Rocket Report 2015

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Jefferson Starship

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Purpose: The purpose of this lab was to figure out how to create a bottle rocket out of multiple bottles and if more bottles would make the rocket go further.

Background: While doing research it was found that other people who built a multi-chamber rocket had better results than people who had done the traditional 2-liter bottle rockets. Creating a multi-chamber rocket requires splicing which is creating a leak proof seal between two bottles. Last year Amy Engle was the only student to successfully create a multi-chamber rocket so her lab report was useful. Amy had used a construction adhesive, but the U.S. water rocket website that Amy sited said that epoxies worked as well as construction adhesive. Based on last years rockets it was obvious that the hardest part about building multi-chamber rocket was the splice. After the research on what bonding agent to use on the splice pvc cement seemed like it would be a good choice. Pvc cement is used to bond pvc pipes together by melting them to become almost one. After picking the bonding agent the U.S. water rocket website had videos and directions on how to properly splice bottles together. The proper way to splice bottles is to cut them where the bottle is all one width then dip one end into a hot pot of water. This allows for one bottle to fit inside the other. Next it is necessary to sand the parts of the bottle that will be bonding together to create more surface area for the bonding agent to hold on to. Lastly follow the directions on the bonding agent that is being used.

Experiment and Analysis:

Launch 1 (9/22/15)

The first launch was to test to see if pvc cement would be a good bonding agent for holding the splice together. Also on the first launch the direction in which the bottles were spliced together was also being tested. One rocket had the bottom of the two bottles spliced together (see figure 1), the other rocket had the bottom cut out of one bottle and the neck of the second bottle was through the hole and into the other bottle (see figure 2). Two 1-liter Polar bottles were used and after they were spliced together duct tape was added around the seam of the bottles for extra support.

