Flight Readiness Report

University of Iowa

Prepared By:

The University of Iowa AIAA

Midwest High Power Rocketry Competition

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May 6th, 2017

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Executive Summary

This report contains information about the University of Iowa's flight readiness for this competitions rocket. Detailed descriptions of all the components of the rocket, such as fins, airframe, propulsion system, and payload, are included. Each description includes any calculations and formulas used as well as the reasoning behind the chosen design. An analysis of the rocket design is included with appropriate figures and plots used to show the rocket simulation data. This analysis is used to predict the flight performance of the rocket as it is designed. There is also a safety analysis included along with all relevant safety procedures necessary. A final section of appendices is included to show a breakdown of all equations as well as any external sources utilized for the design of the rocket.

Rocket Airframe

Rocket Body Specifications

The main body tube of the rocket is approximately 51 in (129.5 cm) long and is constructed out of G12 fiberglass tubing with a diameter of 4 in (10.2 cm). G12 fiberglass was the chosen material because it has been proven as a very strong material, highly suitable for high power rocketry. In order to accomplish the assigned task of capturing visual data of successful parachute deployment, a camera will be mounted on the side of the airframe, coincident with the electronics bay. The camera will be mounted at an upward angle so that it can be mounted without causing any extra drag force, however minimal, while also still being able to record the parachutes successfully deploy. Simulations also estimate the total mass of the launch vehicle to be 10.258 lbs (4.653 kg).

Nose Cone Specifications

The nose cone, which is also made of fiberglass with an ogive shape, adds an additional 15.75 in (40 cm) with a shoulder length of 4.7 in (11 cm). This brings the total length of the rocket to 66.75 in (169.5 cm). The length was extended a small amount to account for the payload bay, which is where a mass will be placed during launch with the larger motor. This concept will be further explained in the payload section.

Fin Specifications

Four fins will be manufactured in-house, comprising of 1/16 in (1.59 mm) thick carbon fiber. This material has been proven to be a strong material to use for fins, and has performed excellently in the past. The fins will be tabbed such that they can be attached to the motor mount via internal filleting for extra strength. This internal filleting will be complemented by external filleting with epoxy resin composite. This will not only provide extra strength on the external airframe, but will also serve to reduce the drag from surface imperfections. Each fin is trapezoidal, with an 8 in base, 4 in free side, and a 5 in height. This shape was chosen to take advantage of the stability of wider wings, and fins will be placed 90 degrees apart from each other in order to achieve symmetry.

Rocket Recovery System

The recovery subsystem is not only comprised of the parachutes that will ensure safe descent, but also the electronics that control the blasting charges. The electronics that control the subsystem are laid out in greater detail in the electronics section. Other than electronics, the recovery subsystem is made up of the drogue parachute, main parachute and blasting caps that will deploy the aforementioned parachutes. The drogue parachute will be 15 in (38.1 cm) in diameter. It will be deployed just after apogee is reached at the start of the descent. Further into the descent stage (roughly 800 - 1000 ft above ground), the main parachute will be deployed. This parachute will be approximately 36 in (91.45 cm) in diameter. Although the mass of the launch vehicle is currently an estimation, the estimate was given a comfortable amount of cushion in order to size the drogue and main parachute.

Rocket Propulsion System

For the propulsion subsystem, the two motors chosen are the J449 for the smaller motor, and the K360 for the larger motor. These motors have a very similar specific impulse, so they will be able to launch the rocket to similar heights. Each motor will be enclosed in an appropriate motor casing, which will then be slotted into 2 in (54 mm) fiberglass tubing. Each motor casing is made out of thin-walled 6061-T6 aluminum tubing with an anodized coating for corrosion protection and also includes a rear enclosure. On the end of the tubing towards the tail end of the rocket, the casing will be secured with a retaining ring. The predicted performance of these two motors will be further detailed in the Analysis of Anticipated Performance Section.

Electronics

Dual Deployment Altimeter and Velocity Data Collection

Overview

The device selected for the dual deployment has a built in altimeter to measure the altitude of flight. The device, known as the stratologger, is capable of deploying two parachutes, a main and drogue. After the flight has concluded, the stratologger communicates to the user the flights apogee. The velocity of the flight is then transferred to the computer for further data evaluation. The velocity data is collected via a DT4U Transfer Kit. This device is able to connect directly to the Stratologger and records data such as velocity and acceleration for the flight.

