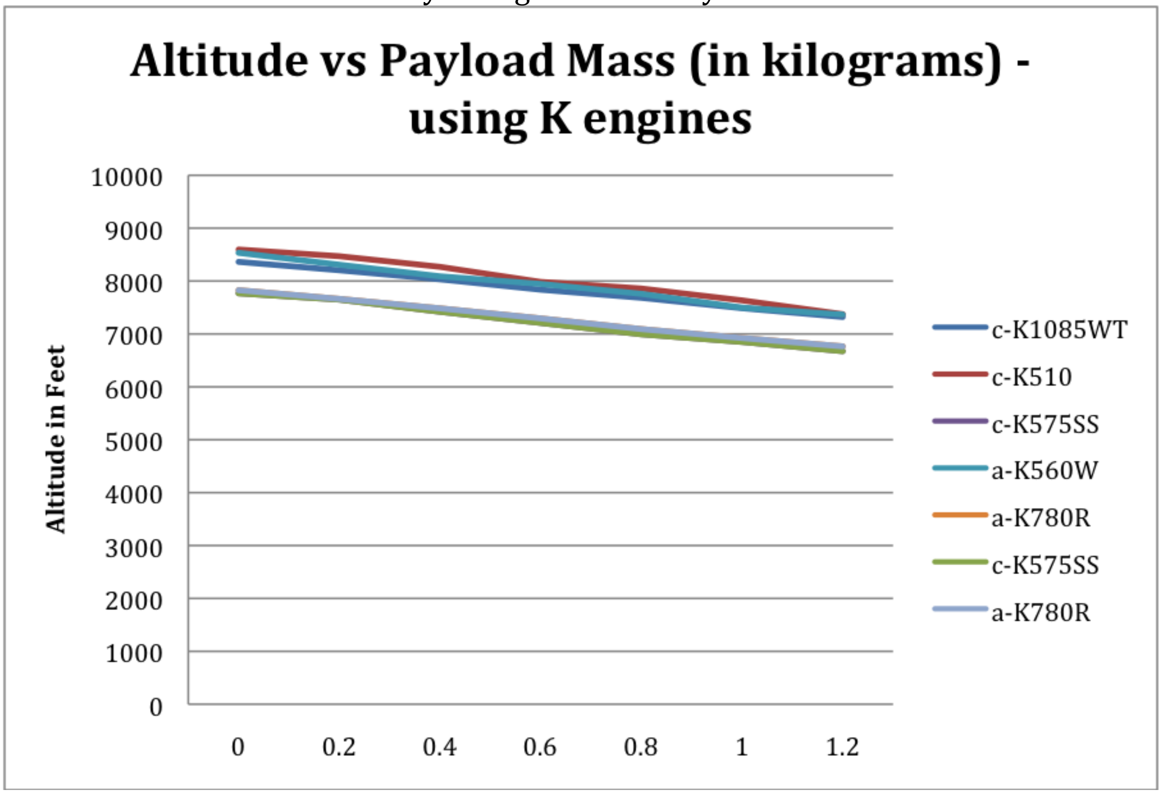
Motor Selection

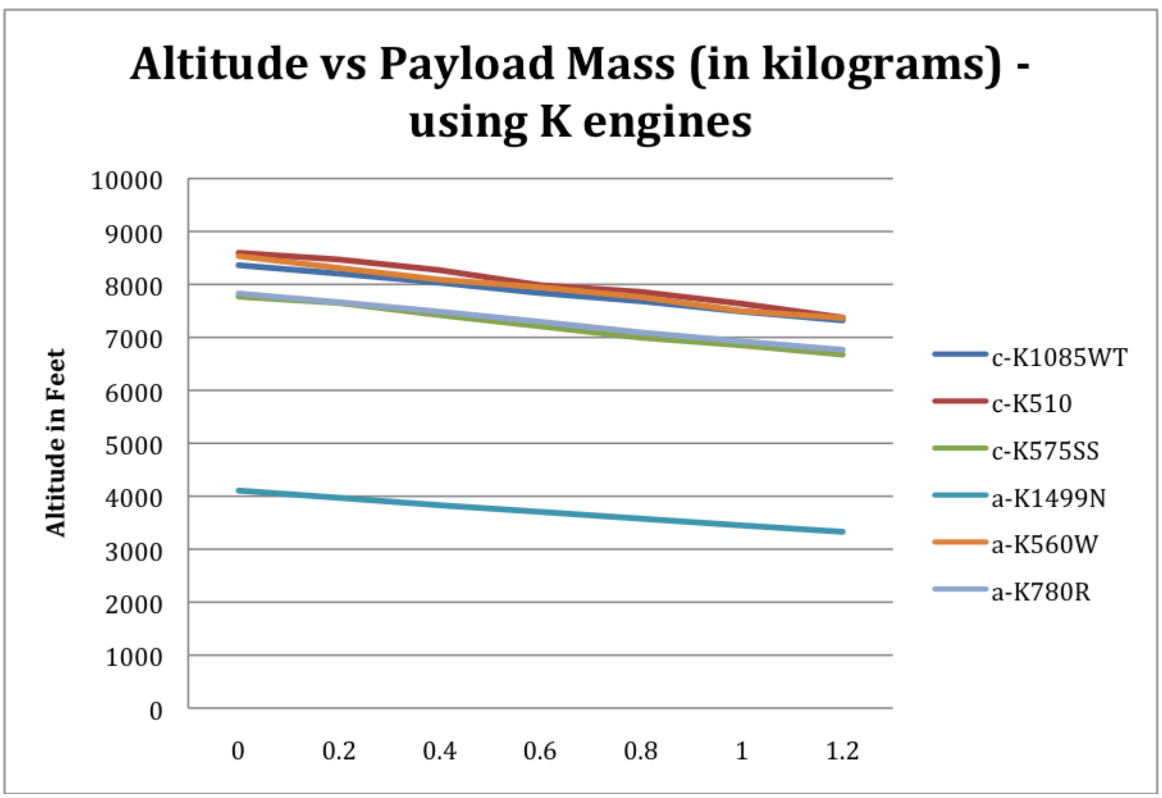
The motor for the Leo Hano rocket was determined through simulations with RockSim. Below are graphs of the data we collected.