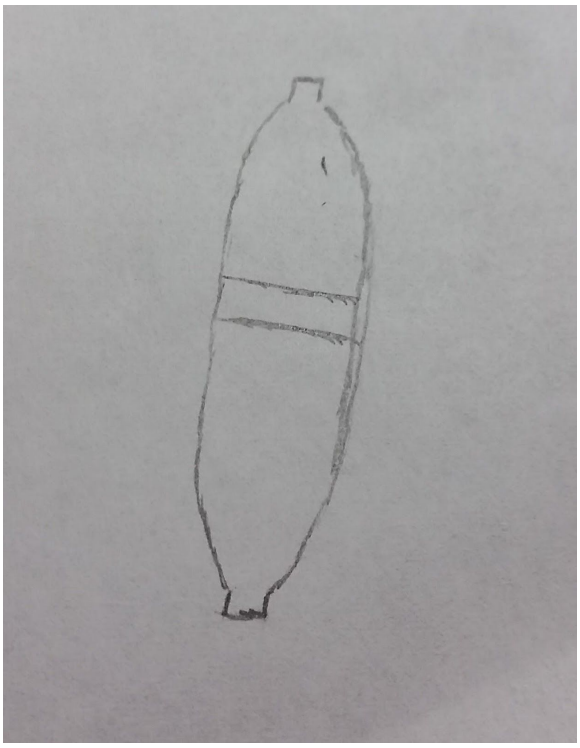

Figure 1

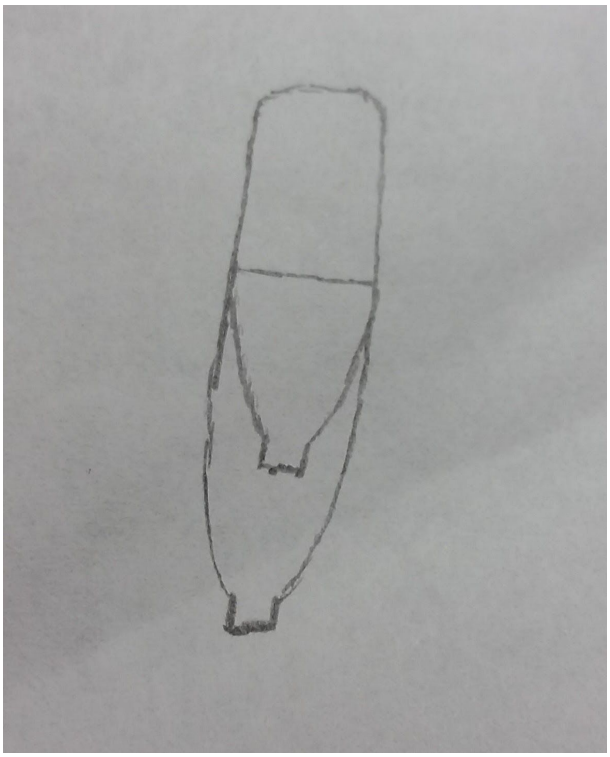

Figure 2

Results of First Launch (Figure 3)

Rocket	Psi	Distance (yards)
Rocket one (ends together)	60	Blew up
Rocket two (neck inside)	60	Blew up

The findings after the launch was that the pvc cement did not bond the bottles together well enough. The bottles are a very different type of plastic and that may be why the pvc cement did not bond the bottles like it bonds pvc pipes. Also the bottle with the neck inside the other bottle did not leave the launcher well, one bottle stayed on the launcher so this design will not be used again.

Based on these findings a different bonding agent will be used in the next launch. The first bottle design of the two ends of the bottles together will be used again since it worked better.

Launch 2 (9/28/15)

The second launch was still testing to find a good bonding agent to hold the spliced bottles together. Two different types of bonding agents were tested. The first was a gorilla glue brand epoxy (see figure 4), and the second was a loctite brand of epoxy (see figure 5). The gorilla glue brand epoxy was a double bonding agent which means that two different epoxies had to be combined and then applied to the rockets. The loctite brand epoxy was only a single bonding agent it just had to be applied. The same steps were followed for splicing the 1-liter Polar bottles together the only difference was the bonding agents that were used. Both of the bottles

were spliced together with the ends together and had duct tape around the seam for reinforcement.