Setup

The materials needed to assemble the dual deployment altimeter and velocity collection system are listed below in table 1:

Table 1: Electronics Materials List

Description	**Altimeter Quantity**	**DT4U Quantity**
9V Battery	1	1
StratologgerCF Altimeter	1	0
Switch	1	1
DT4U Transfer Kit	0	1
Electrical Wire	Arranged	Arranged

The connections for Stratologger and battery can be seen in the wiring diagram below:

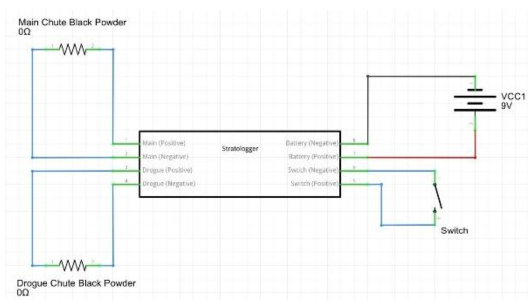


Figure 1: Recovery System Wiring Diagram

Design Features

The Stratologger various features produces a lot of adaptivity in the design of the recovery system. The Stratologger has a set of terminals designated for an external switch. The external switch allows the user to turn on the Stratologger right before launch in order to reduce any possible misfires of the black powder charges. The external switch will be in the off position during mounting on the launch rail. The switch will be activated when the rocket is ready for launch.

Once the launch vehicles reaches apogee, a current is sent through the drogue terminals on the Stratologger to ignite the black powder that will deploy the drogue parachute. The second charge, the main terminals, will send a current when the predetermined height is reached. The main parachute ignition can be chosen from a predetermined values on the Stratologger or programmed manually.

After the flight, the Stratologger will repeat the max altitude and max velocity using audible beeps until powered down. Using, the DT4U transfer kit, PNUT and Stratologger software, the altitude and velocity of the flight can be displayed graphically for the user.

Payload Design Features

The payload bay subsystem will be entirely mechanical, so no electronics will be required to operate it. The payload bay is mounted internally inside the body of the launch vehicle. It is constructed out of the same fiberglass material as the rest of the rocket. This round component is comprised of internal coupling tubes that will slide into the body. The tube is capped on both ends with fiberglass bulkheads on either side. Figure 2 below shows a CAD model of the payload bay.

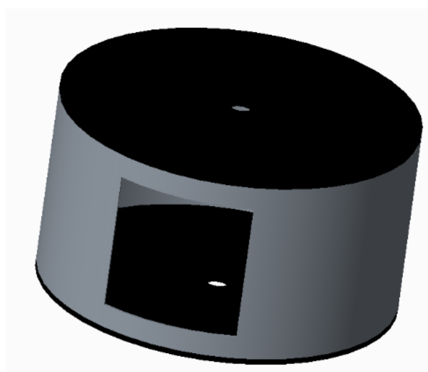


Figure 2: CAD Model of Payload Bay

In order to access the payload bay, a hole was cut into the side, and the payload bay is allowed to freely rotate in order to expose the internal bay to the outside. To achieve this, the coupling tube is restricted from translational movement by the bulkheads. The bulkheads are secured and prevented from moving in any way using epoxy and also 4 elbow brackets.

These brackets are fastened to the exterior body with the head of the fastener on the outside of the body in order to limit the amount of drag on the exterior. Each fastener is also be further secured with epoxy in order to prevent the fasteners from loosening during flight. Once closed, the door will be locked using a simple system that consists of two I-bolts and a quick link, or other self-locking carabiner. Both I-bolts will be secured to the airframe in the same fashion as the fasteners for the brackets.

Because the specific impulse of both motors is very similar, a very small amount of mass is required to bring the larger apogee down to the lower apogee. The projected mass required will be approximately 0.33 lbs (150 g). This brings the cylinder height to be about 0.47 in (1.56 cm).

Budget

The following figure denotes the total amount the team has spent. In the figure, costs highlighted in green indicate items the team has already purchased, and costs highlighted in red indicate items the team still needs to purchase using an estimated cost.