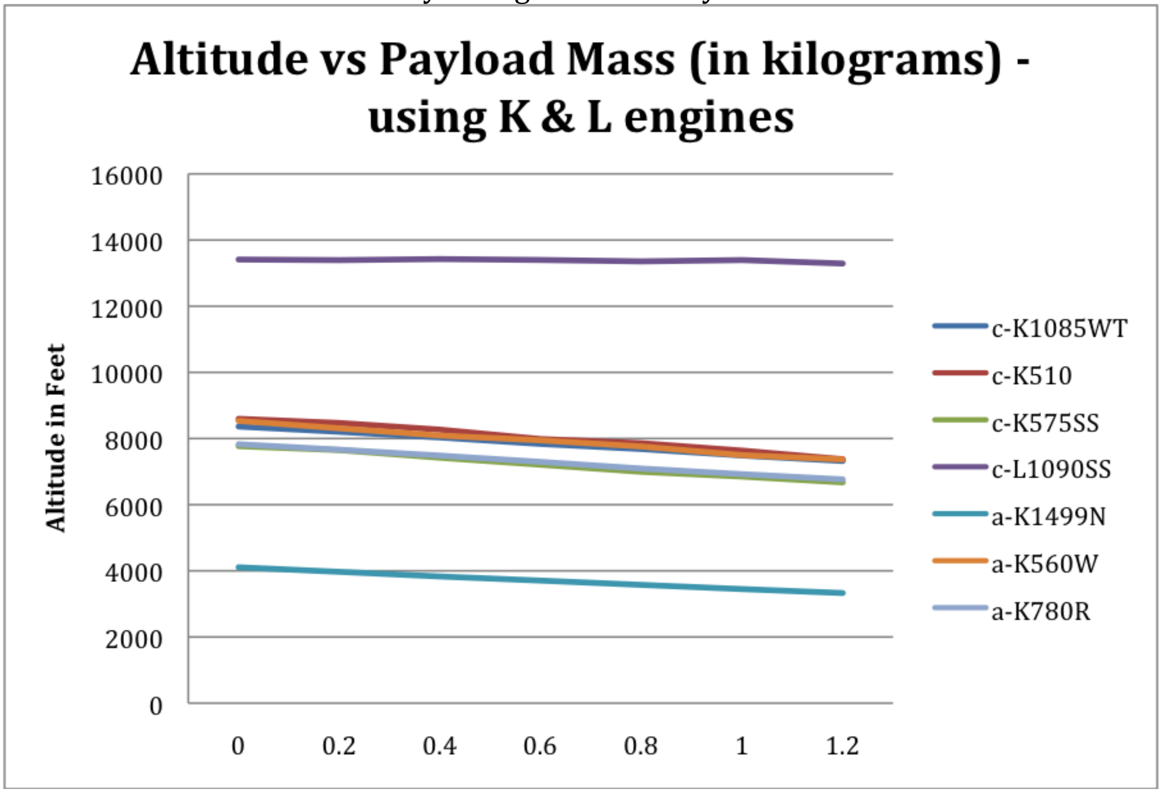
Motors with a "c" before them are motors made by Cesaroni, while motors with an "a" before them are motors made by Aerotech.

The variables that were taken into consideration in this motor selection process were the motor size and potential student payload mass. We needed a motor that got the rocket as close to 5820 feet as possible, while still going over 5820 feet. Also, the maximum altitude could not be above 6864 feet, because we would not be able to achieve the desired altitude of 5820 feet, even with our braking system fully deployed at 30°.




Altitude vs Payload Mass (in kilograms) - using K engines
Altitude in Feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.2
0.4
0.6
0.8
1
1.2
c-K1085WT
c-K510
c-K575SS
a-K560W
a-K780R
c-K575SS
a-K780R


Altitude vs Payload Mass (in kilograms) - using K engines
Altitude in Feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.2
0.4
0.6
0.8
1
1.2
c-K1085WT
c-K510
c-K575SS
a-K1499N
a-K560W
a-K780R



Construction Details

G10 Fiberglass used for body and fins. Birchwood, ½ ply used for bulk heads. Fins also laminated from tip to tip with fiberglass cloth to reinforce structural integrity. Critical bulkheads pinned to body tube with helically spiraled fiber intrusive devices. Slow-cure epoxy is used for attaching bulk heads and fins. JB weld metal adhesive is used to attach aluminum motor retainer and steel hinges to body tube.

Fins are through the wall construction and layered with fiberglass to create a singular unit. All bulk heads attached to body tube are epoxied on both sides. Critical bulkheads are pinned to body tube with helically spiraled fiber intrusive devices. Avionics bay connected using 3x grade 5 bolts and nuts. Booster and Payload section connected to Avionics section using stainless steel quick links. Shock cord connecting Payload and Booster sections is 1'' nylon x 20' sections. Nomex patches used to protect shock cord and parachutes. Payload and Booster bulkheads use stainless steel screw eye bolts. Screw eye bolts have been epoxied. Avionics bay electronics mounted onto and into G10 fiberglass.

Motor mount secured to airframe by the 3 fins via through the wall construction and 2 ½" ply birch wood centering rings. Aero Tech motor retainer attached using JB Weld.

Trapezoidal fin shape used has proven to be robust and resistant to breakage. Fins are 0.187” thick G10 fiberglass. Drag shoes are 0.12” thick.

“There is only one way to build a rocket, correctly,”
~Luftwaffe General Dornberger.

Alignment of fins and parts are mated with precision. No loose or unmatched parts are to be used. Epoxy joints are to be neat and clean. Excess epoxy is to be cleaned up immediately. Work area is to be kept neat and tidy. Personal protective equipment is to be used at all times to ensure the safety of all personnel. Intrinsic care and caution is to be exercised when using powered tools and equipment. Only personnel with qualifications pursuant to level of rocket motor are allowed to handle such motors equivalent to level of certification. NAR & TRA safety protocols are to be exercised at all times.