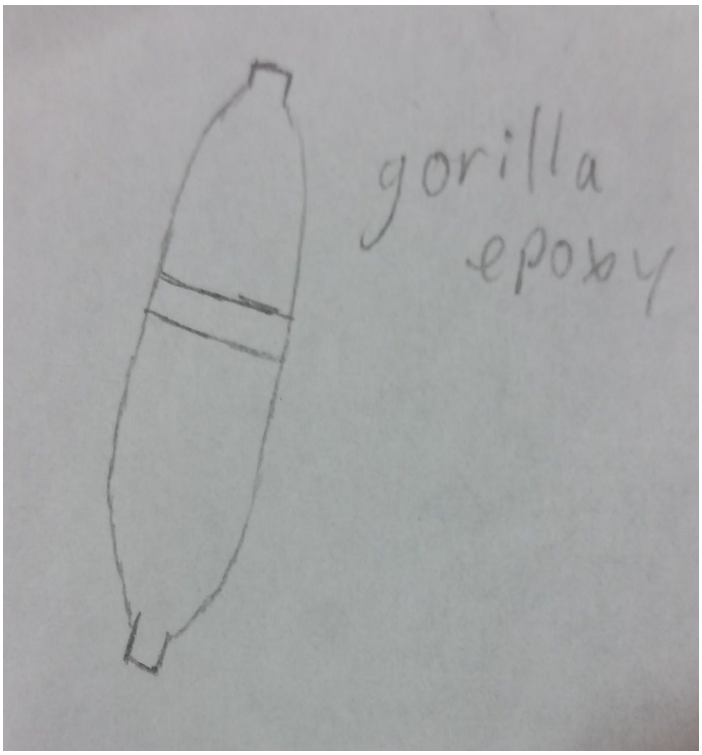

Figure 4

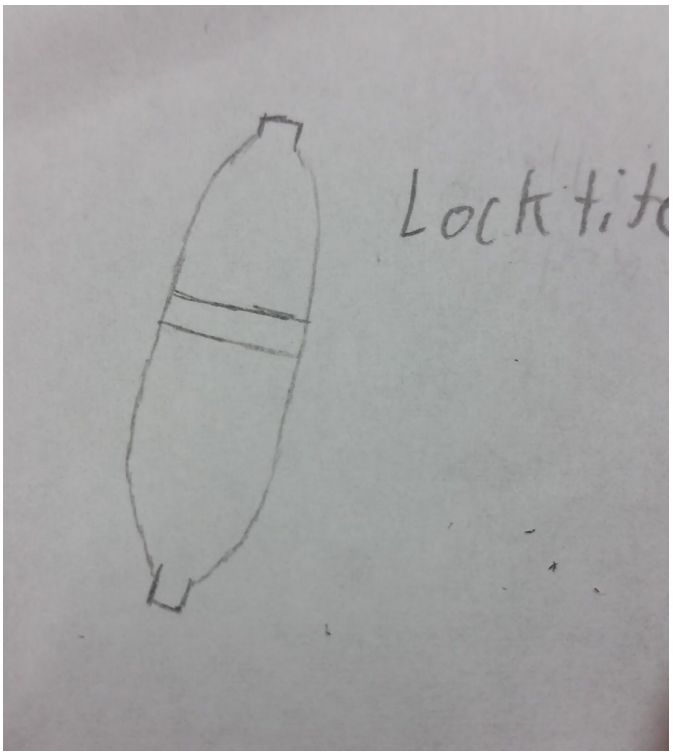

Figure 5

Results of Second Launch (Figure 6)

Rocket	Psi	Distance (yards)
Gorilla Glue Epoxy	80	26
Loctite Epoxy	80	23
Gorilla Glue Epoxy	100	24
Loctite Epoxy	100	28
Gorilla Glue Epoxy	120	30
Loctite Epoxy	120	Blew up
Gorilla Glue Epoxy	130	30

The findings of this launch were that the gorilla glue epoxy held up better than the loctite epoxy. The gorilla glue epoxy held the splice at 130 psi and the loctite epoxy which leaked and didn't even make it off the launcher at 120 psi. The gorilla glue epoxy was also easier to work with, it was painted on to the bottle and had a longer set time which allowed for the bottles to be placed correctly. Whereas the loctite epoxy was put on from the tube which didn't allow for even distribution of the epoxy. Also the loctite epoxy had a much faster set time which didn't allow for placing the bottles together as correctly and evenly.

Based on these findings the gorilla glue epoxy will be used on the next launch because it was very effective and withstood the 130 psi. The design of the rocket with the bottom of the bottles being connected will also be used again next launch. Since the splice is working fins and a nose cone will be added as well.

Launch 3 (10/2/15)

More research was done to decide on fin designs. The fin design would be parallelogram fins because they are a popular fin design and allow for stability. It was also found that the more bottles you had spliced together the more fuel you could have and the greater the distance would be. This launch there was three 1-liter Polar bottles spliced together with the gorilla glue epoxy. The bottles were placed together end to end like the last launches with a third bottle with both ends cut off in the middle. The nose cone was the top to one of the bottles and it was taped on to the front rocket with duct tape. The weight in the nose cone was cat litter with

water and it was very light. There was three large fins on the back end of the rocket that were parallelogram shaped and attached with duct tape (see figure 7). All the seams were reinforced with duct tape.

