Preliminary Design Report

Roaring Lions

Normandale Community College

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Executive Summary

The 2016-2017 NASA's Space Grant Midwest High-Power Rocket Competition was designed to challenge college students to construct and safely fly a dual deploy high power rocket on two significantly different class motors to the same apogee. The challenge also requires the teams to construct a non-commercial data collecting package that would directly measure velocity vs. time.

This report describes the rocket we have designed to meet the competition criteria. As part of this design process we have considered criteria such as material cost, build and maintenance simplicity, low air drag, stability margin greater than 2, thrust to net weight ratio greater than 5:1, max speed less than 1125.33 ft/s (340.29 m/s), off rail velocity greater than 45 ft/s (13.7m/s), landing velocity less than 24 ft/s (7.3 m/s), high figure of merit, and a minimum possible total weight.

In order to meet these criteria, we have decided to construct a 4-inch (10.2cm) diameter by 72 in (183 cm) long rocket out of Apogee Blue Tubing. The rocket will fly using an Aerotech J-1299 and a Aerotech K-185 motor. Based on the outputs from our Open Rocket and Excel simulations, the Aerotech J-1299 and Aerotech K-185 were the best pair of motors to choose for our rocket.

In order to reach the same apogee, our team decided to use a "Retractable fins" idea for our braking mechanism. This mechanism is easy to deploy, takes a very small amount of space and produces a significant amount of braking force to slow down the rocket.

To collect our velocity versus time data we will use a "Pitot Tube" technique. We decided to put the device inside of the rocket's nose cone. This location ensures our data collecting package will accurately measure the ram pressure and then compare it to the data collected for static pressure.

For our dual deploy recovery system, our team decided to go with a conventional method of deploying the drogue and the main parachutes. To deploy the chutes we are using black powder charges ignited by a Stratologger altimeter. The recovery system and altimeters will be powered by an E-Flite LiPo battery. Putting the main parachute in the upper half of the rocket and the drogue parachute in the lower half of the rocket was determined to be the best and simplest way of deploying our recovery system. To log both deployments we are using two E-Flite EFC 721 HD video cameras, one pointing up and the other pointing down relative to the nose cone.

With everything combined, our theoretical apogee without braking according to our OpenRocket simulation for J-1299 turned out to be 3093 ft (943 m) and for K-185 the apogee was 5018 ft (1529 m). With braking, the apogee for the K-185 was 3477 ft (1060 m).

Introduction

The main objective for this year NASA's Space Grant Midwest High-Power Rocket Competition is to design and build a high power rocket that will reach an apogee of at least 3000 ft (914.4 m) on two significantly different class motors. The rocket also has to achieve as close of an apogee as possible on those two different motors. The objective also consists of collecting a direct measurement of velocity versus time through a use of a non-commercial data collecting package. The final part of that objective was to safely deploy a recovery system while logging that deployment as well as landing the rocket at a nominal 24 ft/s (7.3 m/s) velocity.

Our team's design process started off with finding the optimal pair of motors that have the capability of enabling our rocket to meet all of the criteria, which were again: material cost, build and maintenance simplicity, low air drag, stability margin greater than 2, thrust to net weight ratio greater than 5:1, max speed less than 1125.33 ft/s (343 m/s), off rail velocity greater than 45 ft/s (13.7 m/s), landing velocity, the maximum figure of merit, and minimum total weight. We used the combination of Excel and OpenRocket simulations to refine the list of motor choices.

Our team used Autodesk Inventor to construct an overall CAD model for our rocket. Mainly our focus was on the design for braking mechanism. What started as a simple 3 part assembly turned into a more complex structure, which we put under maximum loads using the software's Stress Analysis tool.

Those maximum loads were determined by using maximum velocities that the rocket reached in OpenRocket simulation. In order to compensate for any discrepancies in the design, we significantly increased the distributed loads on the fins. We concluded that this approach was the best to ensure that our braking mechanism will easily hold under stresses produced by air drag at any point of flight.

To determine the stability of the rocket while our air brakes were deployed we used the Computational Fluid Dynamics feature provided in the Autodesk Inventor. To back the simulation results we used hand calculations using the Barrowman equations to see by how much the center of pressure shifts after our rocket deploys the air brakes.

Overall, we predict our design will achieve the desired benchmarks of apogees over 3000ft (914.4 m), a landing velocity under 24 ft/s (7.3 m/s), a thrust to weight ratio of 5:1, reliably record velocity over time, record the deployments of the drogue and main parachutes, visually record the fore & aft directions during flight and completing the launch-to-recovery safely.

Mechanical & Electrical Design Overview

Airframe System Dimensions and Specifications

For overall rocket dimensions, our team decided to go with a 4 inch (102 mm) diameter by 72 inches (183 cm) in length. Our decision for these dimensions was based mainly on three parameters: stability margin greater than 2, the minimum force of drag, and ease of maintenance.

For the rocket's airframe material we chose Apogee Blue Tubing, which has the density of 1.3 g/cm3. Our original plan was to use Kraft Phenolic the density of which is 0.95 g/cm3. Although Kraft phenolic is lighter and stronger than Blue Tubing, it is also brittle at the moment of impact with the ground at landing. To prevent any fractures, we decided to go with Blue Tubing since it has high resistance to fracturing and is relatively easy to work with.

The airframe consists of 4 main parts: nose cone, main parachute segment, air brake segment, and the motor segment. The avionics bay is secured in the upper air brake coupler, which is secured to the airframe via a press fit and use of pop-rivets.

To structurally secure areas of the body that have had material cut or drilled away, a strip of epoxied fiberglass will be added. Since we are using epoxy and rivets to secure our braking mechanism, the fiberglass strip will give more rigidity to the areas where the rivets will be holding our breaking mechanism to the airframe.