Rocket body Safety and Failure analysis

Failure Mode	Cause	Effects	Risk Mitigation
Loss of fin	Damage in shipping	Loss of stability & aesthetics. Falling debris	Rigorous pre-flight inspection
Loss of Drag shoe	Damage in shipping	Loss of aesthetics, slow torque along z-axis. Falling debris	Rigorous pre-flight inspection

Leo Hano booster section during construction

Full scale launch test:

Weather condition for March 14, 2010:

	Current:	High:	Low:	Average:
Temperature:	**71.5** °F	**79.6** °F	**69.7** °F	**73.4** °F
Dew Point:	**67.1** °F	**68.6** °F	**63.6** °F	**66.4** °F
Humidity:	86%	86%	67%	79%
Wind Speed:	**12.0**mph	**15.0**mph	-	**9.8**mph
Wind Gust:	**12.0**mph	**22.0**mph	-	-
Wind:	SSW	-	-	SSW
Pressure:	**30.09**in	**30.13**in	**30.03**in	-
Precipitation:	**0.08**in			

Using an Aero Tech J315 RL motor the rocket for our full scale launched showed a flight that was consistent with the data derived from our RockSim simulations. At launch, with wind speed between 12 to 15 miles per hour, the rocket did undergo some weather cocking off the launch rail. The rocket remained stable throughout the flight and successfully deployed its drogue chute at apogee. The maximum altitude recorded was 851 feet. At 400 feet (dictated by the HCX) our main chute was deployed successfully, and we could see a poof of smoke shortly after, indicating that our back up (MAWD) charge detonated, as it was intended at 300 feet. The rocket landed on a hard asphalt surface. This caused the HCX unit to be reset, so our altitude reading came from the PerfectFlight MAWDs. Despite its landing on a hard surface, the rocket was fully intact.

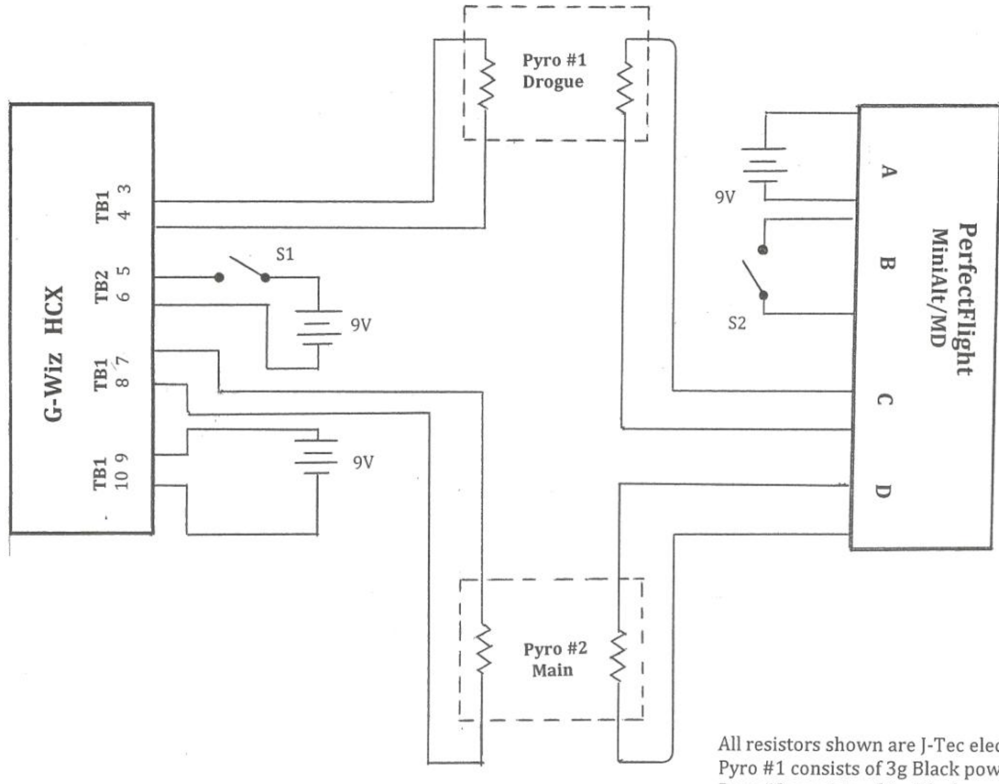
Recovery Subsystem

The rocket's drogue chute size is 36", drogue will yield a decent rate of 63 ft./sec. Main chute size is 96", will yield a decent rate of 20 ft./sec. Drogue and main chutes are attached to rocket using stainless steel quick links. Drogue chute is attached to the Avionics forward bulkhead via a stainless steel eyebolt. Main chute is attached to the Avionics aft bulkhead via a stainless steel eyebolt. Forward Avionics bulkhead is tethered to the Payload bay aft bulkhead via 1" x 20' nylon strap with stainless steel quick links on each end connecting to the stainless steel eyebolts of the bulkheads. Aft Avionics bulkhead is tethered to motor casing via 1" x 20' nylon strap with stainless steel quick links on each end connecting to the stainless steel eyebolt of the aft Avionics bulkhead and the motor casing forward closure. At apogee the drogue chute is deployed using a 3-gram FFFF black powder charge initiated by the G-Wiz HCX Flight Computer. Should the HCX fail to initiate the deployment charge, a second 3-gram FFFF black powder charge will be initiated by the Perfect Flight MAWD. 500 AGL the main chute will be deployed using a 4-gram FFFF black powder charge initiated by the HCX. Should the HCX fail to deploy the main chute the MAWD will ignite a second 4-gram FFFF black powder charge. Ground testing of the pyro charges has shown that the 3 and 4 gram charges are adequate for our design. Further testing of the avionics is planned for March 20, 2010.