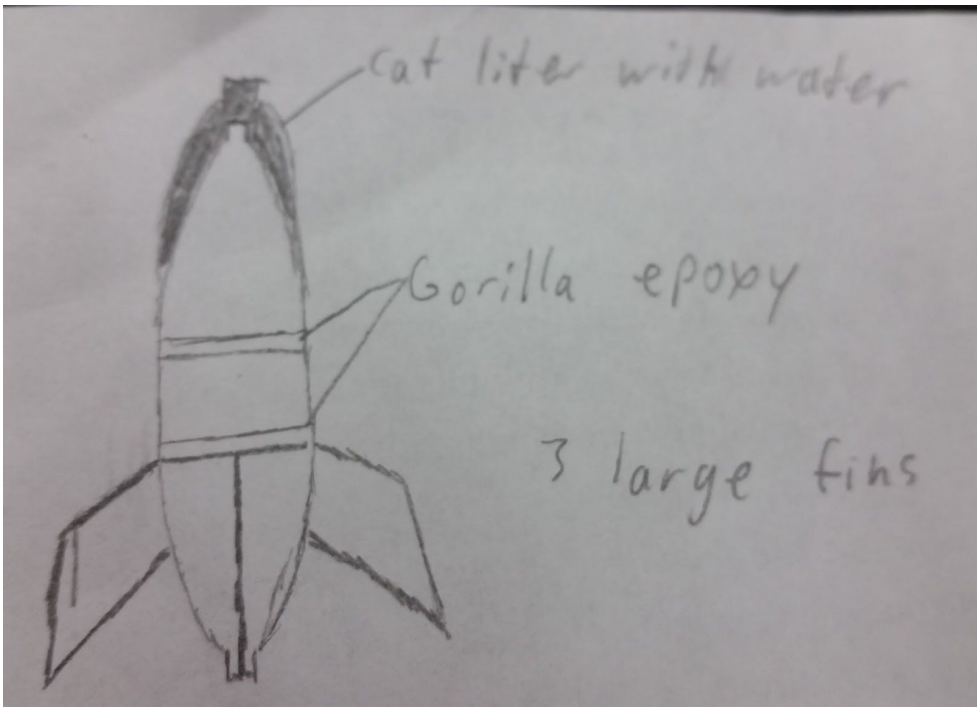

Figure 7

Results of Third Launch (Figure 8)

Rocket	Psi	Distance (yards)
Jefferson Starship Original	100	145
Jefferson Starship Original	140	174

The findings of this launch were that the gorilla glue epoxy still held even with a greater psi and that adding the extra bottle, fins, and nose cone made a huge difference in the distance that the rocket travelled. The fins were not very sturdy. The duct tape did not hold them on well

enough on its own. The water and cat litter sloshed around in the nose cone and made the rocket more unstable. When the rocket landed there was some damage to the nose cone and first bottle but the pressure puffed it out when it was on the launcher.

Based on these findings stabilizing the fins and adding a new weight will make the rocket more stable and allow for greater distance. For the next launch the fins will be hot glued to the bottle as well as taped on to hopefully provide more stability. Next launch the weight will not be a liquid because the water and cat litter did not work well as a weight.

Launch 4 (10/7/15)

For the fourth launch the nose cone was further off the fuselage than the last launch so the fuselage would not get as crushed on impact (see figure 9). The weight in the nose cone was caulk instead of cat litter and water so it would not move around while in flight. The nose cone was still the top of one of the bottles and secured on to the front of the rocket with duct tape again (see figure 9). The fins were set with hot glue and tape to stabilize them more than last launch. There was three 1-liter Polar bottles that made up the body of the rocket again because the focus was on stabilizing the rocket. The bottles were attached the same as last launch (see figure 9). After the gorilla glue epoxy was applied and cured, duct tape was put on the seams of the rocket again.