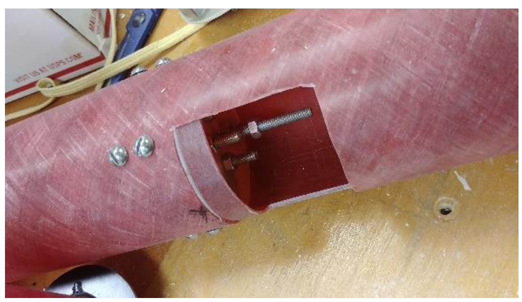
Component	Cost	Needed for both rockets? (Y/N)
Nose cones	$89.49	Y
Centering rings	$28	Y
Bulkheads	$74.24	Y
Competition Motors	$105.98	N
Main chute	$178	Y
Drogue chute	$100	Y
Shock cord	$35	Y
54 mm tube	68.17	Y
Coupling tube	$72.97	Y
Body Tube	$287.51	Y
Data Transfer Kit	$26.85	N
I bolts, Threaded rod, etc.	$20	Y
Motor Casings	$341.89	N
Retaining Rings	$67.07	Y
Batteries	$15	N
Carbon Fiber	$184.40	Y
Camera	$11.08	N
Test Motors	$280.97	N
Rail Buttons	$11.86	Y
Total Cost	$1,998.48	

Figure 3: Cost of Project

Rocket Construction

The rocket was constructed as the following text details. When first receiving all of the components, all coupling tube, bulkheads, centering rings and nosecones were fit into the body tube to ensure that all of the pieces would be able to easily fit together. If any components gave trouble, they were sanded appropriately until the components all fit together.

The first system that was constructed was the payload bay. This was started by finding surplus brackets within the manufacturing lab and attaching them to a bulkhead. The brackets were attached using nuts and bolts, and the nuts were further secured with epoxy to prevent unfastening. With the brackets on the bulkhead, the entire part was inserted into the body tube to ensure that it would all be able to fit. Since this was not possible, all of the brackets had a small amount cut from each side using a hand dremel in order to fit the piece into the body tube. This process was completed for both the forward and aft bulkheads. When installing the bulkheads onto the airframe, first the hole for the payload door was cut using a dremel. This allowed the



team to easily insert the bulkhead and mark where the external holes for the bolts needed to be drilled. With the bottom brackets installed, the bulkhead was inserted and secured as stated above. A longer bolt was also insert so that the mass would have a place to rest during flight.

Figure 4: Payload Door

The payload bay itself then had the door hole cut into it and that piece was inserted into the body tube. This part rests on the bottom bulkhead and then the holes for the top bulkhead brackets could be drilled accurately. This was done in a similar fashion to the first bulkhead. The top bulkhead also had an enclosed I-bolt attached with epoxy to serve as the point of connection between the payload bay and the electronics bay so that when the ejection charges detonated, the two pieces would remain attached together during descent. The inserted coupling tube was then rotated to open the door, and two more holes were drilled in order to insert the I-bolts for the locking system.

The next subsystem constructed was the electronics bay, beginning with the shell. The shell consists of coupling tube and a short (about 2 in long) band in the center of the tube. The band was secured using epoxy.

Figure 5: Electronics Bay Shell

The next step was to construct the electronics sled. This was done using wood scavenged from the manufacturing lab. The wood was cut so that it would be able to fit perfectly inside of the coupling tube. The electronics were then mapped onto the board and it was marked where holes needed to be drilled in order to mount each part using nuts and bolts. After mapping, two wooden blocks were cut. These blocks are how the sled runs along the rails, which consist of threaded rod. The blocks were sized such that they could be epoxied to the bottom of the sled and it into the bay. Holes were then drilled into the blocks and lined up with holes drilled into the bulkheads. The bulkheads would then be secured with nuts screwed onto the threaded rod which will keep the bay enclosed during flight. The main issue with this method is that the electronics sled has a tendency to rotate and not remain in a fixed position, however a solution for this issue was devised. Two small wooden blocks were epoxied to the interior side of each bulkhead with space in between, and one additional wooden block was epoxied on the interior of the bay. The idea is that the single block slots in between the two bulkhead blocks and prevents rotation, as well as allowing the electronics bay to be lined up correctly every time. Enclosed I-bolts were also used to be able to attach the electronics bay with the other components of the rocket so that they remained together as one piece during descent after the detonation of the ejection charges. The last few finishing touches on this system include the blasting caps and some final holes to be drilled. The blasting caps were attached to either bulkhead using a nut and bolt secured with epoxy and an additional hole was drilled in order for the wires sending the blast charge to be able to reach the caps from the altimeter. Because the altimeter relies on pressure readings to read altitude, holes were drilled in the band to allow pressure to enter the bay. At least one of these holes can also be used to activate the switches that turn on the electronics. Some additional holes were drilled in order to allow shear pins to be inserted, and finally the hole for the camera was drilled.