Deployment test video link:

http://www.youtube.com/user/hrapozo#g/c/C63EC3A5EC384256

Recovery Avionics Block-diagram



All resistors shown are J-Tec electronic Matches
Pyro #1 consists of 3g Black powder
Pyro #2 consists of 4 g Black powder
All switches are of the Rotary type

Deployment Safety and Failure analysis

Failure Mode	Cause	Effects	Risk Mitigation
Drogue chute deployment failure	Main avionics failure	Rocket craters	Back-up Avionics
Main chute deployment failure	Main avionics failure	Rocket craters	Back-up Avionics
Drogue chute deployment failure	Main and back-up avionics failure	Rocket craters	Checklist for avionics
Main chute deployment failure	Main and back-up avionics failure	Rocket craters	Checklist for avionics
Drogue chute deployment failure	Main pyro failure	Rocket craters	Back-up pyro
Main chute deployment failure	Main and back-up pyro failure	Rocket craters	Checklist for avionics
Separation of sections	Shock cord severed	Falling debris, rocket damage	Checklist
Separation of sections	Shock cord anchor points	Falling debris, rocket damage	Checklist

Mission Performance Predictions

Mission Statement

It is the mission of the WCC Leo Hano rocket to promote interest in science, technology, engineering, and mathematics, for high school and college students, by providing a safe, reusable lifting body with safety being the primary concern.

This means that the safety of our prelaunch, flight, and recovery are of the highest priority. To have a successful mission the team must ensure that all safety requirements are maintained throughout the mission. The team must also meet all the following criteria below. A perfect mission with absolute success will meet all of the following criteria.

Mission Criteria:

- Payload functions properly
- Successful recovery the rocket and all its components
- Both parachutes deployed
- The rocket is completely intact
- The data is downloadable via EEPROM
- The voice-over performs it programmed duties (public is addressed)
- The subcontracted payload performed as it was planned to
- The appropriate levels of safety are maintained throughout the entire process of preparation, launch, flight, and recovery of the rocket

To achieve any type of success in the mission, the rocket must have deployed a parachute and must be intact upon recovery, meaning it has the ability to be considered flight ready and meets all safety requirements without any repairs done it. If the team does not have a parachute deployment and the rocket is not intact upon recovery, the mission will be considered a failure. A partially successful mission will be defined as meeting 6 of the 8 criteria, and has also deployed a parachute and remains intact upon recovery.

Performance Criteria

- Motor performed as expected
- Rocket will follow expected trajectory
- Desired altitude of 1 mile will be attained and not exceeded
- Drogue chute will be deployed at apogee
- Main chute will be deployed at 500 feet
- Leo Hano performs through the entirety of the mission

Major Milestone Schedule

WCC's major milestone schedule follows the USLI Timeline with the addition of our team's specific events. The USLI Timeline we follow is out of the 2009-2010 University Student Launch Initiative Booklet. Our team specific events can be seen on the Gantt plot. This Gantt plot provides the team's time line schedule for doing things, such as construction.

WCC's Major Milestone Schedule

August 2009:
14 Request for proposal (RFP).
15 Sky Performance Rocket Club of Hawaii (SPRCH) launch at WCC

September 2009:
19 SPRCH launch at WCC

October 2009:
8 Completed proposal due to NASA MSFC.
17 SPRCH launch at WCC
29 Notification of selection.
30 USLI team teleconference

November 2009:
12 Web presence established for each team.
21 Hawaii Space Grant Consortium (HSGC) Presentation, SPRCH launch at WCC

December 2009:
4 Preliminary Design Review (PDR) report and PDR presentation slides due
14 PDR video conference.
19 Launch at Pacific Missile Range Facility (PMRF) and SPRCH launch at WCC, Stability testing of 3/8 scale model

January 2010:
16 SPRCH launch at WCC
20 Critical Design Review (CDR) report and CDR presentation slides due

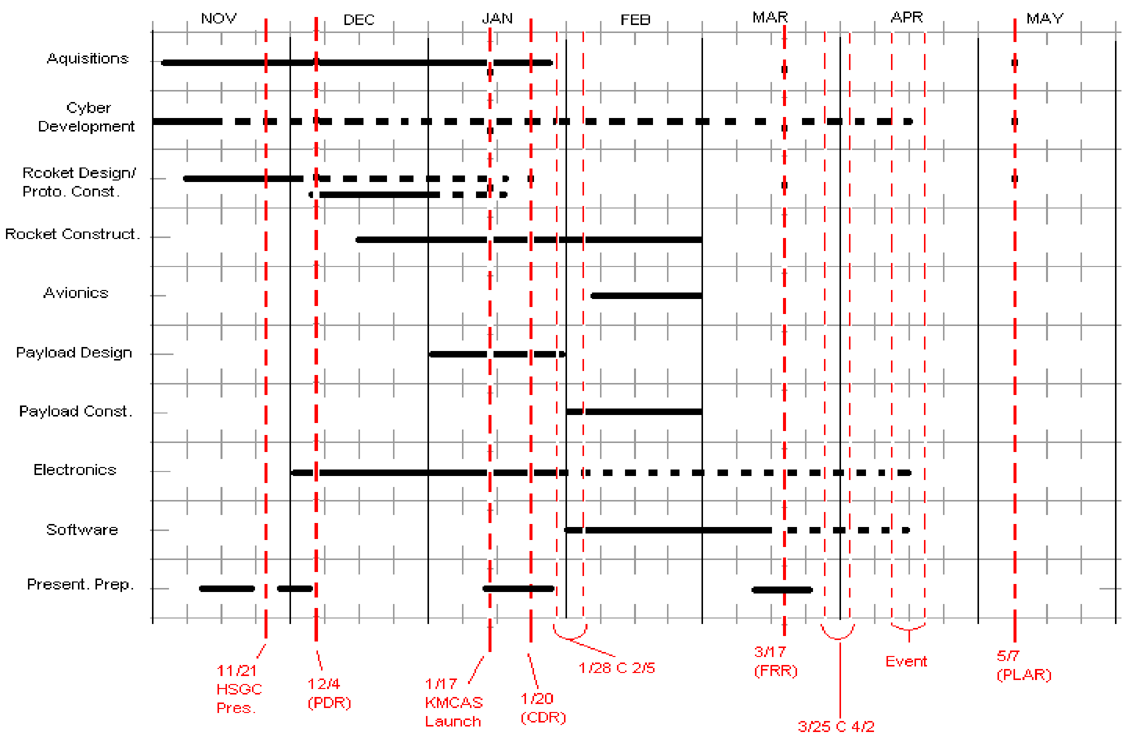
February 2010:
1 Booster section completion
4 Critical Design Review presentations
14 avionic section complete
20 SPRCH launch at WCC, recovery deployment test
21 payload section and carrier completion
28 nose section completion