To hold all of the permanent components together we are going to use a two part general use epoxy. The only components we will not use general use epoxy on are the motor mount and flame wall. Those parts will be secured with the heat resistant epoxy.

After a few considerations and debates, our team decided to go with a set of four plexiglass fins with the square cross-sectional area and a thickness of 0.118 inches (3mm). The fins have the root chord of 6 inches (152 mm), tip chord of 3 inches (76.2mm), the height of 4 inches (102 mm), and the sweep angle of 25 degrees. All fins are secured to the rocket in two locations. First, they are secured to the motor mount using a two part epoxy fillet on both sides of each fin and on the top of the airframe also using two part epoxy fillet on both sides of the fin.

Propulsion System Dimensions and Specifications.

For our propulsion system, we decided to use J-1299 and K-185 motors. This choice of motors was determined through numerous OpenRocket and Excel flight performance simulations as well as calculations via Excel for a high Figure of Merit.

J-1299 is a reloadable Aerotech solid state motor that can provide a maximum thrust of 1468.3 Newtons of thrust but on average it produces a thrust of 1291.6 Newtons. This motor produces a total impulse of 843.0 Newton-seconds and it burns for 0.7 seconds. The motor's total mass is 29.4oz (834 g) whereas its propellant total mass is 13.1oz (372g). Finally, J-1299 has a length of 23.1 centimeters and a diameter of 54.0 millimeters.

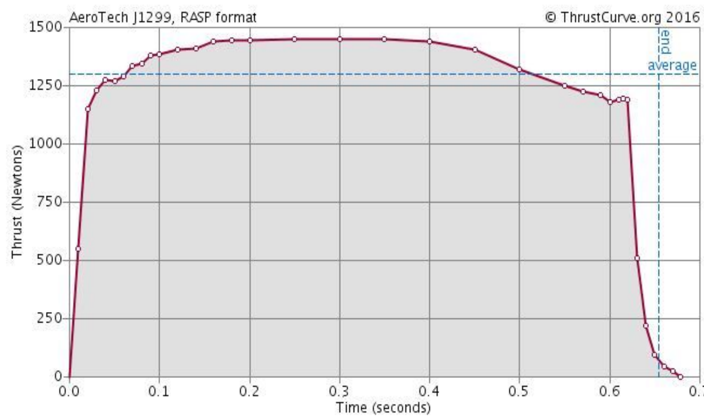


Figure 2.

K-185 is a reloadable Aerotech solid-state motor that can produce a maximum thrust of 404.7 Newtons, but on average it can provide a thrust of 185.0 Newtons. It produces a total impulse of 1417.2 Newton-seconds and it burns for 6.9 seconds. K-185 has a total mass of 50.58oz (1434g), but the propellant mass is only 29.5oz (837g.) The motor's length is 17.2in (43.7cm) and a diameter of 0.21in (54mm).

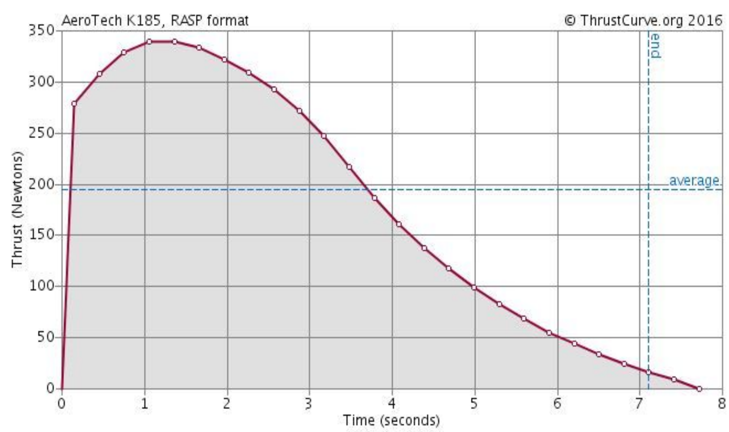


Figure 3.

Air Brake Overview and Drag Analysis

The braking module is located between the drogue shoot and avionics bay. Decoupling points above and below the module allow for easy serviceability. The air brake is composed of two layers, each including four flaps. The flaps will simultaneously protrude up to 1 inch horizontally from the body. At full extension, the flaps add eight square inches of cross sectional area. Figures 4 and 5 illustrate our breaking mechanism at full extension.

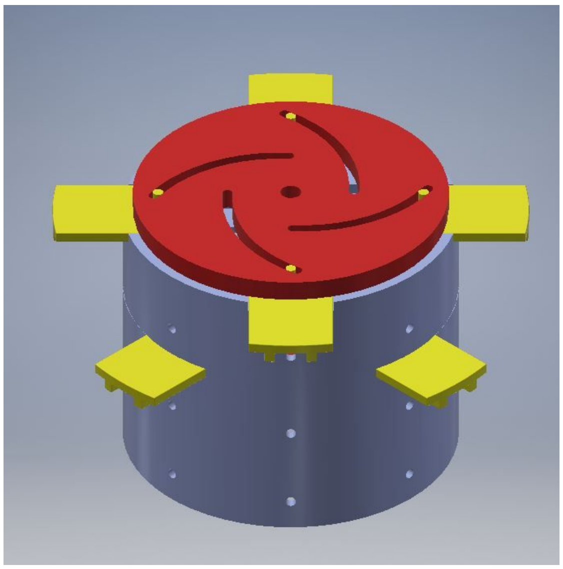


Figure 4.