The next part constructed was the nose cone. This process was very simple to assemble. First, a long piece of Kevlar shock cord was cut and tied on one end to a nut. This nut was dropped into the tip of the nose cone and surrounded by epoxy. This was done so that the nose cone could remain attached to the electronics bay after the ejection charges were set off. The Kevlar was then fed through a hole in a bulkhead and epoxied to the base of the nose cone. This was done so that when the main parachute ejection charge went off, the parachute was ensured to not be just pushed into the nose cone and could instead be successfully deployed.

The final system that was constructed was the propulsion system. This included the motor mount and fins. 54 mm tube was used as the motor mount, with two centering rings epoxied on the tube. The spacing between each ring was equivalent the root length of the fins. A retaining ring was next bonded to the tube using JB Weld.

Figure 6: Motor Mount

This adhesive is very strong and proven to work well in this application. With a small amount of epoxy applied to each of the centering rings, the mount was then inserted into the bottom of the body tube. When the body tube was purchased, the fins slots were cut in by the manufacturer, so the mount was positioned such that the fins could be adhered to the mount in between the centering rings. Once the epoxy had set, the fins were installed one at a time using the following method. Each fin had epoxy applied to one edge in order for it to have a small amount of support when inserted and all fins were inserted at the same time. Holes were then drilled, two on each side of each fin. This was to allow the internal epoxy to be applied. The epoxy was comprised of boat epoxy with carbon fibers mixed in. This was done to create a type of composite material that would give the internal fillets extra strength. This mixture was inserted using syringes through the drilled holes. Once the epoxy mixture was given time to cure, the next set of internal fillets on the next fin could be inserted. After all four of the fins had the internal structure installed, the external fillets were made. This was done using the same boat epoxy, although this time a fume silica powder was mixed in. The mixture was applied to the corners between the fins and the body tube, and then was smoothed out using a popsicle stick to ensure there would not be any raised edges causing excess drag.

Deployment Monitoring System

The parachute deployment is to be monitored using an Arducam Sensor Camera Module, available commercially on the internet. This model is compatible with an Arduino computer board, which members of the team have access to. The camera will be mounted appropriately onto the electronics sled and will be aimed out of a pre drilled hole. The camera lens will then be angled so that the camera captures video that is not directly outside the hole, but rather an amount of the body tube. The idea is that during descent the camera is able to capture at least one parachute deploying and possibly both after the second ejection charge deploys the main parachute. To verify the capture of both parachutes instead of just one, the parachutes are two distinct colors which should prevent mistakenly capturing the same parachute in different frames of the video. The camera will be powered using a 9 volt battery and also be activated using a switch, similar to the altimeter. These will be separate switches and batteries, however, so that each system can have its own dedicated power source and be activated when needed.

Test Flight Performance

Unfortunately, the team was unable to secure a test flight in time before the competition. Therefore, the actual test flight performance of the current rocket is not known. However, a similar airframe and recovery design was utilized in a previous competition with a few minor differences. The first one being that the previous rocket required a secondary altimeter and ejection charge for redundancy in case the primary failed. The second difference was that a different motor was flown due to the rocket being heavier than the current rocket. However, as stated, the logic behind the system is extremely similar so a comparison can be made. In the previous rocket flight performance was consistent with the simulated performance. As shown in the following figures, the apogee of both graphs is extremely similar.