March 2010:
6 Recovery Deployment test at WCC
14 Kaneohe Marine Core Air Station (KMCAS) full scale test launch
17 Flight Readiness Review (FRR) report and FRR presentation slides due
20 SPRCH launch at WCC
29 FRR presentations

April 2010:
14 Travel to Huntsville
15 or 16 Rocket Fair/hardware and safety check
17-18 Launch weekend
19 Return home

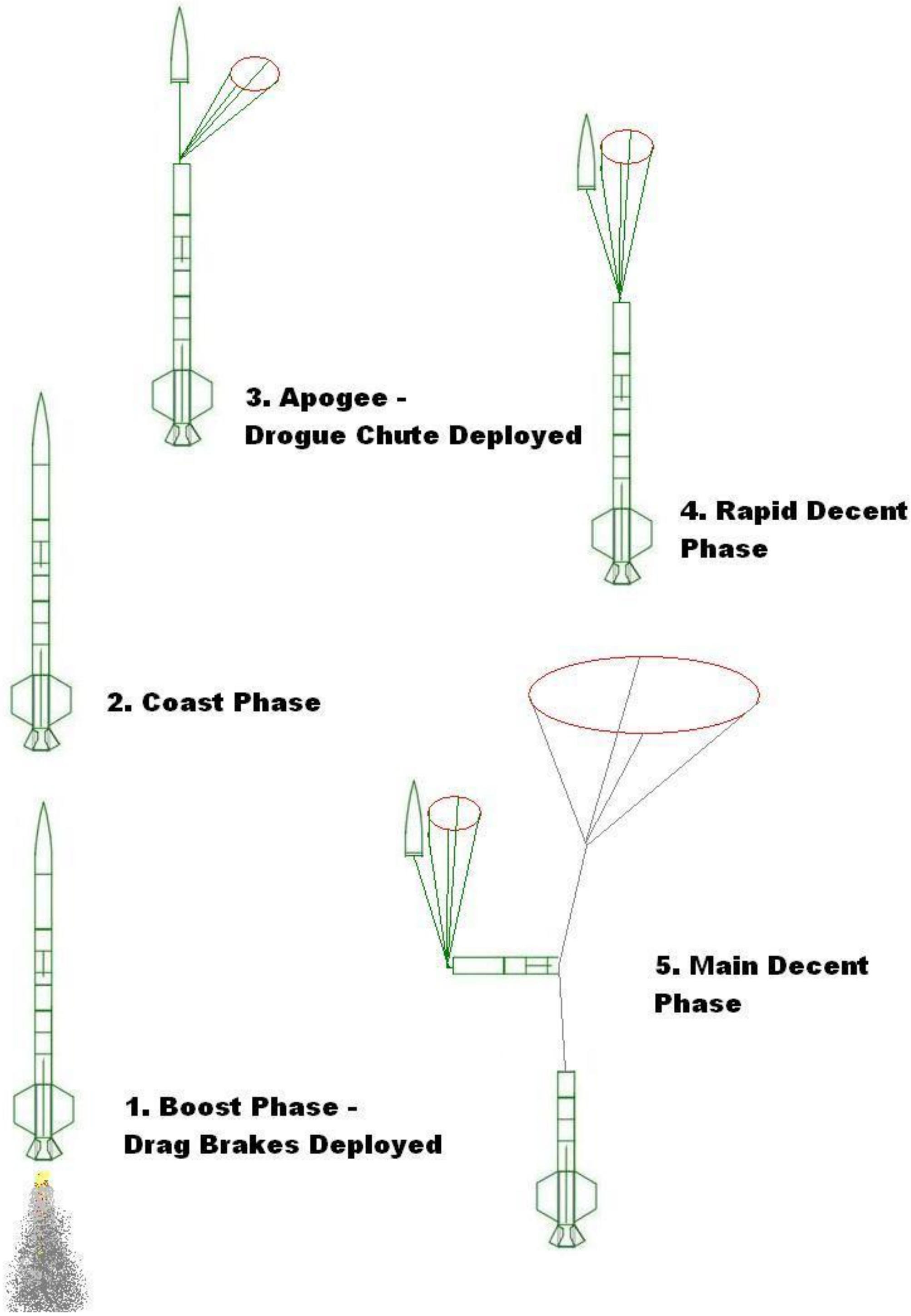
May 2010:
7 Post-Launch Assessment Review (PLAR)
21 Announcement of winning USLI team