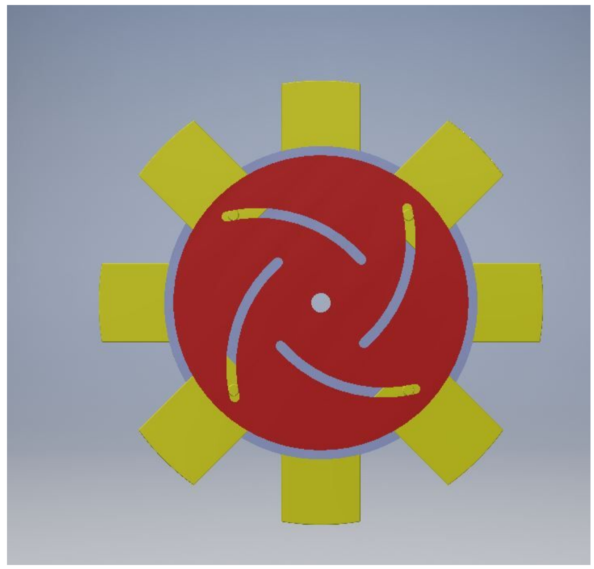
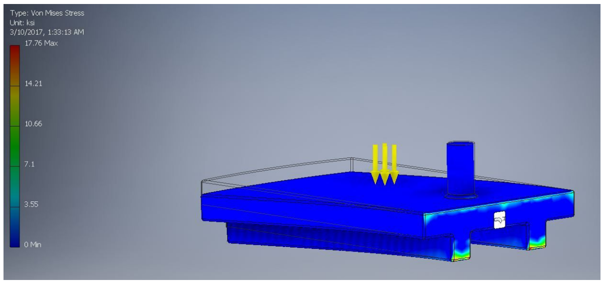


Figure 5.

Using OpenRocket as well as our excel simulations, we equated the average force of drag on the rocket to be approximately 12N when the air brake is retracted. While the air brake is deployed the average force of drag increases to 42N. The average force was calculated using 1.28 as the coefficient of drag on the air brake. This increase in drag force will allow us to use two significantly different motors and achieve our desired apogees.

The braking mechanism will be printed out of ABS plastic. Stress simulations in Autodesk show the flaps will stay rigid. The Von Mises Stress of the flap constrained at the back side and being under of 100N (22 psi) of force reaches the maximum of 17.76 kilopounds per square inch (122.45 MPa). As it seen in the Figure 6, the only spot that experiences the maximum Von Mises Stress are the edges of the two bottom ribs. The same type of stress analysis was performed for the the whole breaking mechanism and the Von Mises Stress of the flaps reached only 2.875 kilopounds per square inch (19.822 MPa). This simulation can be seen in Figure 7. According to teststandard.com the flexural yield strength of ABS plastic is between 60.6 MPa -73.1 MPa.



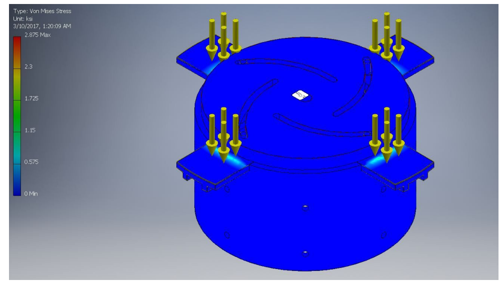
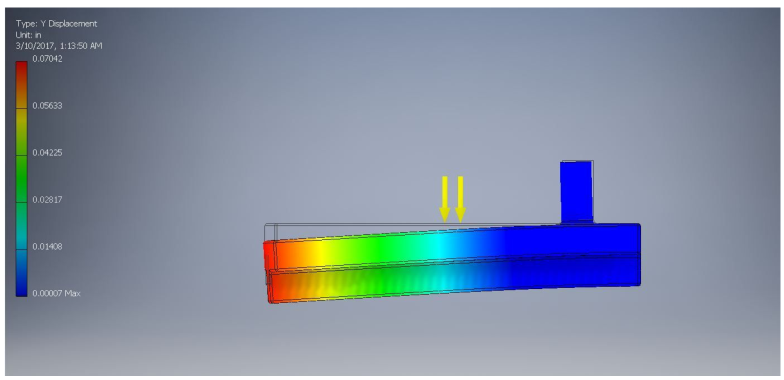


Figure 6. **Figure 7.**

The maximum displacement that the fin experienced under those load was 0.07 in



(1.778mm) and that can be seen in Figure 8. Further evaluation will show whether or not ABS plastic is the

Figure 8.

best material that our braking mechanism would be made of. The next candidate is Aluminum 6061 which has a higher flexural yield strength. Few stress analysis simulations were ran and both the maximum of Von Mises Stress and the displacement were much lower.

The flaps are deployed and retracted by a high torque servo(s). The servo(s) rotates a slotted plate which then moves the flaps via cylindrical pins. The flaps slot into two grooves that ensure correct deployment and add rigidity. To ensure smooth and resistance free movement of each part, the air-brake is lubricated with a silicon grease. The air brake module will be fastened to the body using 16 rivets top and bottom. The force generated in the braking module will be distributed evenly to the rocket body through the body tube sections direct contact with each other.

Recovery System Design Specifications

The recovery system is a dual deploy system using a Stratologger CF altimeter to trigger the deployment of both the main parachute and the drogue parachute at their appropriate heights. The drogue parachute also has a backup system which uses the engine's ejection charge for deployment in case the primary system fails. The drogue parachute module is designed to withstand a blast from above as well as below. The black powder charge from the altimeter will decouple and deploy the drogue parachute at apogee. In the event the charge connected to the altimeter does not deploy the drogue chute, the secondary charge on top of the motor will deploy the chute.