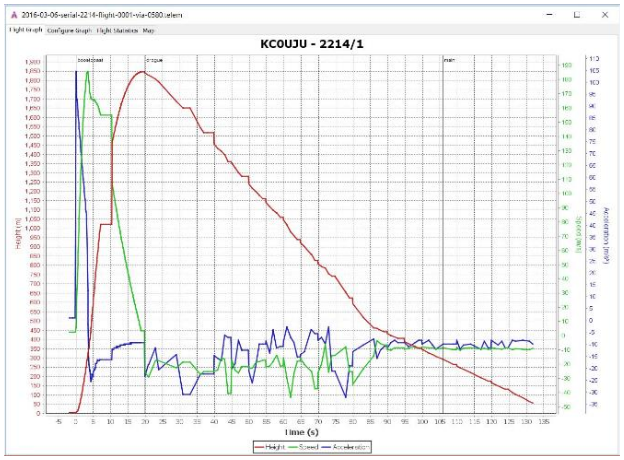


Figure 7: Previous Actual Flight Data

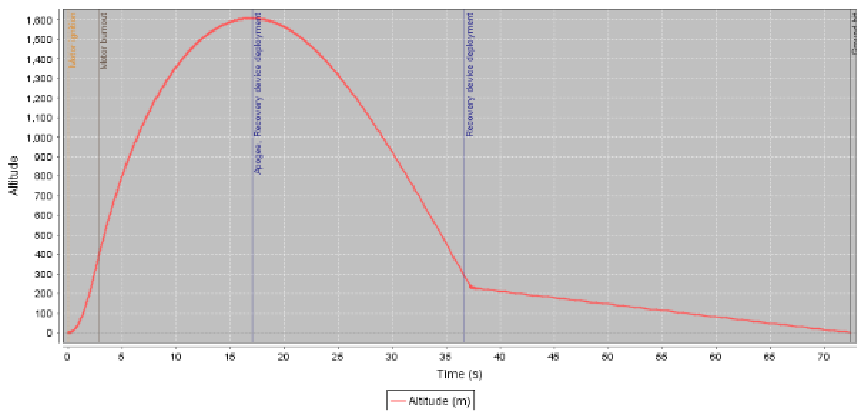


Figure 8: Previous Simulated Altitude Data

As shown in the figures, the altitude data is quite similar with the actual performance peaking around 1850 m and the simulated performance peaking around the same height. This gave the simulation an error of around 0.22%, which is well within acceptable bounds.

The actual recovery system performed as expected in the previous rocket. The drogue parachute was deployed at apogee, and the main parachute was deployed between 800-1000 feet above ground level to ensure a safe landing. The only recovery issue from the previous rocket that was encountered was that when the main parachute ejection charge was set off, it instead pushed the parachute into the nose cone instead of deploying it properly. This possibility was removed with the application of an additional bulkhead at the base of the nose cone. The following table shows flight characteristics from both the previous year's test flight as well as simulated data.

Table 2: Comparison Between Flight Characteristics

Parameter	**Simulated**	**Actual**
Max Altitude	1849 m	1845 m
Max Velocity	248 m/s	185.9 m/s
Max Acceleration	121 m/s^2	104.6 m/s^2

Analysis of Anticipated Performance

In order for any rocket to be launched and to fly properly, the center of gravity and center of pressure must be oriented correctly to have a successful, vertical launch. These factors were determined using the OpenRocket software this student organization uses for creating and simulating their rockets. Since the competition requires teams to launch a rocket using two motors, there will be different centers of gravity and centers of pressure at each launch. Table 3 shows these values, and how the static margin falls approximately within the general standard of 2 to 3 Cal.

Table 3 CoG and CoP for J-449 and K-360 Motors

Motor	Center of Gravity (inches from base)	Center of Pressure (inches from base)	Static Margin (cal)
J449	20.47 in	11.81 in	2.06
J449 Burnout	24.88 in	11.81 in	3.06
K360 (weighted)	19.69 in	11.81 in	1.88
K360 Burnout	24.72 in	11.81 in	3.12

Although the static margin falls on the lower end of the standard requirement for rockets, as the rocket launches and burns out, the rocket will become more stable since the mass at the base of the rocket will drop, causing the center of gravity to move closer toward the tip of the rocket. The test flights will be used to determine whether the flight of the rocket is satisfactory. If the flight is not as straight mass will be added towards the tip of the rocket to make the rocket more stable during flight.

Figure 9 below gives a visual depiction of the center of gravity and center of pressure on our competition rocket.