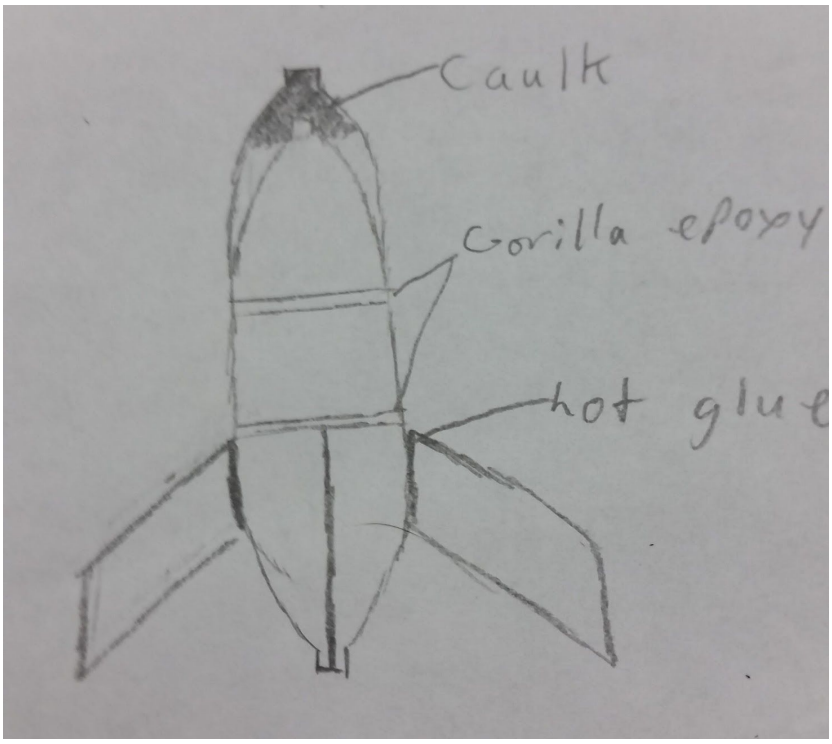

Figure 9

Results for Fourth Launch (Figure 10)

Rocket	Psi	Distance (yards)
Jefferson Starship #2	130	195
Jefferson Starship #2	130	197
Jefferson Starship #2	138	203* This was the class record up to this point
Jefferson Starship #2	138	197

The findings for this launch were that the attempt at stabilizing the rocket worked in it being launched a greater distance. The fins with the hot glue were much more stable and the caulk in the nose cone was heavier than the water with cat litter. Also it didn't slosh around and cause

the rocket to become unstable. The nose cone was damaged pretty badly from the impact of the fall.

Based on the findings not much needs to be done to the rocket. Stabilization and adding more bottles it the next step in getting a greater distance. Also adding a second nose cone to try and keep the fuselage from crushing as much.

Launch 5 (10/14/15)

For the fifth launch the number of bottles was increased from only three bottles to four bottles. The Polar bottles were spliced together with the gorilla glue epoxy just like the other launches. The bottles were spliced together like the original design in figure one but with more bottles. The bottles were added to the middle and just extended the rocket to allow the rocket to have more fuel to launch with. A second nose cone was added to try and absorb some of the impact from the fall (see figure 11). The weight in the nose cone was caulk again. Both of the nose cones had caulk in them. The nose cone closest to the body of the rocket had more caulk in it to keep the rocket balanced. The nose cones were attached with duct tape to the front of the rocket. The fins were hot glued and taped to the rocket and the seams were taped with duct tape for support.