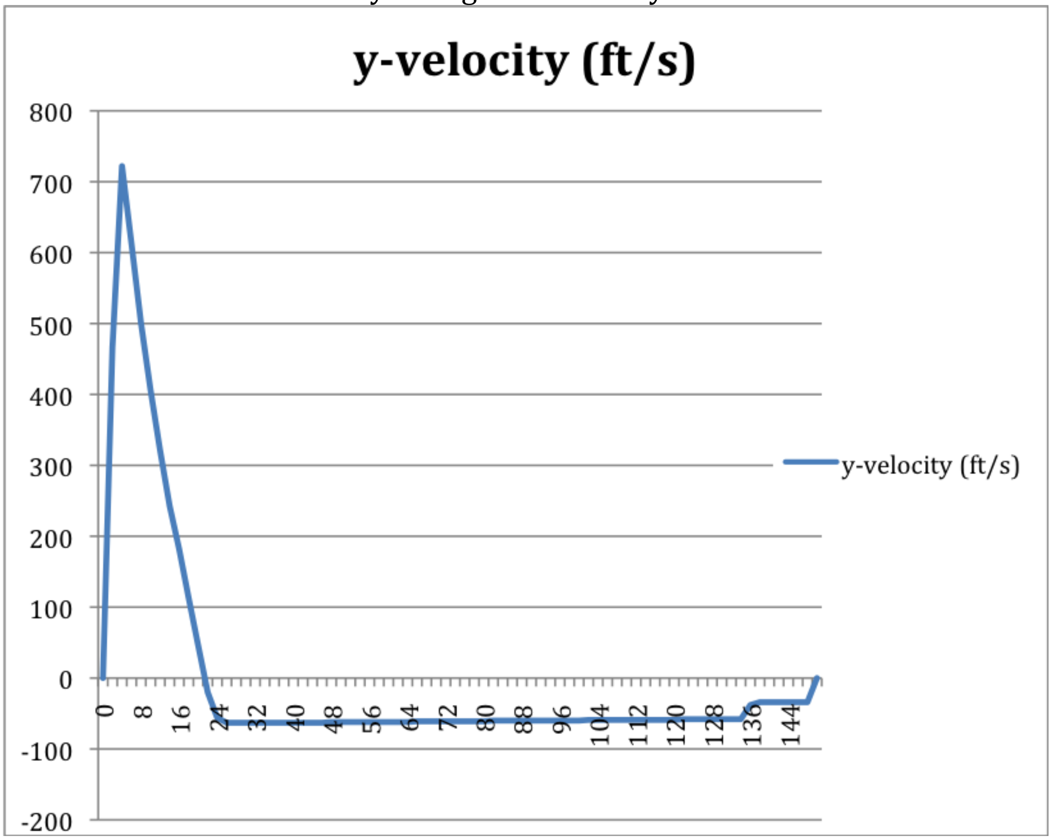
WCC's Gantt Chart

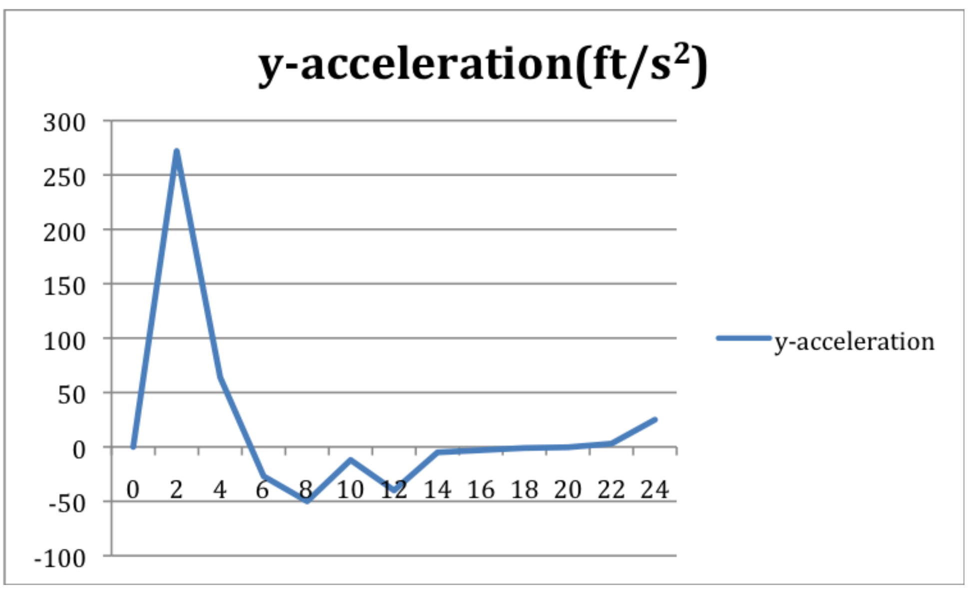


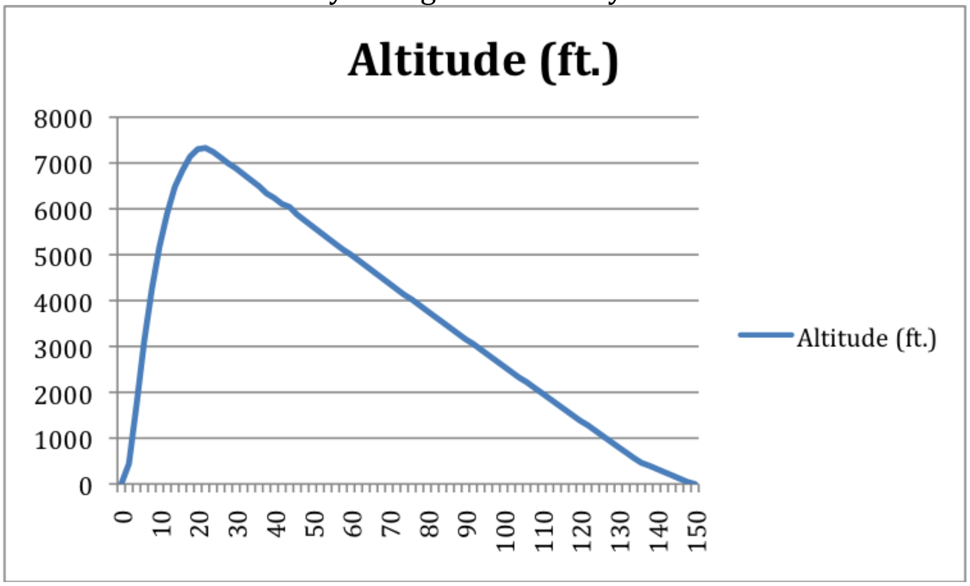
(Refer to Appendix A for larger image)

Flight Profile




y-velocity (ft/s)
800
700
600
500
400
300
200
100
0
-100
-200
0 8 16 24 32 40 48 56 64 72 80 88 96 104 112 120 128 136 144
y-velocity (ft/s)


y-acceleration(ft/s²)
300
250
200
150
100
50
0
-50
-100
0 2 4 6 8 10 12 14 16 18 20 22 24
y-acceleration



The motor that we have chosen is the Aero Tech K560W.

Manufacturer:	AeroTech
Entered:	May 25, 2006
Last Updated:	Apr 1, 2008
Mfr. Designation:	K560W
Brand Name:	K560W
Common Name:	K560
Motor Type:	reload
Diameter:	75.0mm
Length:	39.6cm
Total Weight:	2744g
Prop. Weight:	1425g
Cert. Org.:	Tripoli Rocketry Association, Inc.
Cert. Designation:	K590 (88%)
Cert. Date:	
Average Thrust:	560.0N
Maximum Thrust:	753.7N
Total impulse:	2417.0Ns
Burn Time:	4.1s
Isp:	179s
Case Info:	75/2560
Propellant Info:	White Lightning

Data provided by thrustcurve.org

Safety and Environment (Vehicle)

The safety officer for WCC's team is Dr. Jacob Hudson.