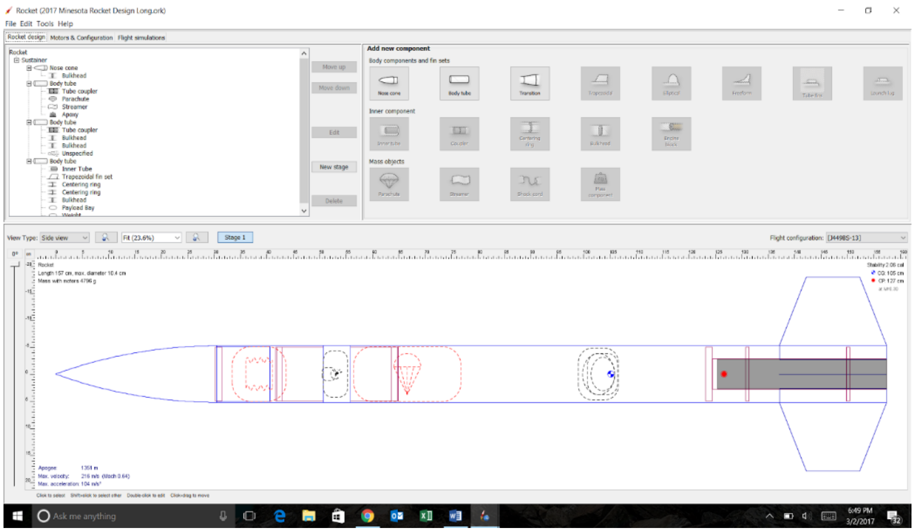


Figure 9: Center of Gravity (blue dot) and Center of Pressure (red dot).

The estimated maximum altitude, peak velocity and peak acceleration, are mostly dependent on the size of the motor used for launch. Table 4 below gives these estimated values using our J-class and K-class motors.

Table 4: Anticipated Performance of J and K-Class motors for Competition

Motor	Max Altitude	Max Velocity	Max Acceleration
J-449	1370 m	222 m/s	107 m/s^2
K(weighted)	1366 m	206 m/s	71.9 m/s^2

Fin Flutter

Our teams beginning design consisted of a shorter body length and larger fins, giving us a rocket just as stable as our current design. The problem that came about with this previous design, however, was the possibility of fin flutter during launch and burnout. The larger fins would be more prone to fluttering at a high velocity, so calculations and design changes were made to prevent this from occurring. Figure 10 includes our current design calculations used to find fin flutter velocity.

Fin Flutter Equation: $V_{flutter}=a*G1.337AR3*P(\lambda+1)2(AR+2)(tcr)3$

Geometric Equations: Area of Fin: $S=12(cr+ct)b$

Equation in Fin Flutter $AR=b2s$

Tip/Root Chord ratio $\lambda=ctcr$

Temperature variation (°F) $T=59-0.00356h$

Pressure variation(lb/in^2) $P=2116144*T+459.7518.65.256$

Speed of Sound (ft/s) $a= 1.4*1716.59*(T+460)$

Known Variables:

Properties during flight:

Shear Modulus (G) = 600,000 psi

Max Altitude (h) = 4,432.24 ft

Max Velocity (Vmax) = 216 m/s

Fin Properties:

Root Chord (cr) = 8 in

Tip Chord (ct) = 4 in

Span (b) = 5 in

Thickness (t) = 0.1 in

$V_{flutter}=332.72ms > V_{max}=222ms$

Figure 10: Fin Flutter Calculations for Current Design

From this data, it can be concluded that this competition rocket will not experience fin flutter since the maximum rocket velocity will not exceed the fin flutter velocity calculated. The flight path of each launch appears quite similar (Figures 11 and 12). However, the K launch achieves a higher apogee compared to the J launch. To achieve roughly the same apogee, a 150-g weight will be placed within the payload bay of the rocket, which is located at the center of gravity of the rocket. This allows the rocket to achieve a slightly smaller apogee, while not jeopardizing the static margin or flight path of the second launch.