Main Parachute

The rocket's main parachute will be an IFC-27 Chute from Fruity Chutes. Based on a requirement of a terminal velocity of 21.5 ft/s (6.55m/s), and a predicted mass of 5.042lb (2.287 kg) of an empty rocket, we have calculated the required diameter of the main parachute to be 27.05in (68.72cm) in diameter with an estimated drag coefficient of 2.2. The diameter of the main parachute was determined using the equation in Figure 9. It has 8 shroud lines each rated at 6400 oz (400lb). The parachute has a weight of 5.0 oz (142g) and a volume of 27.6 in^3 (452 cm^3). It will be connected with the shock cord to the eye bolts which is connected to the bulkhead in the rocket body The shock cord for the main parachute will be 252 in (640.08 cm) long, based on the convention of choosing the length of the shock cord to be between 3-4 times the total length of the rocket. The shock cord is made of of ½ inch tubular nylon webbing rated at 1200 lb (544.8 kg). The parachute will be ejected between 1000-700 ft (305-213m) during rocket's descent. The ejection will be achieved through a black powder charge triggered by the altimeter. A 13 in (33.02 cm) Nomex blanket will be attached to the shock cord to protect the chute from hot gases produced by the black powder charge.

Drogue Parachute

The rocket's drogue parachute will be a CFC-19 Chute from Fruity Chutes. The chute is 19 inches (7.5 cm) in diameter with an estimated drag coefficient of 1.5. Our drogue chute diameter was determined using a predicted mass of 5.04lbs (2.287kg) for an empty rocket and equation found in Figure 9. The parachute has 8 shroud lines rated at 220lb (99.8kg). The total weight of the drogue chute is 1.3 oz (.037 kg) with a packing volume of 7.4 in^3 (121 cm^3). It will be connected to a bulkhead in the air brake section and the motor section. The length of the shock cord for the drogue chute will be 144 in (366 cm) long. This length was determined through the use of the conventional rule of thumb. The rule states that the length of the shock cord should be in the range between 2-3 times the length of the rocket. made of ½ inch tubular nylon webbing rated at 1200 lb (544.8 kg). The drogue chute will be ejected at apogee via a black powder charge located on the bulkhead. The backup charge will be the motor's deployment charge. Two 13 in (33.02 cm) Nomex blankets will be attached to the shock cord in order to protect the drogue chute from the hot gasses. One blanket will be positioned above the drogue next to the bulkhead, and the second blanket will be positioned below the drogue next to the tail. The calculated velocity of the rocket after the drogue is deployed is 78.5 fps (23.9 m/s).

$$D = \frac{1}{2}\rho v^2 C_d \pi \;\rightarrow\; d = \sqrt{\frac{8W}{\rho v^2 C_d \pi}}$$

Main $v = 22$ ft/s (6.7 m/s), Drogue $v = 96.5$ ft/s (29.4 m/s), $\rho = 1.225$ kg/m^3, $C_d = 2.2$

Figure 9: Equation for Parachute Diameter

Parachute data for different motors including the weight of the motor mount.

Type	Predicted Rocket weight		Calc. Main Diameter		Calc. Drogue Diameter	
Name	kg	lb	cm	in	cm	in
AeroTech J1299	2.749	6.06	75.3	29.66	20.7	8.15
AeroTech K185	2.894	6.38	77.3	30.4	21.3	8.4

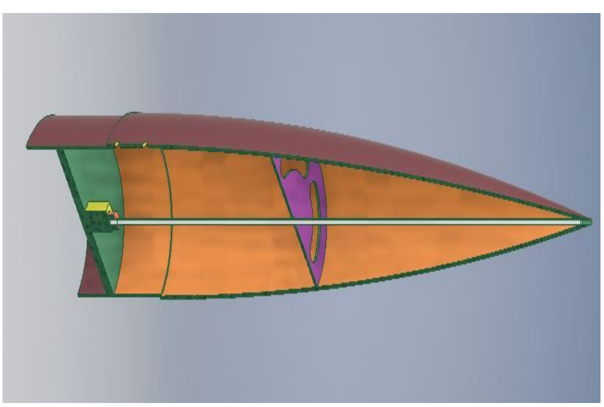
Pitot-Static Nosecone

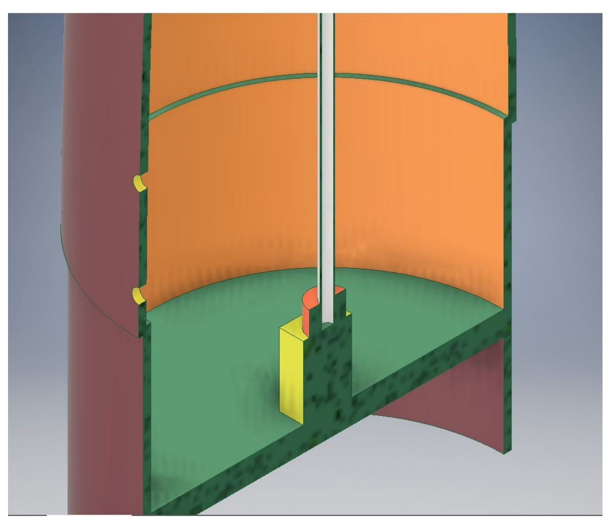
This device measures the air pressure entering the tip of the nose cone as the rocket moves through the air. These measurements will be used to calculate velocity in terms of time before being stored in the rocket's onboard memory.

The sensor we're using a Honeywell HSCDRRN015PDSA5, which is a digital pressure differential sensor which can measure a difference in pressure up to +-15 psi (103.4 kPa). This sensor was picked based the the use of the formula for fluid kinetic energy (Fluid KE) to estimate a highest pressures the sensor would endure. $P = \rho v^2/2$ where P is pressure, ρ is density of fluid (air in this case) and v is velocity. Assuming a max velocity of 300 m/s and ρ is 1.225 kg/m^3, we find P is equal to about 7.98psi (55 kPa). With a calculated 8 psi as a roof pressure the sensor will be under 15 psi leaves us plenty wiggle room.