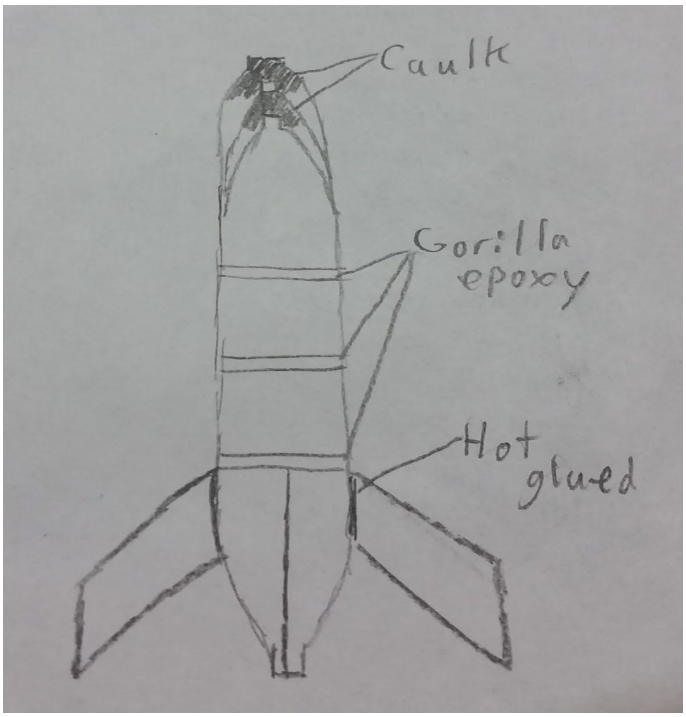

Figure 11

Results of Fifth Launch (Figure 12)

Rocket	Psi	Distance (yards)
Jefferson Starship #3	138	Blew up

The results of this launch were not expected, the gorilla glue epoxy had been holding in the past. The rocket blew up right at the seam, it was possibly a bad glue job.

All the things would be done the same in the next launch.

Launch 6 (10/20/15)

For launch number six it was the same ideas for launch number five except another bottle was added. The rocket had two nose cones again with caulk in both, with more caulk in the nose cone closest to the body of the rocket and were attached with duct tape. The rocket was spliced together like the rocket in figure one with three Polar bottles in the middle (see figure 13). The gorilla glue epoxy was again used for the splice. The fins were held on by hot glue and duct tape. All of the seams were reinforced with duct tape.

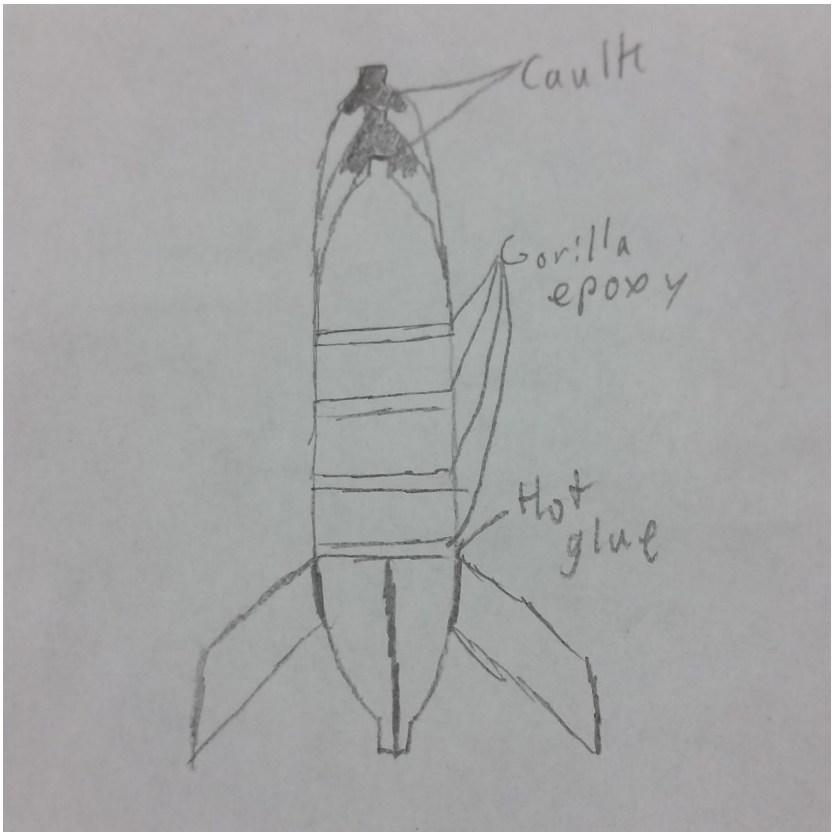

Figure 13

Results of Sixth Launch (Figure 14)

Rocket	Psi	Distance (yards)
Jefferson Starship #4	138	Blew up

Again the results from this launch were unexpected. This time the point that blew up didn't start at the seam, it started in the bottle. This means that the bottles are not strong enough for the pressures anymore.