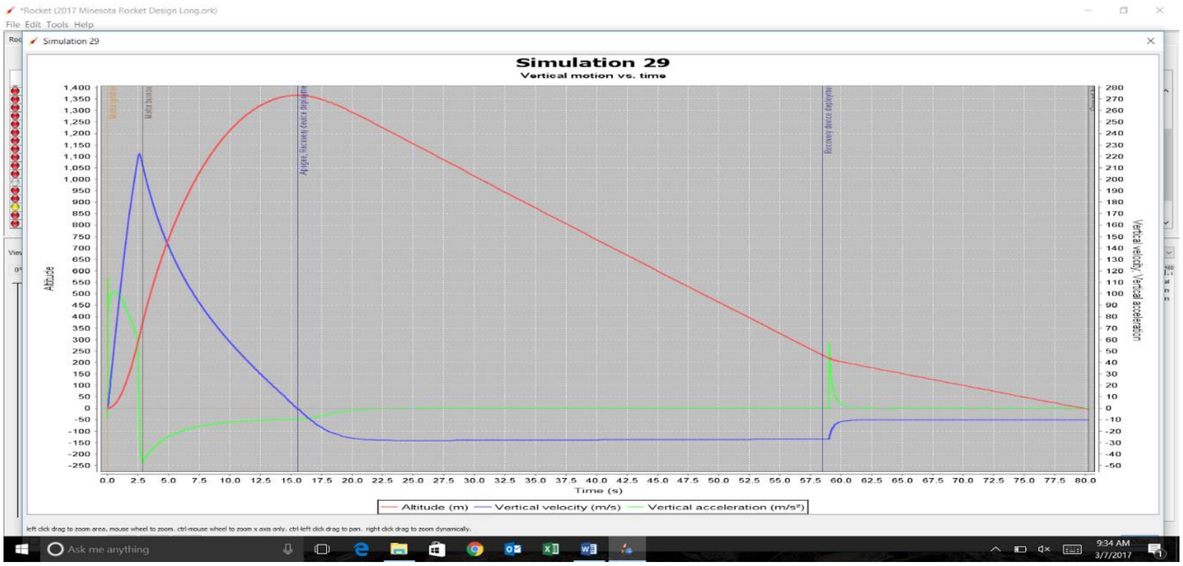


Figure 11: J launch and flight path using J-449 Motor

Figure 12: K launch and flight path using K-360 Motor and 150-g weight

Discussion of Results

According to Figures 11 and 12, our predicted apogees for the J and K launch are 1370 m and 1366 m respectively. Comparing these predicted results to last year's SLI competition, our apogees only differed by 0.22%. (Predicted Apogee of 1849 m to an actual apogee of 1845 m). With this kind of accuracy for the simulations, we can predict a positive or negative change of 0.22% for the actual apogees we will receive during the competition launches. There are very limited error’s from last year’s test launch, so there are no noticeable factors that could affect the reason for such a small difference.

As for peak velocities, these values can be found in Table 4, where the J and K launch values are 222 m/s and 206 m/s respectively. Our predicted max velocities compared to the actual max velocities for last year’s competition had a percent error of about 33.3%. The actual max velocity of the SLI competition launch was 186 m/s, compared to the predicted 248 m/s. This somewhat large error may be that the Openrocket software did not consider the humidity in the air, or possible wind that could have slowed down the rocket during the motor duration.

In regards to the performance of an on-board video, there is still testing to be done to determine the lens range of the camera. If our camera does not meet the optional up/down video, we will ensure that our dual deployment recovery system is fully operational. We have not experienced any difficulties with it so far, so we are keen that the dual deployment will past our testing and work during our competition flights.

Innovation

The innovation with this launch vehicle design is focused on the payload bay. This is because it is entirely mechanical, requiring absolutely no electronics to control it. Another innovation would be the lack of changes that need to be made in order to achieve the goal of reaching a consistent apogee with 2 different class motors. This task may seem rather daunting at first, but the goal can nearly be achieved with the correct selection of motors. The camera system, while not necessarily a complex system, is innovative in how simple it is. Since the camera will not be mounted externally to the body, it will not be creating any additional drag force and will also not be at risk of detachment due to the immense shear force during launch and flight.

Safety

Work on the rocket shall not be permitted unless there are at least two general members and the safety officer present in the work area. The safety officer makes the final determinations on who is allowed to use power tools, and ensures proper supervision during the use of power tools. The safety officer is also responsible for making sure that all members make proper use of personal protective equipment (PPE) while working. The minimum necessary PPE required are safety glasses/goggles, with other protective equipment like gloves, earplugs and respirators used when needed for certain tools and materials. Before the first construction session, the safety officer will ensure that all members have been informed of the health hazards associated with different areas of shop work, have taken all safety quizzes required by the University of Iowa and have signed the required paperwork. The University of Iowa adheres to the guidelines of the Occupational Safety and Health Administration (OSHA). An additional form written by the safety officer will be signed by all members, and details rules specific to the building process, to ensure competition rules are followed.