With this sensor, we can then use Bernoulli's to calculate the velocity the rocket is moving compared to the air. Using Bernoulli's equation, $v = \sqrt{2(P_{ram} - P_{static})/\rho}$, where v is the velocity, P_{ram} is the pressure of the air entering the nose, P_{static} is the static pressure inside the nose and ρ is the density of the fluid.

The following diagrams are the preliminary design idea of the device created with Autodesk Inventor. A tube connects the opening in the point of the nose cose and directs the air to the sensor at the base.





Electronics overview

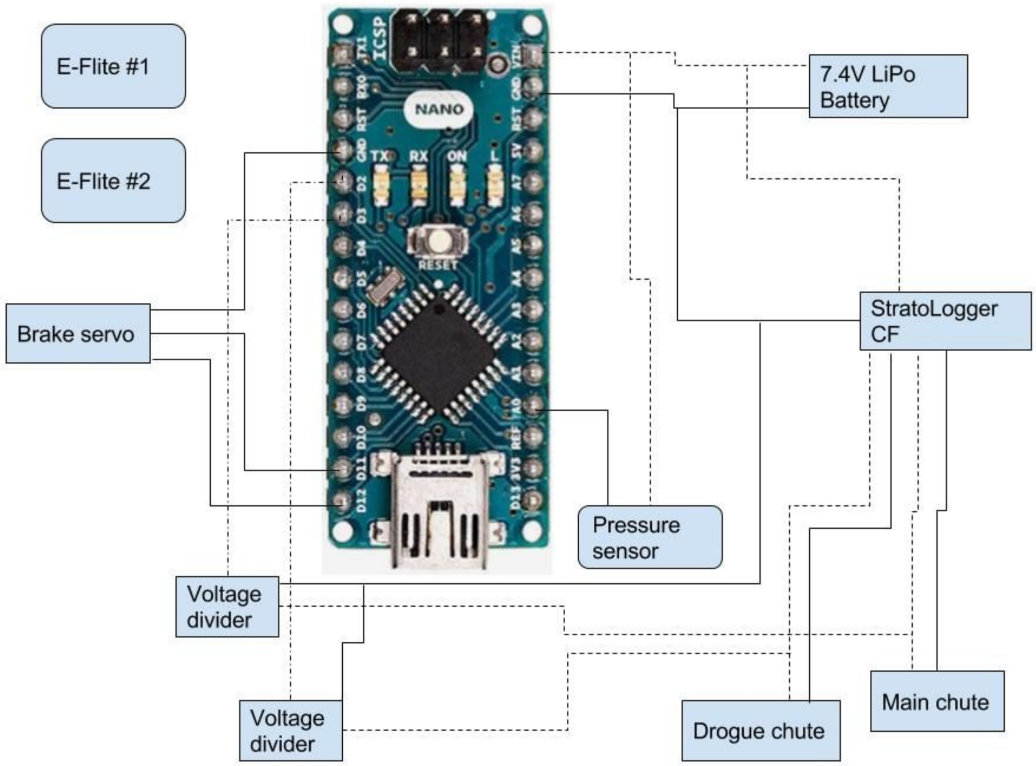
The avionics consists of three systems: a control system, a recovery system, and a visual data system. These systems will work in tangent to collect data during flight, control the craft's drag system to achieve the desired altitude, and return the rocket safely back to the team

The first system, the video capturing system, consists of two E-Flite EFC-721 720p HD video cameras. These cameras are mounted externally to the hull with one pointed toward the fore and the second is pointed to the aft. Each camera has an internal 3.7V Li-Po battery that is rechargeable via USB and will each uses an SD micro card to store the video data. These SD cards can be from 2GB to 32GB in storage size.

The second system is the control system. The central processing unit (CPU) is an Arduino Nano, which will collect pressure data to calculate and store velocity data then use this data to calculate the expected apogee while also controlling the drag system to achieve the desired apogee. The Arduino Nano has a 16MHz clock and uses an ATmega328 which has 32KB of flash memory, 2KB is used for the bootloader and the rest will be available for the program and storage of the flight data collected from the pressure measuring device. The data will be recovered after each flight using mixture of AVRDude and a custom script. The Nano was chosen because of its capabilities, cost, and size.

The CPU will also be monitoring the lines using it's interrupts INT0 & INT1, which are pins D2 & D3 respectfully. Because the Nano can't handle the 9V the Stratologger uses to deploy the chutes, there will be a high resistance voltage divider in parallel to lower the voltage to an acceptable level of less than or equal to 5V and avoid drawing current away from the igniters for the chute ejection charges. Once triggered, the Nano will log this on its internal memory.

The Nano will also be controlling and powering the servo which controls the air break from the time it leaves the rail to just before apogee, when, after retracting the breaks, it will deactivate the servo to save on power.



The third system is the primary recovery system using a commercial altimeter, the Stratologger CF, to control the deployment of the main and drogue chutes for retrieval and a locator beacon, an AT-MdP transmitter, to assist in retrieval should we lose line of sight of the rocket. The locator beacon is self-contained and uses a single 3V CR2032 “coin” battery for power, has a 20-inch wire antenna and has a range of 3 miles.

In addition, a Stratologger altimeter device by PerfectFlite will be used to deploy the main parachute. It has a deploy range between 100 to 9,999 ft (30.5 to 3048 m) (above ground level (AGL) and has a maximum altitude of 100,000 ft (30480 m) above sea level (MSL). This device can store data at a rate of 20 samples per second over for at least 9 minutes. However, it can also store up to 31 flights of data. It will be powered by the main battery pack. A positive and negative output lead will supply 10A of current for up to one second to ensure the main parachute deployment at the specified altitude.