Material Safety Data Sheets: Refer to Appendix A

NAR Regulations: Refer to Appendix B

Hazard Mitigations: Refer to Appendix C

● Discuss any environmental concerns.
As concerns MSFC; we are unaware of any environmental concerns.

I) Payload Integration
● Describe integration plan with an understanding that the payload must be co developed with the vehicle, be compatible with stresses placed on the vehicle and integrate easily and simply.

- Mynah Bird 2 payload limits are:
  - Mass - 500 grams (17.63 ounces)
  - Diameter - 72 mm (2.83 or 2-13/16 inches)
  - Length - 203 mm (8 inches)
- Each Sparrow will be built under the following limits:
  - Mass – 141.75 grams (5 ounces)
  - Diameter- 42 mm (1.64 or 1-21/32 inches)
  - Length - 177.8 mm (7 inches)
- The Sparrow packages will not be ejected from the Leo Hano rocket.
- There is no need for a hole in the payload bay of the Leo Hano rocket
- Each Sparrow can be flown on an Omega rocket powered by C to E motor.

Safety and Environment (Vehicle)
Payload integration and launch operations, including proposed and completed mitigations.
II) Payload Criteria
Selection, Design, and Verification of Payload Experiment
● Review the design at a system level, going through each system's functional requirements. (Includes sketches of options, selection rationale, selected concept and characteristics.)

- Devices in the project were selected based on price, availability of parts and vendor documentation.
- The DS1620 temperature sensor do not need any calibration
- Still need to figure out how to calibrate the MMA7455L accelerometer

● Describe the payload subsystems that are required to accomplish the payload objectives.

Sparrow1 – temperature sensing

- Basic Stamp 2 (Parallax) – controller for the project
- Support
    - 24LC512 (Microchip) – 32Kbyte EEPROM for data storage
    - DIP switches – input
    - LED – status
    - Serial I/O port – data transfer
- Sensors
    - DS1620 (Dallas Semiconductor) – temperature sensor:
- Power supply - 9 volt alkaline battery
- Data
    - 4 bytes/event
    - 1 event/second
    - 8100 total events
    - 135 minutes

Sparrow10

- Basic Stamp 2pe (Parallax) – controller for the project. Also includes 16K bytes EEPROM for data storage
- Support
    - DIP switches – input
    - LED – status
    - Serial I/O port – data transfer
- Sensors:
    - MMA7455L (Free scale Semiconductor) – 3 Axis -/+ 8g accelerometer
- Power supply - 9 volt alkaline battery
- Data
    - 3 bytes/event
    - 1 event/second
    - 5280 total events
    - 88 minutes

Sparrow12

- Basic Stamp 2p (Parallax) – controller for the project
- Support
    - 24LC512 (Microchip) – 64Kbyte EEPROM for data storage
    - DIP switches – input
    - LED – status
    - Serial I/O port – data transfer
- Sensors:
    - MMA7455L (Free scale Semiconductor) – 3 Axis -/+ 8g accelerometer

- Power supply - 9 volt alkaline battery
- Data
    - 3 bytes/event
    - 21840 total events
    - 364 minutes at 1 event/second
    - 182 minutes at 2 events/second
    - 121 minutes at 3 events/second
    - 91 minutes at 4 events/second
    - 72 minutes at 5 events/second

● Describe the performance characteristics for the system and subsystems and determine the evaluation and verification metrics.

- Sparrow10 is currently being built and tested. 3 units are in operation (1 ground test and 2 in flyable condition)
- Sparrow1 has been flown at least 3 times using 2 different units
- Sparrow12 hasn't been built yet but is a variation of Sparrow10.

● Describe the verification plan and its status.

Sparrow1

- A unit that was built in 2008 is still around and has been flown at least two times.
- Another unit will be constructed using updated techniques for this project.

Sparrow10:

- Unit #1 is constructed on a Parallax Board of Education development board, this would help with debugging controller code, device hookups and battery life issues. Work on this unit started on February 20, 2010.
- Unit #2 is constructed on a breadboard. This unit was completed on March 5, 2010 and has been used in the testing of the Leo Hano deployment test on March 6, 2010 and 3 flights on an Omega 24e on March 14, 2010.
- Unit #3 is constructed on a breadboard and was completed on March 12, 2010. It was flown on the Leo Hano rocket on March 14, 2010.
- Unit #4 will be constructed on a circuit board which will be the actual unit that will fly in the Leo Hano rocket. Some parts for this unit need to be purchased as well as a circuit board from Express PCB.

Sparrow12

- This project hasn't been started yet but it plans to share the same code and most of the parts from Sparrow10 (using a faster controller and adding an external EEPROM).

● Describe preliminary integration plan

- Each Sparrow be housed in a section of Estes BT-60 body tube and will be capped with a balsa bulkhead.
- Each Sparrow project uses a different controller which has a different color
  - Sparrow1 – Basic Stamp 2 – green
  - Sparrow10 – Basic Stamp 2pe – dark red
  - Sparrow12 – Basic Stamp 2p – yellow
- Data dumps from each Sparrow project will contain a project id, project code version and unit number.

● Determine the precision of instrumentation, repeatability of measurement and recovery system
.

- Sparrow1 – air temperature sensor accurate to a half Centigrade
- Sparrow10 and Sparrow12 – accelerometer reporting is accurate to .0625g (2 ft/sec/sec)

Payload Concept Features and Definition
● Creativity and originality

- Using 3 independent packages allows for different data collection sample rates and redundancy. In case one package fails it will not affect the other two packages.