Based on these results new types of bottles and new bonding agents will be used for next launch. The nose cone design and the fin design will stay the same because they have been working.

Launch 7 (10/30/15)

For launch seven it was back to the drawing board because the Polar bottles being used or the gorilla glue epoxy was no longer holding up against the pressure. The bottle type and bonding agent were being tested. Three rockets were launched on day seven. The rockets still had the double nose cone attached with duct tape as well as the three fins attached with hot glue and duct tape. The first rocket was two bottles spliced together using the gorilla glue epoxy and Adirondack seltzer bottles (see figure 15) to see if the different type of bottle help up better under the pressure. The second rocket was spliced together using a new bonding agent of construction adhesive, and the new Adirondack seltzer bottles (see figure 16). The third bottle was spliced together using the new construction adhesive and using the original Polar seltzer

bottles (see figure 16). All three rockets were three bottles and put together like in figure 1. The seams were all reinforced with duct tape.

Figure 15

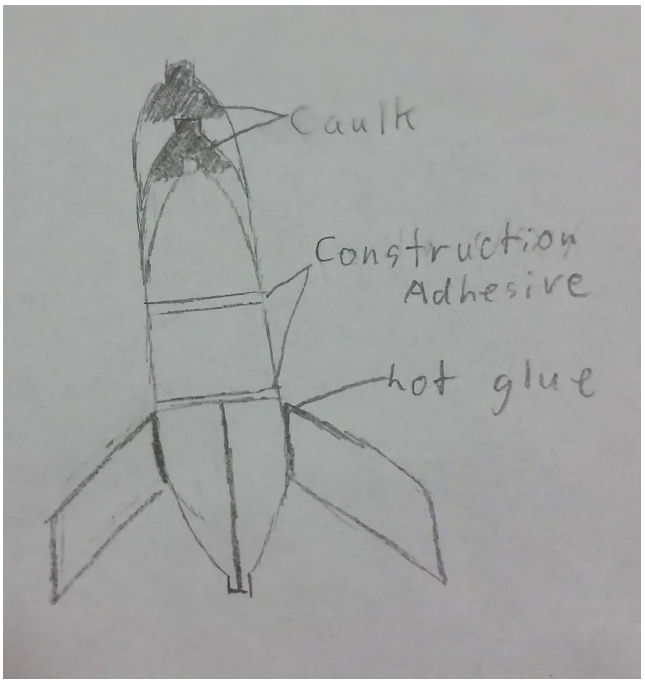

Figure 16

Results for Seventh Launch (Figure 17)

Rocket	Psi	Distance (yards)
Rocket 1	138	Blew up
Rocket 2	138	Blew up
Rocket 3	138	Blew up

The results of this launch were very devastating because nothing was working and it was the last launch before rocket day. All three of the rockets blew up at the seams which meant that the bonding agents were not bonding well enough or properly.

Based on these results the rocket would need to be through up from scratch again.

Conclusion:

The most valuable lesson was that bad results are still results. Even though the rockets kept exploding it was telling that the bonding agent was not strong enough and to try a new one, or that the bottles were weak and try new bottles. When the front end of the rocket caved in it indicated that the front needed more support for the impact. While failures are very hard to take they also teach you a lot and help lead to get to a success. The other lesson that was learned was that the hot glue on the fins made them much more stable and allowed for the distance to be greater.

There was also lessons learned from other groups. Trudi and Laura were also building a multi-chamber rocket were using smart water bottles and it was withstanding the pressure. Tony and Jose had a very good idea for the nose cone putting a bouncy ball in the very tip of the nose cone which would help absorb some of the impact.