The main battery pack is an E-flite 120mAh 7.4v LiPo battery pack that will be supplying rocket’s electronics, with exception of the cameras and the tracking beacon. This saves on weight, but at the cost of life expectancy. Though, even with the batteries low Amp Hour (Ah) rating, the rocket’s systems will have a limited life expectancy of two minutes, which is much lower than the expected one-minute launch cycle. Table 1 breaks down the current consumption for each device.

	Draw (mA)	"On" time (s)	Total mAh per
Nano	19.0	120.0	38.0
Stratologger CF	1.5	120.0	3.0
Ematchs	1000.0	2.0	33.3
Servo - idle	5.4	30.0	2.7
Servo - running	150.0	16.0	40.0
		Total mAh	117.9

Table 1: expected current draw using the formula $\Sigma(Draw * \text{"}On\text{"}\ time) = Total$

Predicted Performance

To get our estimation for the overall performance of our rocket on two different class motors our team used primarily OpenRocket Software. To determine the overall performance of our rocket while in the braking maneuver, we constructed an Excel spreadsheet that allowed us to simulate our rocket's flight under different types of conditions such as timing of the air-brake deployment. Both of these softwares helped our team to come to an optimised rocket model.

Launch Analysis

Aerotech J-1299

The launch of our rocket powered by the Aerotech J-1299 motor was operating under parameters such as launch rod's length of 80 in (2.03m), launch site's latitude of 45.5 $^\circ$N, latitude of $-93\,^\circ$E, and an altitude of 904 ft (276m). Wind conditions were assumed to be, average windspeed of 7.35ft/s (2.24 m/s), standard deviation of 8.82in (224 mm/s), wind direction of 90 degrees, and turbulence intensity of 10%. Using J-1299 motor our off rail velocity was at 141 ft/s (43.0m/s), which is significantly above the threshold of 45 ft/s (13.7 m/s) for a guaranteed stable launch. Launch was measured starting at ignition of the motor and finishing at the motor burn out. The total launch span was for 0.653 seconds.

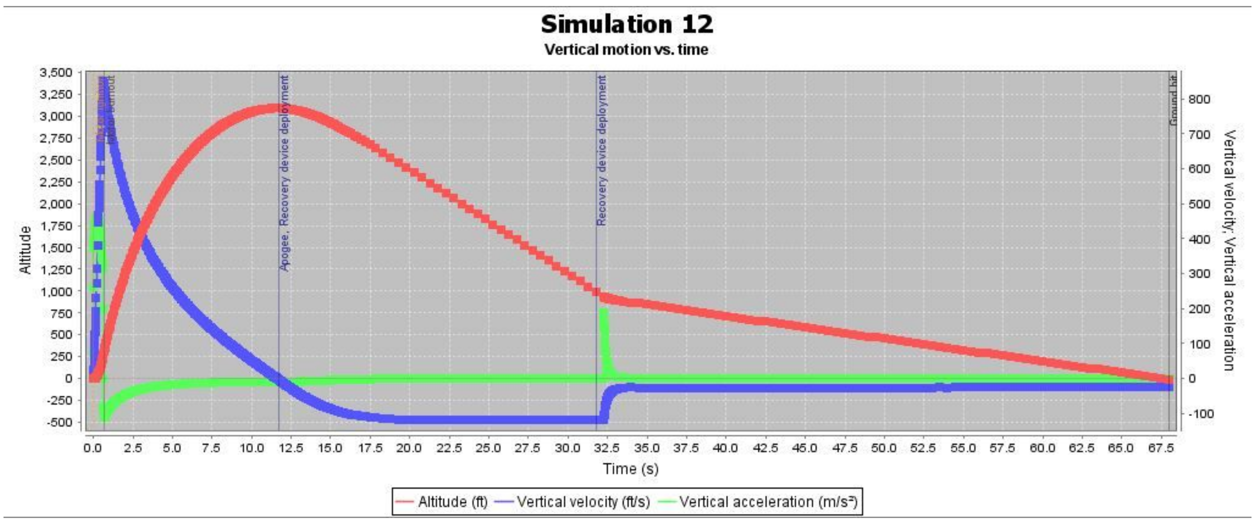
Aerotech K-185

The launch of our rocket powered by the Aerotech J-1299 motor was operating under parameters such as launch rod's length of 80 inches, launch site's latitude of 45.5 °N, latitude of −93 °E, and an altitude of 904 ft. Wind conditions were assumed to be, average windspeed of 7.35 ft/s (2.24 m/s), standard deviation of 8.82in (224 cm/s), wind direction of 90 degrees, and turbulence intensity of 10%. Using K-185 motor our off rail velocity was 54.1 ft/s (16.5m/s), which was above the threshold of 45 ft/s (13.7m/s). Launch was measured starting at ignition of the motor and finishing at the motor burn out. The total launch span was for 7.1 seconds. During the Launch period our rocket reach a maximum velocity of 656 ft/s (200m/s).