● Uniqueness or significance

- The Sparrow projects have 2 modes of operation based on DIP switch settings
  - Mission mode – On power up at this setting Mynah Bird 2 will gather data from the sensors and store this information on the EEPROM provided that the Safety mode switch is on at startup
  - Setup mode – On power up at this setting and with a computer connected to its serial I/O port it will display a menu of available options which will allow the user to:
    - Dump the EEPROM contents to a computer display (the computer will capture the output to a file).
    - Test each sensor individually.
    - Run a short term mission

● Suitable level of challenge

- Have used the Basic Stamp 2p and Basic Stamp 2 controller, DS1620 temperature sensor and the 24LC256 EEPROM in other projects before.
- Haven't integrated a project into custom designed printed circuit board before.

Science Value

● Describe Science Payload Objectives.

- Sparrow10 and Sparrow12 will be used to determine the forces acting on the rocket during its flight. Sparrow10 will sample once a second while Sparrow12 is planned to sample between 2 to 5 times a second..
- Sparrow1 will be used to measure the air temperature within the payload section of the Leo Hano rocket.

● State the payload success criteria.

- Complete Success – All three Sparrows returns intact and all data from the sensors have been retrieved.
- Success – All three Sparrows returns intact but data from some of the sensors have been retrieved.
- Minimal Success – Acceleration data has been recovered
- Disappointment – All three Sparrow returns but no data has been recovered.
- Set Back – Any of the Sparrow returns with damage such that it cannot be repaired at the launch site
- Complete Failure – All three Sparrows are lost and no data has been recovered.

● Describe the experimental logic, approach, and method of investigation.

- Will compare acceleration readings between Sparrow10 and Sparrow12.

● Describe test and measurement, variables and controls.

- Will use canned air to test temperature sensors.
- Test flights on a model rocket.

● Show relevance of expected data, accuracy/error analysis.

- Will compare results of recovered acceleration data against simulated projections from either RockSim or RASP.

● Describe the Preliminary Experiment process procedures.

- Will need to generate RASP or RockSim simulations based on the final build of the Leo Hano rocket and the model rocket test.

Safety and Environment (Payload)
● Identify Safety Officer for your team.

- Helen Rapozo for the building and testing phase.

● Provide a Preliminary analysis of the failure modes of the proposed design of the rocket, payload integration and launch operations, including proposed and completed mitigations.

- Since all three Sparrows remains inside the Leo Hano throughout the entire flight it shares its fate with that rocket.
- If the Leo Hano spends too much time on the launch pad the either the battery needs to be replaced or the amount of events Mynah Bird 2 can record has exceed its limit.

● Provide a listing of personnel hazards, and data demonstrating that Safety Hazards have been researched (such as Material Safety Data Sheets, operator's manuals, NAR regulations), and that hazard mitigations have been addressed and mitigated.

- Canned air – do not use it in confined spaces and make sure that people don't touch surfaces after it has been sprayed upon.

● Discuss any environmental concerns.

- Updated parts list after the unit has been constructed.
- Will be using alkaline batteries as the power source.
- The outer shell of the Sparrows will use a paper tube and balsa bulkheads.

V) Launch Operations Procedures
Checklist
Provide detailed procedure and check lists for the following.

Recovery preparation
- ❖ Chutes were packed,
- ❖ Shock cord attachments checked
  - o Attachment at aft bulkhead payload section
  - o Attachment at forward bulkhead payload section
  - o Attachment at aft bulkhead avionics section
  - o Attachment at forward motor case I-let.
- ❖ Parachutes are attached
  - o Drogue is attached to the aft bulkhead of the payload section
  - o Main parachute is attached to the aft bulkhead of the avionics section
- ❖ Forward drogue pyrotechnics are placed

- Nomex patch is placed over forward drogue pyro
- Drogue chute inserted
- The payload section is seated onto the coupler
- Avionics are attached via quick connect to the forward pyrotechnics
- Avionics board is inserted into avionics section
- Aft pyrotechnics for main chute are connected to avionics via quick connect
- Aft bulkhead is inserted into the avionics bay firmly secured via three wing nuts
- After pyrotechnics are placed above motor mount in booster section
- Nomex patch is placed over that
- Main chute is inserted
- Booster is seated onto aft avionics section coupler

- ● Setup on launcher

- Launch pad tilted over
- Rail buttons are aligned with the rail launcher
- Avionics are armed
  - Make sure that avionics are functioning properly.
- M-Tech electronic match Igniter is installed into the nozzle and pushed up until firmly seated in the motor.
- Launch pad up righted
- Rocket is slid down the rail and placed on an offset
- Igniter leads are connect to the launch control system
- Test for continuity

- ● Launch procedure

- Make sure that we have clearance to launch from the range safety officer
- Alert spectators of the launch
- Ensure that everyone is proper distance away from the launch pad
- Launch at LCO desecration

- ● Post flight inspection

- Are all rocket sections intact?
  - Booster
  - Avionics
  - Payload
- Are they still connected?
- Is shock cord still attached?
- Is there any charring of the chute of the shock cord?
- Are the avionics still functioning and giving off consistent signals?
- Are all quick links nominal?

Safety and Quality Assurance
Provide detailed safety procedures for each of the categories in the Launch Operations Procedures. Include the following:

● Provide data demonstrating that risks are at acceptable levels.

Test launch video:
http://www.youtube.com/user/hrapozo?feature=mhw4#p/c/2876F744B00AF01E/0/lENAOq6s7q0

● Risk assessment for the launch operations, including proposed and completed mitigations.

● Discuss environmental concerns.

● Identify individual that is responsible for maintaining safety, quality and procedures checklist.

Dr. Jacob Hudson

VI) Activity Plan
Show status of activities and schedule

● Educational engagement
Windward Community College in association with Sky Performance Rocket Club of Hawai’i (SPRCH) hosts monthly launches every third Saturday from 2:30 pm to 5:00 pm. The launches are open to the public encompassing families, students, and amateur rocket enthusiasts.
WCC has also assists with launches on the neighboring island of Kauai providing Range Safety, Launch Control, and Technical assistance.
The launches at WCC provide a pathway to bigger and better opportunities. Students have utilized our launches to perform science experiments for school which have led to the state science fair and national competitions. An example would be the Team America Rocketry Challenge (TARC).

VII) Conclusion

All components of the rocket have been tested. The rocket has performed as expected for the motor that was used in the test. It was recovered intact, and we are ready for Marshal