In the final design smart water bottles were used instead of Polar bottles because the smart water bottles were withstanding the pressures with Trudi and Laura's rocket. For the bonding agent the gorilla glue epoxy was used because it was the most successful throughout the lab. For the body design four bottles were used and they were placed together exactly like in figure 11. There was not two nose cones on the final rocket because the bouncy ball idea was used instead. In place of the double nose cone a bouncy ball was placed into the top of the nose cone (see figure 18) to try and absorb some of the force of the impact. This method worked for

Tony and Jose's rocket. The shape of the fins did not change in the final rocket they were still parallelograms and attached with hot glue (see figure 18). On the final rocket for attaching the wings, nose cone, and covering the seams gorilla tape was used instead because it has a much stronger hold.

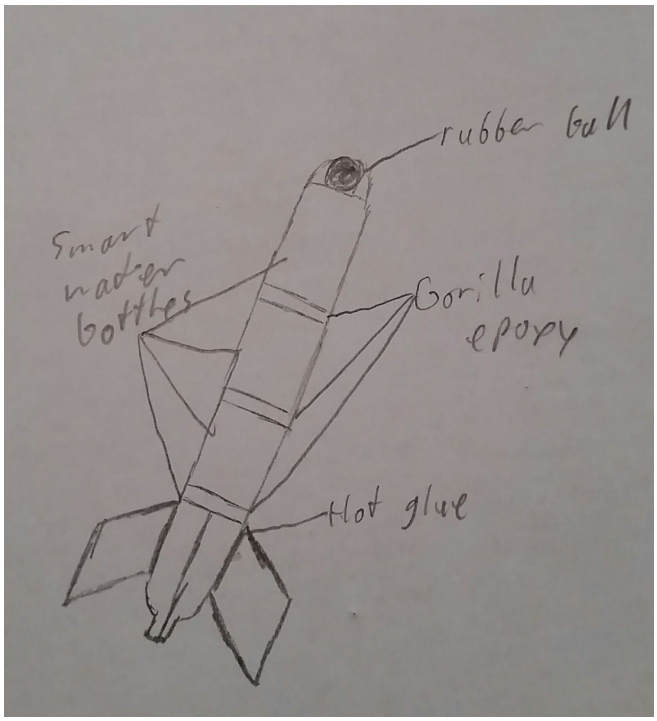

Figure 18

Results of Rocket Day (Figure 19)

Rocket	Psi	Distance (yards)
Jefferson Starship	138	159
Jefferson Starship	138	210 * This was the record for our rocket

Advice:

If you are going to try and make a multi-chamber rocket it is very frustrating and difficult. It can be done though you just have to be willing to put in the time. Also keep organized and on top

on the launch days. Make sure you have your lab notebooks when you go out to launch so you can write how your rocket did right then and there. Make a chart in your notebook that has the name of the rocket, the date, launch day, distance, and psi. This will help you to write the lab report after. Another good thing to do is to use all of the possible launch days. Each day even if you used the same rocket you could learn something new that could better your design, those days are there to help you work out the kinks in your design before rocket day.

Launch Team:

The scribe is responsible for keeping track of all of the rocket names, rocket dates, launches, psi of every launch and the distance that each rocket travels. The scribe is also incharge of making the launch order of the rockets and making sure the rockets go in the correct order.

The water team had to fill all the rockets with the correct amount of water and bring them to the launcher in the correct order. Most of the rockets required one liter of water but others that were muit-chamber rockets got more water because they were larger tanks and cold hold more water. Also all of the rockets had to be fill beforehand and carefully held or set down so the water did not spill. The water team works closely with the scribe because the rockets must go in the correct order that the scribe has written down.

Sources:

Amy Engle's Lab Report

Linsey Carlson's Lab Report

U.S. Water Rockets." *U.S. Water Rockets*. N.p., 5 July 2003. Web. Oct.-Nov. 2015.

http://uswaterrockets.com/