Flight Analysis

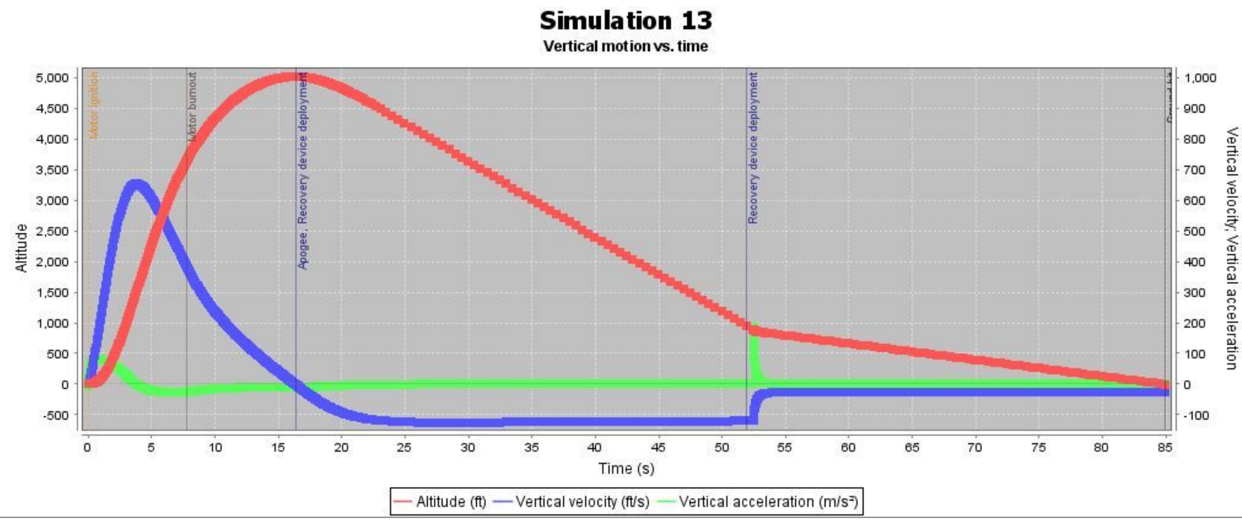
Aerotech J-1299

For simulation with a use of J-1299 motor, our flight time started right after the motor burnout which was at 0.653 seconds. During the flight portion, our rocket traveled 2973 ft (906.2m) up in total of 10.997 seconds, which puts total of 3093 ft (942.7m) of maximum altitude. During the flight portion, our rocket reached a maximum velocity of 852 ft/s (260.m/s).



Aerotech K-185 (No air-brakes)

For simulation with a use of K-185 and no air-brake deployment, our flight started right after the motor burnout, which was at 7.1 seconds. During the flight portion our rocket traveled 4668 ft (1422 m) up in total of 9.2 seconds, which puts our maximum altitude at 5018 ft (1529 m).



Aerotech K-185 (With air-brakes)

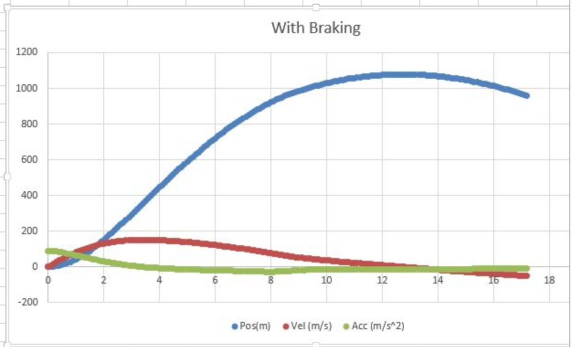
For simulation with a use of K-185 and with the deployment of our air-brake deployment, our flight started right after the motor burnout, which was at 7.1 seconds. The maximum altitude that our rocket reached while our air-brakes were deployed was 3480 ft (1060 m). We deployed our air brakes during launch period at 49 ft (50 m) and retracted at 3280 ft (1000 m). The simulation run for this portion of the analysis used Excel to numerically simulate the position, velocity and acceleration as a function of time taking into account air drag, force of gravity, thrust, and the braking force.

Motion of a Rocket subject to Drag & Braking Mechanism

Rocket Parameters -	K185			**Braking Mechanism Parameters**			
F_T Δ(t)	8	s		Length=	0.0254		m
F_T	370	N		Width=	0.0254		m
m=	3.72	kg		Number=	8		
g=	9.81	m/s^2		Area=	0.005161		m^2
v_y_init=	0	m/s		C=	1.28		
C=	0.76			b=	0.003964		kg/m
Density=	1.2	kg/m^3		Braking Mechanism deployed between Y0 & YF (adjustable)			
d=	0.102	m		Y0=	15		m
A=	0.008171	m^2		YF=	1000		m
dt=	0.1	s					
b=	0.003726	kg/m					
mab=	2.9	kg					

Time(s)	Pos(m)	Vel (m/s)	D (N)	F_g (N)	F_T (N)	B (N)	Acc (m/s^	mass(kg)
0	0	0	0	-36.4932	370	0	89.65237	3.72
0.1	0.448262	8.965237	-0.29949	-36.4932	365.375	0	88.57263	3.70975
0.2	1.787649	17.8225	-1.18357	-36.4932	360.75	0	87.32889	3.6995
0.3	4.006543	26.55539	-2.62761	-36.4932	356.125	0	85.92646	3.68925
0.4	7.091714	35.14803	-4.60317	-36.4932	351.5	0	84.37174	3.679
0.5	11.02838	43.58521	-7.07837	-36.4932	346.875	0	82.67214	3.66875
0.6	15.80026	51.85242	-10.0183	-36.4932	342.25	-10.6575	77.92292	3.6585
0.7	21.37511	59.64471	-13.2556	-36.4932	337.625	-14.1014	75.04277	3.64825
0.8	27.7148	67.14899	-16.801	-36.4932	333	-17.873	71.97164	3.638
0.9	34.78956	74.34616	-20.5955	-36.4932	328.375	-21.9097	68.74141	3.62775
1	42.56788	81.2203	-24.5801	-36.4932	323.75	-26.1486	65.38441	3.6175
1.1	51.01683	87.75874	-28.697	-36.4932	319.125	-30.5281	61.93271	3.60725
1.2	60.10237	93.95201	-32.8903	-36.4932	314.5	-34.9889	58.41746	3.597

K185 | I200 (2) | I200



Recovery Analysis

Our recovery phase of the launch started at the apogee with the deployment of our drogue chute. Since we used two different motors, our apogees varied from one another. At a height of 1000 ft (304.8m) our main parachute was deployed and slowed down our rocket to the minimum descent velocity of 21.4 ft/s (6.52m/s).