Materials:

-all epoxies will be handled with proper PPE (safety glasses, gloves, ventilation masks) in a well-ventilated area

-all power tools will be used by people trained in their use, with additional supervision

-no power tools will be used without the approval of the safety officer, and all power tools will be inspected before use to ensure that they are in proper working order

-all tools and materials will be stored in their proper places, with drawers and cabinets being labeled

Risks to Successful Completion

-poor rocket design: Proper design of the rocket is crucial. An unsafe design will be prevented by following NAR guidelines for safe rocket design. These guidelines will be read by all members at the first meeting for design. The team mentor will be involved throughout the process, and will be allowed to have final say on the rocket’s design.

-injury to members during construction: This will be mitigated by proper instruction of all members prior to use of power tools and/or hazardous materials, and through the proper use of PPE. All members will take safety quizzes as required by the University of Iowa, and will not be permitted into the workspace without successfully completing these quizzes.

-poor construction quality: Poor quality control during the construction phase could lead to the rocket breaking upon launch or while in the air, posing a threat to spectators. This will be mitigated by quality control throughout the construction process. Supervision will be provided, with more experienced members leading the construction process. Detail-oriented tasks will be performed slowly with proper materials to ensure quality.

-electronics failure: If our electronics package fails to work properly and does not send the correct signals through the circuits, then there are risks that the parachutes don’t deploy. To mitigate this risk, we are including a backup altimeter to act as a failsafe option. Proper electronics expertise will be applied in creating the electronics, but sometimes the components and solder do not properly conduct.

-shock cord failure: Our drogue chute is designed to slow the rocket in order to provide an appropriate speed for opening the main chute. The drogue chute must be opened properly, at the point of apogee, in order to provide ample drag and allow the main chute to open without issue.

The NAR/TRA mentor will either perform the preparation of the motor on launch day, or will assist team members in this process. Prior to launch, the safety officer and mentor will coordinate on launch day procedures, with the mentor having final say on who performs specific launch-related tasks.

Prior to construction of the rocket, all participating members will be trained in the use of power tools. Explanation of hazards in the work area, including flammable and hazardous materials, will be given in a mandatory meeting to be conducted by the team leader and safety officer. PPE will be worn by all members working on the construction process. Supervision will be provided when working with hazardous materials to ensure the safety of all members.

The pre-launch briefing will be planned by the safety officer and team mentor. This is to ensure that all important details are mentioned during pre-launch briefings. Pre-launch briefings will be conducted by the team safety officer and team mentor and will go over all important details of the assembly and launch process. These briefings will be mandatory for all members attending the launch, even if they will only be spectating. Only a few members will take the rocket to the launch pad, and they will be accompanied by a NAR/TRA member.

All written plans for the rocket will include pertinent safety information regarding the specific materials. Each member will be responsible for reading the given safety information before handling any hazardous materials. Prior to the first construction session, all participating members will be given a sheet detailing safety procedures and rules within the workspace. Members will be asked to sign these sheets as proof that they have read and understand the safety guidelines for the construction space. These sheets will be written by the safety officer, with input given by the team leader. All submitted materials required for the competition will contain the pertinent safety information as prepared by the safety officer.

Prior to the construction process, laws and regulations regarding flammable materials and fire prevention will be read. This is to ensure that safety is kept in mind throughout the construction process. Prior to launch, all regulations concerning airspace, fire prevention, and motor handling will be read through by all participating members, even if they will not be handling the motor. The NAR/TRA mentor will be consulted during this time to ensure that all members and the mentor are in agreement with launch procedures.

Any and all motors needed will be purchased through the NAR/TRA mentor, and will be kept by the mentor until needed for launch. The NAR/TRA mentor will assist the team in preparing the motor for launch to ensure safe use of the motor. Any other energetic devices that will be used in the rocket will be cleared through the mentor before being added to the rocket itself to ensure proper assembly and safe use. Storage and transport of the energetic devices will be coordinated with the mentor as needed.

All members will be given a written statement detailing safety regulations. This will include basic safety during the construction process, as well as details of safety before and during the launch. All members will be informed of the required safety procedures on launch day during the pre-launch briefing, and will be expected to listen to the RSO throughout the launch process and respect the RSO's final decision on the launch. The safety officer will coordinate directly with the RSO during the inspection to answer any questions and ensure that the rocket will be able to be safely launched.

Planned Changes

Currently the team does not plan to make any changes between now and the day of the competition.