Safety

Designed for Safe Flight and Recovery

- Calculate center of gravity (CG) and center of pressure (CP)
- Calculate drag forces created by braking system and rocket
- Calculate drogue and main parachute diameter
- Design rocket body around one standard diameter
- Design rocket for dual deployment
- Aline thrust with CG on central axis with proper parts that are balanced

- Fins are aligned with rocket body and securely bonded to a flat surface
- The main and drogue parachute is deployed via black powder charge
- The drogue chute is deployed via a backup charge from the motor if the black powder charge fails
- Charges are triggered by altimeter at required altitude
- Nomex blankets are used to protect the shock cord and parachutes from the hot gases created by the black powder charges
- Shock cords are secured to eye bolts and bulkheads
- Simulations and calculation were done to optimize successful recovery

Documented Material Handling Procedures

Careful consideration must be taken into effect when handling harsh chemicals to ensure safety. Epoxies and paints will be used in well-ventilated areas where fumes can easily dissipate. Black powder charges will be secured in a controlled environment absent of open flames and excessive heat. Charges will be tested outside in areas with optimal space and prior approval. Charges will only be ignited during testing and launches. Always wear eye protection when handling black powder charges. The rocket and its components will be stored in a dry and cool area when not in use.

Planned Assembly Procedure

The rocket will be constructed in four individual sections: nosecone, main parachute bay, avionics bay, and tail section with drogue chute. The blue tube will form the shell walls of all the sections except for the nosecone which will be made out of plastic. The nosecone and avionics bay will be built first since the components they will house require more attention. The nose cone will be milled so that the Pitot tube can be inserted; furthermore, it will be tested for pressure error and calibrated as needed. The tail section will then be constructed once the nosecone and avionics bay are finished. It will be built along with the fins and reinforced with a strong epoxy. Next, the main parachute bay will be constructed. This bay will just be a simple tube with a bulkhead at one end. The finished sections will then be primed, painted, and fitted with decals. The shock cords and parachutes will be carefully secured and packed inside the rocket. Nomex blankets will be fastened onto the shock cords to protect the parachutes from the black powder charges.

Planned Pre- & Post-Launch Procedures

Pre-Flight Checklist

Physical Inspection & Assembly

- ☐ Inspect all wiring and connections
- ☐ Insert motor
- ☐ Test power supply
- ☐ Inspect Pitot tube for dirt
- ☐ Insert black powder charge for the tail section
- ☐ Inspect drogue parachute (ensure there are no holes or tears)
- ☐ Inspect drogue shock cord, eyebolts, and Nomex blanket
- ☐ Prepare and pack drogue parachute into tail section
- ☐ Insert black powder charge for the main section.
- ☐ Inspect main parachute (ensure there are no holes or tears)
- ☐ Inspect main chute shock cord, eyebolts, and Nomex blanket
- ☐ Prepare and pack main parachute into main bay
- ☐ Secure nosecone to the main bay with plastic break pins
- ☐ Secure main parachute bay to avionics bay with bolts
- ☐ Press fit tail section to avionics section
- ☐ Inspect cameras and mount

Pre-launch

- ☐ Ensure motor is secure
- ☐ Ensure safe zone is clear
- ☐ Insure SD micro is installed in fore facing camera
- ☐ Insure SD micro is installed in aft facing camera
- ☐ Secure Altimeter 2 into the avionics bay
- ☐ Turn on fore facing camera
- ☐ Turn on aft facing camera
- ☐ Ensure all section connections are secure
- ☐ Connect power supply to electronics
- ☐ Clear launch area

Post-Flight Checklist

- ☐ Locate Norman
- ☐ Take pictures of landing site and rocket
- ☐ Disconnect power supply
- ☐ Turn off fore facing camera
- ☐ Turn off aft facing camera
- ☐ Retrieve provided altimeter 2
- ☐ Retrieve SD micro card from fore facing camera
- ☐ Retrieve SD micro card from aft facing camera
- ☐ Inspect & clean pitot nosecone hole
- ☐ Extract avionics bay
- ☐ Retrieve flight data
    - ○ Retrieve video from fore SD card
    - ○ Retrieve video from aft SD card
    - ○ Retrieve data from avionics bay

Budget

Item	Count	Weight (g)	Cost ($)	Total Weight (g)	Total Cost ($)
Arduino Nano 16Mhz 5V	1	7	22.00	7	22.00
Hitec Micro servo	1	11	18.99	11	18.99
Pressure sensor differential	1	1	45.25	1	45.25
E-Flite Camera	2	15	39.99	30	79.98
SD Micro card 2GB	2	0.4	3.49	0.8	6.98
120mAh 2S 7.4V 20 LiPo	1	9	9.99	9	9.99
Stratologger CF	1	10.77	71.95	10.77	71.95
AT-MP transmitter	1	12.75	75.00	12.75	75.00
Jolly Logic "Altimeter 2"	1	6.7	0.00	6.7	0.00
IFC-36 parachute	1	142	125.00	142	125.00
CFC-12 Drogue	1	37	47.00	37	47.00
13 in Nomex blanket	3	170	16.00	510	48.00
7 yd shock cord	1	227	18.00	227	18.00
4 yd shock cord	1	159	15.00	159	15.00